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CURRENT APPLICATIONS OF LASER IN CONSERVATIVE DENTISTRY AND ENDODONTICS. A SCOPING REVIEW.

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Abstract

The use of lasers is considered an innovative method for clinical use in dentistry. Recently, multiple studies have been undertaken regarding the possible applications of laser therapy in dentistry. Furthermore, owing to their ablation, penetrability, and disinfection properties, lasers have excelled in conservative and endodontic procedures, encompassing root canal therapy, vital pulp therapy (pulp capping and pulpotomy), treatment of dentinal hypersensitivity, and management of dental pain associated with pulp and periradicular diseases. This study highlights the advantages of laser-assisted pulp therapy through summarized clinically controlled trials and histological investigations. Furthermore, the innovative application of lasers to enhance root development and facilitate the removal of foreign objects (such as fractured files and fiber posts) in canals has rapidly emerged as a leading trend in contemporary research. This review provides a synthesis and analysis of the existing literature on all the previously stated laser applications. Additionally, the attributes of laser devices, such as erbium lasers, neodymium-doped lasers, CO2 lasers, and diode lasers, are elucidated and examined here, offering valuable references for laser utilization in endodontics. We also concentrate on the various wavelengths pertaining to the lasers utilized in endodontics. High-power lasers function effectively as surgical tools; moreover, low-level lasers facilitate the modulation of pulp inflammation and enhance pulp healing. This narrative review summarizes the expanded applications of lasers alongside various devices in endodontics and seeks to inspire creative ideas on the use of lasers for treating dental disorders, particularly pulp diseases, in the future.

Keywords- Laser, pulp, conservative, endodontics

Introduction

"LASER" stands for "Light Amplification by Stimulated Emission of Radiation." When an outside field is applied, it creates electromagnetic radiation with a uniform wavelength, phase, and polarization. This creates light that is one color, coherent, intense, and collimated. Comprehending the interaction of laser wavelength with oral tissue can enhance patient management. Unlike other medical and surgical disciplines, dentistry views lasers as adjunctive tools for delivery. In 1964, Sognnaes and Stern utilized the Ruby laser to melt enamel and dentin in dentistry. The rapid advancement of lasers, characterized by varying wavelengths and complex factors, may continue to significantly influence the field and application of dentistry. The radiation involved in generating laser light is non-ionizing and does not produce the same effects attributed to X-radiation. For example, the Food and Drug Administration has approved the use of different lasers to remove diseased gingival tissues and other soft tissues, to get rid of dental cavities, to help put in tooth-colored restorations, and as an extra tool during root canal procedures, such as pulpotomies. [1] Some publications have provided details regarding the advantages of CO2 laser treatment of oral environments. The clinical applications of lasers continue to expand, establishing their use as one of dentistry's most exciting advancements, offering significant benefits to patients.

History of Laser

Around 47 years ago, researchers first theoretically developed laser light generation and used it on extracted teeth. Researchers used the first pulsed Nd:YAG laser in 1900 to enhance interaction with dental hard tissues. In the 1970s, researchers identified medical carbon dioxide (CO2) and discovered the clinical application of Nd:YAG lasers in oral soft tissues. Commercially available dental lasers have gained prominence just in the past 3–4 years [2].

