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Laser for Dental Rehabilitation in Children-An Overview

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ABSTRACT:

Laser technology has revolutionized pediatric dentistry by offering minimally invasive and modern approaches to diagnosis, treatment, and prevention . By using lasers, dental professionals can provide painless and efficient dental care for children, leading to better treatment experiences and improved oral health outcomes. Laser applications in pediatric dentistry include caries detection, prevention, restoration, pit and fissure sealants, endodontics, soft tissue procedures, traumatology and vitality testing, preservation of pulp vitality, disinfection and decontamination, and pain management.Various categories of lasers are utilized in dentistry, depending on the specific dental treatment, including solid-state lasers, liquid lasers, gas lasers, and semiconductor lasers. With their numerous advantages and applications, lasers have become an integral part of pediatric dentistry, offering safe and effective treatment options for children.

Keywords: LASER, psychology, rehabilitation, children

INTRODUCTION:

Laser technology has recently been introduced in medicine to improve diagnostic and therapeutic procedures(1).The inception of the theory of stimulated emission, which was originally introduced by Einstein in 1916, paved the way for the creation of the inaugural functional laser device with the help of Maiman.. Laser acronym is "light amplification by stimulated emission of radiation." Dental researchers quickly recognized the potential of lasers due to their unique characteristics, especially in minimally invasive dentistry. Laser treatments offer advantages such as reduced pain, sound, and vibration compared to traditional drilling methods (2). Additionally, lasers can provide a clear view of the treatment area by maintaining a dry environment, resulting in better outcomes. The utilization of lasers instead of traditional sharp dental tools also appeals to a greater number of patients, thereby increasing their inclination to visit dental clinics(3).

While lasers were originally employed for making incisions in soft tissue, the most recent iteration of lasers, equipped with their unique ability to interact with water molecules and can now be employed for the purpose of ablating dental hard tissue.. Advancements in application of LASER have made them efficient for caries prevention, diagnosis, and treatment in various dental fields (3,4).

In pediatric dentistry, creating a positive and painless first dental visit is crucial to establishing good dental habits and pleasant memories for children (5). Laser technology offers a minimally invasive and modern approach, which can significantly reduce the pain associated with dental treatments.This approach proves to be an efficient, preventive, and therapeutic tactic, as lasers demonstrate their versatility in diagnosing oral and dental ailments, treating both hard and soft tissues, and halting the advancement of dental problems in pediatric patients.

Given the influence of health and well-being of the oral cavity and teeth on the overall physical well-being of kids, the main aim of this study is to conduct a comprehensive analysis on diverse categories of lasers and their respective uses in the field of pediatric dentistry.

LASER HISTORY:

The laser, utilizing a synthetic ruby crystal, was developed by Theodore Maiman on May 16, 1960. Initially, lasers were used for diagnosing and treating skin conditions, and later they found applications in endoscopic surgery and ophthalmology (6).In the field of dentistry, lasers were initially employed for surgical procedures involving oral soft tissue, functioning as a scalpel that utilizes laser light energy to cut or eliminate tissue.Laser technology operates by stimulating a synthetic material housed within a chamber of light, generating intensified light that is emitted uniformly and continuously towards the target area without direct contact (7). Dental lasers come in different types with varying wavelengths, operating in continuous-wave, pulsed, or running pulsed modes. The wavelength of a laser determines its clinical applications and device type, with applicable wavelengths ranging from 193 to 10,600 nm in medicine and dentistry.

Dental lasers can be categorized into four primary groups: solid-state lasers, liquid lasers, gas lasers, and semiconductor lasers(8).When compared to other types of lasers, gas lasers possess a relatively simpler design, with emitting atoms dispersed relatively evenly, making them continuous-wave lasers.Liquid lasers demonstrate the capability to alter their frequency, and semiconductor lasers are popular due to their lightweight nature and high optical output power (8,9).

LASER APPLICATION IN PEDIATRIC DENTISTRY:

Motivating children to visit the dentist is crucial for preventing oral and dental issues. Therefore, in addition to dental principles, pedodontists need to familiarize themselves with new mechanisation.Laser technology provides an effective approach for diagnosing and treating oral and dental conditions in pediatric patients, encompassing both soft and hard tissues (3,8,9).Children and their parents widely appreciate laser therapy for its minimally invasive nature.

Studies have indicated that the use of lasers during restorative, pulpal, and surgical treatments enhances children's cooperation levels, leading to improved quality of care and treatment experiences (3,8–10).The expectation is that lasers will soon be widely adopted as the standard approach in pediatric dentistry. Pediatric dentistry incorporates diverse types of lasers with specific applications. Here are examples of different lasers and how they are used in this field.

HARD TISSUE APPLICATION OF LASER

Detection of dental caries

Accurate detection of dental caries is crucial for clinicians to provide suitable and efficient tooth restorations while minimizing time and cost (11).Several studies have provided evidence of the improved precision and efficiency in clinical caries detection through the use of laser fluorescence (LF).

By employing a nonablative red light with a wavelength of 655 nm, LF can function as a supplementary method for detecting occlusal surface caries in both primary and permanent teeth(12).The high reliability, predictability, and reproducibility of LF contribute to a reduction in diagnostic errors.In in vitro studies, the commercial product DIAGNOdent, which utilizes LF technology, has showcased superior effectiveness in detecting caries. Compared to visual inspection, probing, and radiography, laser fluorescence (LF) has shown advantages in the detection of occlusal dentin caries in primary teeth.. Previous research has also revealed that LF exhibits comparable or higher accuracy than bitewing radiography in identifying caries and cavitation in proximal areas of primary teeth. However,the performance of LF is affected by the depth of the carious lesion. It demonstrates higher accuracy in detecting dentin caries compared to enamel caries. However, its efficacy is limited in identifying initial enamel caries and tooth demineralization. (13).

Another diagnostic laser, the argon laser, operates at a wavelength of 488 nm (blue-green color) and utilizes fluorescence properties to detect caries, particularly on interproximal and occlusal surfaces. Quantitative-light induced fluorescence (QLF) technique has demonstrated higher efficacy in quantitatively detecting demineralization in primary teeth, surpassing its effectiveness in permanent teeth. QLF also offers the convenience of identifying caries beneath pit and fissure sealants during routine and periodic examinations.

Prevention of dental caries

Strengthening tooth surfaces to resist cariogenic agents is crucial for preventing dental caries. Both Erbium and CO_2 lasers have shown effectiveness in enhancing the resistance of newly erupted permanent teeth in children and adolescents against acid erosion (2). Research indicates that CO_2 lasers operating at specific wavelengths of 9600 nm, 9300 nm, and 10,600 nm, as well as erbium lasers at 2780 nm and 2940 nm, along with argon lasers, have the potential to improve the enamel's resistance to caries.

Moreover, the concurrent utilization of laser therapy and fluoride treatment has demonstrated additional benefits in enhancing tooth resistance. For instance, the combination of argon laser with acidic phosphate fluoride (APF) showcased a noteworthy 50% decrease in caries depth compared to the use of the laser alone (14). These results underscore the potential of combining laser therapy with fluoride treatment to augment the preventive effects against dental caries.

Restoration, Pit and Fissure Sealants

Laser technology can be utilized to prepare tooth surfaces before the application of pit and fissure sealants (15). It serves various purposes such as conditioning, cleaning, and disinfection of pits and fissures. For instance, if caries is detected in pits and fissures based on laser fluorescence (LF) values ranging from 11-20 to 21-30, an