In dentistry, conservative and endodontic treatment includes getting rid of bacteria, cleaning out the root canal system, restoring the tooth's shape, and getting it to work again [3]. Clinical settings extensively utilize mechanical and chemical therapies for decontamination and preparation during root canal procedures. Ultrasonic devices, handpieces, and rotary instruments are essential tools for the cleaning, contouring, and obturation of root canals [4]. We use intracanal medicine as a root canal dressing to cleanse and reduce irritation [5]. The repeated use of medications, including calcium hydroxide, mineral trioxide aggregate (MTA), sodium hypochlorite washing solution, and many antibacterial treatments, may raise concerns about antimicrobial resistance [6]. Mechanical contact between the device and oral tissues may result in unforeseen injury or illness. Furthermore, endodontic failure, resulting from insufficient therapy, invariably leads to enduring intraradicular infection. Moreover, only about two-thirds of retreatment cases achieved a favorable outcome [7]. Dentistry has been using lasers of varying wavelengths and devices for decades due to their properties related to debridement, ablation, inflammatory modulation, and healing acceleration [8]. Laser therapy has rapidly emerged as a cutting-edge technique in maxillofacial surgery, oral implant surgery, periodontics, conservative dentistry, and endodontics. The initial report regarding its application to periodontics emerged in the 1980s [9]. Periodontal surgery currently employs it as a commonly used instrument. The scaling and root planing (SRP) procedure may utilize a high-power laser, while a low-level laser could aid in reducing harmful bacteria in periodontal pockets [8]. Furthermore, lasers may be a good alternative to osteotomy, the removal of precancerous growths, and the treatment of periimplantitis [10]. Despite numerous research advancements in laser treatment within conservative dentistry and endodontics, a comprehensive overview of the role of lasers in all aspects of tooth conservation and endodontic therapy remains absent.

Aim

This review talks about the advanced uses of lasers in restorative dentistry and endodontic treatment. It covers root canal therapy, pulp capping, pulpotomy, treating dentinal hypersensitivity, and managing dental pain caused by diseases of the pulp and periradicular areas. Furthermore, laser technology for enhancing root development and eliminating fractured files and fiber posts is presently at the forefront of numerous study investigations. This review aims to facilitate the discovery of innovative laser applications in conservative dentistry and endodontics, thereby addressing the evolving demands of clinical practice.

Materials and Method

An electronic search of databases was conducted: Scopus, PubMed, Embase, Web of Science, and Cochrane were searched for relevant articles using keywords. A total of 701 articles were retrieved.

The Prisma 2020 statement and flowchart were used to streamline the selected articles [Table 1]. After removing the duplicates, a total of 31 records were identified. Endnote 20 was used to manage the electronic records. Two independent reviewers screened the eligible articles and manually checked their citations for relevance.

Data extraction

Four reviewers independently reviewed the retrieved articles following the specified inclusion and exclusion criteria. Disagreements were resolved by discussion. Following that, full texts of the chosen articles were retrieved.

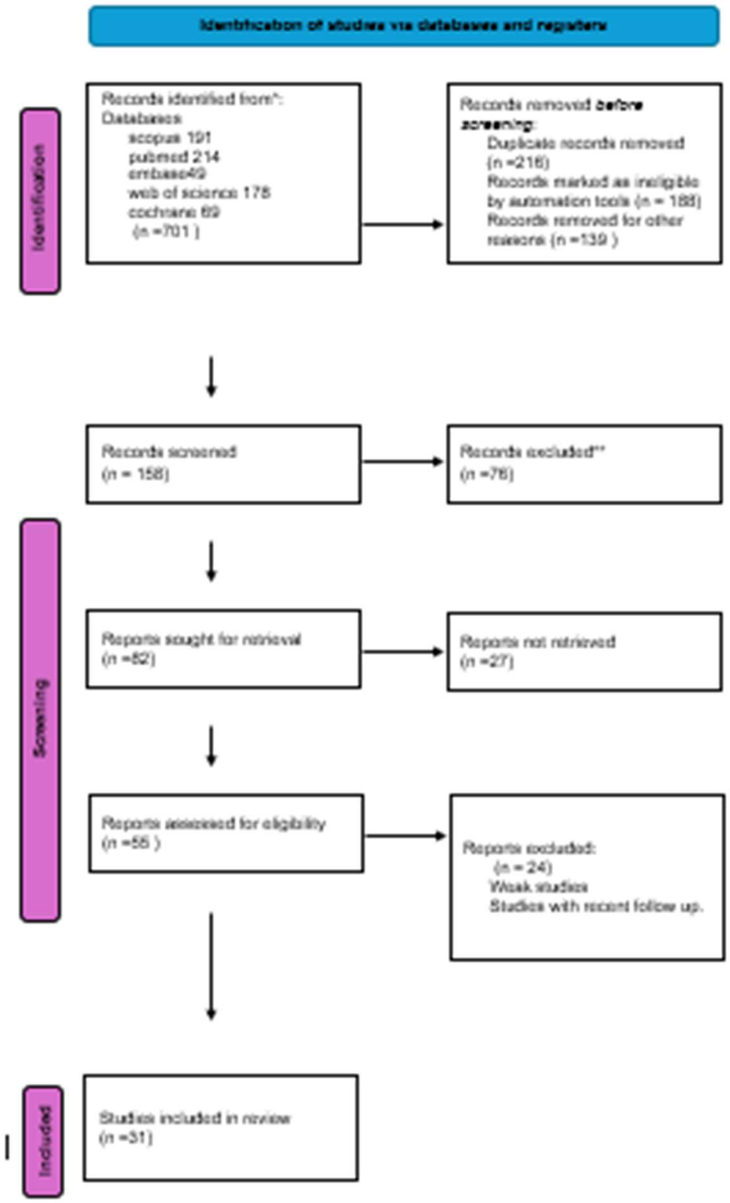

Table 1-PRISMA FLOW CHART

Discussion

Types of Lasers

The laser systems created thus far have been categorized based on the active medium stimulated to generate photon energy. This categorizes laser systems into solid-state (Nd:YAG, Er:YAG, Er,Cr:YSGG), gas (CO2, Argon, Helium Neon), diode, excimer, and dye lasers. Laser systems can be categorized based on their maximum output level, specifically as low output (soft) or high output (hard). Lasers can be categorized based on their oscillation mode, either continuous wave or pulsed wave. The pulsed wave mode can be employed by generating independent pulses (a free-running pulse), as seen in Nd:YAG, Er:YAG, and Er,Cr:YSGG lasers, or by interrupting a continuous wave (gated or chopped pulse), as observed in CO2 and diode lasers [12]. The lasers frequently employed in clinical conservative and endodontic procedures comprise erbium:yttrium–aluminum–garnet (Er:YAG) lasers; erbium, chromium-doped yttrium scandium gallium garnet (Er,Cr:YSGG) lasers; neodymium-doped yttrium aluminum garnet (Nd:YAG) lasers; neodymium:yttrium–aluminum–perovskite (Nd:YAP) lasers; carbon dioxide (CO2) lasers; and diode lasers [13].

Er:YAG Laser

Erbium lasers were included into dentistry for the preparation of dental hard tissue, as their radiation is readily absorbed by water, resulting in the instantaneous evaporation of water within the tissue, which induces a micro-explosion that dislodges minute particles of hard substance. Their independent cooling system generates minimal heat in the adjacent tissues [14]. The Er:YAG (2940 nm) laser, a kind of erbium laser, exhibits superior water absorption relative to CO2 and Nd:YAG lasers [15]. The Er:YAG laser is useful in ablation and hard tissue removal during root canal therapy and pulpotomy because its wavelength precisely aligns with the absorption peak of water and may be absorbed by hydroxylapatite [11,12]. In clinical application, it is essential to regulate the pulse energy and repetition rate of the Er:YAG laser to prevent leaflets, cracks, and other adverse consequences [2].

Er,Cr:YSGG Laser

The wavelength of Er,Cr:YSGG lasers is 2780 nm, closely aligning with the absorption peak of water. Their applications and limits in endodontic treatment are analogous to those of Er:YAG lasers, as both are classified as erbium-type lasers. Furthermore, investigations have shown that when an Er,Cr:YSGG laser irradiates dental tissue with a water spray, the temperature experiences minimal increase due to the total removal of the friction source that would typically produce heat. Simultaneously, the cutting efficiency will be enhanced [6].

Nd:YAG Laser

The Nd:YAG laser is a free-running pulsed laser that generates light at a wavelength of 1064 nm. Unlike the Er:YAG laser, the Nd:YAG laser exhibits minimal absorption in water, resulting in energy scattering and penetration into surrounding biological tissues [17]. It is applicable to root canal irrigation [16]. Nonetheless, its energy and efficacy in cutting hard tissue are inferior to those of the Er: YAG laser owing to its wavelength. Consequently, in clinical practice, it is imperative to precisely regulate the output power and restrict the irradiation duration to safeguard the adjacent tissue.

Nd:YAP Laser

The Nd:YAP laser emits in the near-infrared spectrum at a wavelength of 1340 nm. It is readily absorbed by dark materials and metals, with its absorption by water being twenty times more than that of the Nd:YAG laser. The Nd:YAP laser's flexible fiber optic can transmit energy during curved root canal surgery [17]. Numerous investigations on this subject have shown that the Nd:YAP laser may effectively remove the smear layer adhering to root canal walls [18]. Additionally, it must be employed in pulsed mode with intervals of rest to prevent heat injury to adjacent tissues [19].

CO_2 Laser

The inaugural 10,600 nm CO2 gas laser was developed in 1964. The CO2 laser at this specific wavelength is extensively utilized in medicine and dentistry. In contrast to the Nd:YAG laser, it is readily absorbed by enamel and dentin. Nonetheless, CO2 laser irradiation may induce fissures on the enamel surface, thereby facilitating caries progression along the fissure lines [20]. The CO2 laser is employed in direct pulp capping because it may control hemorrhage [21].

Diode Laser

The diode laser is a category of laser characterized by low power output. As a therapeutic approach, it is typically administered at a wavelength of 810–980 nm [4]. The diode laser has superior water absorption within dental hard tissues compared to the Nd:YAG laser, enabling it to effectively target bacteria within the dentinal tubules due to its enhanced penetration capabilities [21]. Conversely, the diode laser demonstrates significant divergence, leading to suboptimal optical performance. Consequently, it can be efficacious in root canal therapy to eradicate bacteria from root canals and diminish post-operative endodontic pain [22].

Clinical Applications

Lasers in Conservative Dentistry

Role of Lasers in caries detection

Although laser fluorescence has high sensitivity and remarkable reproducibility in detecting caries, it cannot quantify the extent of decay. Laser fluorescence has also demonstrated efficacy in the identification of persistent caries. While safety is not a worry regarding this low-power laser application, additional research are necessary to substantiate the clinical interpretation of the data and to expand its clinically relevant implications despite the limits of this technology.

Laser technologies can effectively remove caries and prepare cavities without causing major heat effects, collateral damage to the tooth structure, or discomfort to the patient. An Er-based laser system can facilitate efficient ablation at temperatures below the melting and vaporization thresholds of enamel. To date, many laser systems, including super-pulsed CO2, Ho:YAG, Ho:YSGG, Nd:YAG, Nd:NLF, diode lasers, and excimers, have not proven to be practical for cavity preparation in typical practice environments. Aside from caries exclusion, there exists a variety of established laser hard tissue procedures, including cervical dentine desensitization utilizing Nd:YAG, Er:YAG, and Er,Cr:YSGG lasers; laser analgesia employing Nd:YAG, Er:YAG, Er,Cr:YSGG, CO2, KTP, and diode lasers; and laser-enhanced fluoride uptake with Er:YAG, Er,Cr:YSGG, CO2, argon, and KTP lasers [23].

Diagnostic/curing lasers

The DIAGNOdent is used for caries and calculus detection by emitting a nonionizing laser beam at a wavelength of 655nm (at a 900 angle) towards a specific darkened groove on the occlusal surface of a patient's tooth where bacterial decay is suspected, or along the long axis of a root surface to detect the presence of a bacteria-laden calculus. This diagnostic technology, in which the photons of this laser wavelength are absorbed into any existing bacteria in these areas of the patient's tooth, is called laser-induced fluorescence. The instrument's digital display indicates the number of bacteria in this area of the tooth and it may correspond to the extent of decay of the existence of the calculus [8,9].

Cavity preparation

Cavity preparation by using lasers has been an area of major research interest ever since lasers were initially developed in the early 1960s. At present, several laser types with similar wavelengths in the middle infrared region of the electro magnetic spectrum are being used commonly for cavity preparation and caries removal. The Er: YAG laser was tested for preparing dental hard tissues for the first time in 1988. It was successfully used to prepare holes in the enamel and dentine with low 'fluences' (energy (mJ)/unit area (cm2)). Even without water-cooling, the prepared cavities showed no cracks and low or no charring, while the increase in the mean temperature of the pulp cavity was about 4.3degrees C). In 1989, it was demonstrated that the Er: YAG laser produced cavities in the enamel and dentine without any major adverse side effects [10].

Restoration removal

The Er: YAG laser is capable of removing cement, composite resin and the glass ionomer. The efficiency of the ablation is comparable to that of enamel and dentine. Lasers should not be used to ablate the amalgam restorations, however, because of the potential release of mercury vapour. The Er: YAG laser is incapable of removing gold crowns, cast restorations and ceramic materials because of the low absorption of these materials and the reflection of the laser light. These limitations highlight the need for adequate operator training in the use of lasers [11].

Lasers in Endodontics:

All pre-clinical research of laser-assisted endodontic therapies have provided the foundation for the advancement of a laser-assisted endodontic treatment protocol[23]. Laser techniques have been used into the traditional endodontic treatment framework to unequivocally enhance conventional therapy owing to their distinct bactericidal properties. Clinical trials have led to the development of a laser-assisted therapy protocol, with validated outcomes proven over a specified time frame, so enabling assertions regarding the efficacy of laser-supported endodontic treatments. Researchers have noted that the decline of microorganisms, crucial for a successful therapeutic procedure, may be clearly attributed to the laser, based on their clinical practice and patient follow-up findings. The aforementioned statistics must be assessed as a notable outcome when considered alongside the complex starting clinical condition and the stringent selection applied to the cases. The likelihood of a preparation instrument fracturing is significantly elevated (3 to 4%). Another advantageous aspect of laser treatments is their efficacy in addressing severely curved root canals, including ones that can only be prepared to ISO 30. The emitted laser energy exhibits a reduction of positive microorganisms within the dentine layers next to the canal lumen and in the periapical region. Conversely, washing solutions employed in conventional disinfection processes exhibit negligible or minimal efficacy in such narrow lumina due to their significant constraints. This is especially relevant to the issue of endodontic regions within the apical third. Typically, laser treatment necessitates additional time in general practice. However, patients' expectations are elevated because to the potential to preserve the tooth. Between 1991 and 1992, 40% of the test cases were conducted; thus, we may infer that similar positive assertions may also pertain to the medium or long-term post-treatment period.

Lasers in Root Canal Treatment

The main pathogenic factor regarding endodontic diseases and periapical diseases is microorganism infection in the root canal systems. Root canal treatment is the most effective and widely used method for controlling infection, promoting periapical healing, and avoiding reinfection, through the steps of root canal shaping, disinfecting, and filling.

Root Canal Shaping

Currently, root canal shaping is typically performed with hand and rotary instruments. The smear layer produced during the procedure is expected to be removed from the root canal walls. In addition, the bacteria that existed in it will undoubtedly affect the f inal effectiveness of the therapy [25]. Following the development of lasers, it was found that laser irradiation could help shape root canal walls, and remove the smear layer. The mechanismoflasersinthecontext ofroot canal shapingis that laser irradiation can vaporize water in dental hard tissues and ablate the surrounding tissue, so that the dentinal tubules will be opened, and the smear layer will thus be removed. In respect of this, an in vitro study demonstrated that the Er:YAG laser could ablate dental hard tissues, open dentinal tubules, and clear the smear layer when the distance between the dentin and the tip was close. Not only that, the Er:YAG laser can also reduce the risk of dentine suture formation, thus avoiding root fractures [12]. Similarly, Samiei et al. [27] conducted a comparative study of root canal preparation with and without the Nd:YAGlaser in vitro, thereby selecting sixty single-rooted human premolars and dividing them into four groups according to different preparation methods. In group 1, conventional K-files and step-back techniques were used for tooth preparation. In group 2 and 3, the teeth were prepared using the Nd:YAG laser and rotary NiTi instruments, respectively. In group 4, the Nd:YAG laser and NiTi instruments were combined to prepare the teeth. The results showed that among the four groups, group 4 resulted in the best cleaning efficiency of the canal walls. Indeed, it was even better than the traditional K-files and step-back technique.

Root Canal Irrigation

All this time, the cleaning and antisepsis of root canals—which is of keyimportance to a successful root canal treatment—primarily depends on two procedures, namely mechanical instrumentation, and the disinfection of irrigates. However, when considering the fact that the anatomy of the root canal system is extraordinarily complicated, canal shaping performed with instrumentation is largely regarded as a means of creating access to the apical anatomy in the present [26]. Thus, in this regard, irrigation does play a key role in the context of infection control [24]. Traditional root canal therapy uses syringe and needle irrigation (SNI) in order to remove debris and biofilms, which is still the most favored form of irrigation protocol in clinical practices [25]. Despite its convenient and inexpensive nature, SNI also possesses certain inevitable shortcomings, such as being difficult to standardize and control [26], as well as disabling greater penetration into irregular anatomical structures [27]. Due to the limitations of conventional SNI, innovative techniques in order to help improve irrigation efficiency have been developed, including ultrasonic activation, sonic activation, and laser activation [28]. Laser-activated irrigation (LAI) was applied as an adjunctive method for root canal irrigation many years ago. The mechanism of LAI uses fiber tips to generate small cavitation bubbles in irrigation solutions, whose volumetric oscillation can result in high speed fluid motion, the making of biofilms, as well as other contents in the root canals, movingvertically. Due to these continuous rapid movements, the contents that are attached to root canal walls fall off, and are finally flushed out of the canals. Introduced for the purposes of clinical use in 2012, photon-induced photoacoustic streaming (PIPS) is an example of one of the emerging LAI techniques. When compared with conventional LAI methods, it renders features of low energy (10 or 20 mJ) and short pulse length (50 s) [29]. Furthermore, this method also possesses the ability to prevent thermal damage to the root canal walls and the periapical tissue, by placing its working tip in the crown side of root canals. Shock wave-enhanced emission photoacoustic streaming (SWEEPS) was created in order to increase the debriding efficiency of the PIPS method [27]. The working mechanism of SWEEPS is similar to extracorporeal shock wave lithotripsy. As the cavitation bubble begins to collapse, a second pulse is transmitted through the liquid, thereby causing a second cavitation bubble. Then, the second cavitation bubble accelerates the collapse of the first one, thus forming a violent collapse and finally emitting a shock wave. In addition, the collapsing secondary cavitation bubbles that are close to the root canal walls also emit shock waves, thereby removing the debris attached to the walls. Accumulated hard tissue debris is a type of byproduct from root canal shaping, which should be removed during irrigation. A comparative experiment used 30 extracted human mandibular molars to compare the effectiveness of three different auxiliary means for removing accumulated hard tissue debris, including ultrasonically activated irrigation, PIPS, and SWEEPS. In addition, the evaluation was performed by microcomputed tomog raphy. The PIPS and SWEEPS groups were performed with special fiber tips (PIPS 600/9 and SWEEPS600) using a 2940 nm Er:YAG laser. The results showed that there was less remaining debris after SWEEPS than after ultrasonically activated irrigation and PIPS, especially in regard to complicated structures, such as isthmuses [30]. As for the elimination of biofilm and calcium hydroxide, multiple studies have shown that LAI performed significantly better than SNI. The ability of the Er:YAG laser for the purposes of biofilm removal was explored in a study using pig models. In addition, the remaining bacteria level after irrigation in the LAI group was clearly lower than that of the SNI group [31].

Nonetheless, the comparison between the efficiency of ultrasonically activated irri gation and LAI, engendered different results and views. The results of a comparative study, which used transparent resin blocks in two standardized root canals as the test models, demonstrated that LAI using a 2940 nm Er:YAG laser resulted in greater biofilm mimicking hydrogel removal than ultrasonically activated irrigation [33]. Another in vitro study performed by Liu et al. with thirty-eight mature single root canal premolars showed a different result [34]. They found that the efficiency of passive ultrasonic irrigation for the purposes of bacteria removal presented more advantages in the coronal and middle thirds of the root canals when compared with LAI using a Nd:YAP laser, while both of them resulted in similar effects in the apical third. Similar to accumulated hard tissue debris removal, none of these adjuvant procedures could completely clear away biofilm components in root canal systems. There are also some limitations to LAI, such as increased apical extrusion. The apical extrusion of debris, pulp tissue, solutions, bacteria, and their byproducts, is one of the causes of post-operative inflammation and pain, which can delay the healing of periapical tissue. Certain investigations have proved that irrigation activated by the Er:YAG laser or the Nd:YAP laser caused more extrusion of debris when compared to needle irrigation [35]

Fiber Posts Surface Treatment

Gomes et al.performed an in vitro investigation involving thirty-two mandibular bovine incisors and concluded that the efficacy of laser irradiation in enhancing push out bond strength (PBS) was contingent upon the specific laser system employed [36]. Pre-treatment of glass fiber posts using an Er:YAG laser or a 980 nm diode laser did not enhance the PBS relative to a silane control group, however the group treated with the Er,Cr:YSGG laser greatly improved the PBS. An in vitro study shown that Er,Cr:YSGG laser irradiation enhanced the push-out bond strength (PBS) between quartz fiber posts and dentin; furthermore, an output power of 1.0 W was advised to reduce damage and optimize the PBS. Additionally, another in vitro investigation shown that Er:YAG laser irradiation enhanced the bond strength between quartz fiber posts and resin cement, whereas Nd:YAG laser irradiation failed to achieve the desired effect [37]. The contentious efficacy of laser surface treatment for fiber posts differs among various laser systems and fiber post materials. Additional research is necessary to ascertain whether the laser's energy, frequency, potency, pulse duration, irradiation duration, and operational distance affect the outcomes of fiber after surface treatment.

Lasers inVitalPulpTherapy

The maintenance of pulp vitality is a crucial objective in endodontic therapy. Unlike root canal therapy, vital pulp therapies, including as pulp capping and pulpotomy, present less invasive alternatives with a greater likelihood of success for cariously exposed pulps. Pulp capping is a treatment employed to apply healing materials directly or indirectly to the pathologically exposed pulp. Pulpotomy involves excising the diseased coronal section of the pulp while preserving the radicular pulp. Mineral trioxide aggregate, calcium hydroxide, and formocresol are often utilized agents. Calcium hydroxide has been extensively utilized for pulp capping treatment for decades. It is important to acknowledge that this method frequently yields varied and unpredictable results. Additionally, mineral trioxide aggregate shown effectiveness but is comparatively costly. Simultaneously, the cytotoxicity, carcinogenicity, and mutagenicity of formocresol may influence the long-term outcomes. Consequently, alternative options, like laser-assisted treatment, are also permissible. Laser irradiation may expedite the development of the fibrous matrix and the dentin bridge. Moreover, laser irradiation may enhance the expression of lectins and collagens in the exposed dental pulp tissues, facilitating wound healing in the pulp. A low-power laser has been shown to activate a growth factor complex for dentin regeneration in the pulp-capped teeth of rat models [38]. Low-level lasers may control inflammation and facilitate healing, whereas high-level lasers can enhance pulp repair by elevating temperature. Moreover, low-level laser therapy has demonstrated a favorable outcome as an adjunctive alternative to pulpotomy in the research.

Lasers in Pulp Capping

Clinical study was conducted on the usage of lasers in pulp capping. A pilot investigation demonstrated that the 808 nm diode laser-assisted technique, which encompasses hemostasis and decontamination, can improve the results of pulp capping treatment for carious exposures. Yazdanfar and associates similarly integrated a diode laser operating at 808 nm with a resin-modified tricalcium silicate. The research revealed that the laser TheraCal group had a thicker dentin deposit and reduced sensitivity to cold stimulation compared to the TheraCal group. Calcium hydroxide paste, resin-based tricalcium silicate material, an Er,Cr:YSGG laser, and a Gr laser were utilized, either individually or in conjunction, for the treatment of exposed pulp. The findings from a 6-month follow-up period suggested that laser irradiation, in conjunction with pulp capping chemicals, is advisable for direct pulp capping treatment. A systematic evaluation indicated that 80% of the studies demonstrated adjunct laser therapy's superiority over conventional therapy alone in preserving pulp vitality. The results seemed to be affected by additional factors, such as pulpal hemorrhage circumstances, leading to pulp exposure, and neighboring pollution [39]. A consensus was achieved through several histology tests conducted on animals. The histology of pulpal and periapical tissues following direct pulp capping with a low-level 980 nm laser application was examined. The laser-assisted group exhibited mild inflammation, organized odontoblasts, increased predentin thickness in the pulp tissue, and enhanced fibrosis in the periapical region. Histologic sections shown that lasers could facilitate healing following direct pulp capping. Nonetheless, there has been some contention over the tissue reaction to lasers. Suzuki et al. indicated that CO_2 laser irradiation may impede the development of dentin bridges by generating heat-denatured tissue surrounding the exposed pulp. The thermal-induced denaturation increased with the strength of the lasers. Consequently, the choice of wavelength or frequency of the irradiation was considered significant. Lasers may be considered a viable supplementary technique for preserving pulp vitality; however, appropriate devices and wavelengths require further investigation.

Lasers in Pulpotomy

In traditional pulpotomy procedures, the dentist excises the necrotic coronal pulp using a round bur at low speed and extracts this segment with a spoon excavator. Following the flushing and drying of the pulp chamber, damp cotton pellets infused with ferric sulfate, formocresol, or alternative coagulative agents are inserted into it. Following complete hemostasis, lasers may be employed in operations to ablate the pulp to the canal level and to facilitate coagulation and healing of the pulp. The clinical efficacy of pulpotomy treatment for primary teeth may be affected by the use of lasers. To address the challenges associated with varying levels of cooperation and behavior management in children undergoing dental procedures, lasers were introduced due to their minimal noise and decreased contact between the tooth and mechanical instruments, making them particularly appealing to pediatric dentists [40]. The effects of an Er:YAG laser used in pulpotomy for primary molars with extensive carious lesions were assessed. The 1.3 mm laser fiber tip was positioned 1 mm from the pulp tissue at the root canal aperture for irradiation. Compared to traditional low-speed ball drilling pulpotomy, the Er:YAG laser group exhibited a reduced hemostasis duration, decreased overall treatment time, and superior clinical efficacy in long-term evaluations. Diode laser irradiation, whether low-power or high-power, was regarded as an effective alternative for the treatment of primary teeth. Additionally, regarding mineral trioxide aggregate and laser therapy, the mineral trioxide aggregate group and the low-power diode laser mineral trioxide aggregate group achieved a clinical success rate of 100% in a randomized trial on deciduous molar pulpotomy, whereas 87.5% of the high-power diode laser mineral trioxide aggregate group evaded clinical failure [41]. Clinical research indicates that lasers may serve as an alternative to primary teeth pulpotomy, yielding improved patient compliance and outcomes. Nonetheless, further investigation is required about the selection of devices and the wavelengths of the lasers. In the meanwhile, given that some trials demonstrated little statistical significance, additional survey samples and extended follow-up periods are anticipated and advocated for further investigation.

Conclusion

This review summarizes the innovative applications of lasers in conservative dentistry and endodontics, considering laser-based therapy as a viable choice for specific dental operations. Nonetheless, the review is narrative; therefore, a thorough study of the literature has not been conducted. Certain conclusions regarding the optimal laser type and characteristics for specific clinical applications still necessitate discussion. Additionally, lasers possess certain disadvantages, such as the risk of erythema, skin hyperpigmentation, thermal injury, and ocular damage. The clinical application of lasers necessitates execution by properly qualified dentists, presenting a hurdle to their implementation in clinical practice. A significant limitation that impedes the utilization of lasers is the financial aspect. It is unequivocal that lasers will be more utilized in conservative dentistry and endodontics in the future. Consequently, next research in this domain will concentrate on addressing deficiencies, mitigating treatment-related incidents, and enhancing its application in clinical evaluations and therapies.

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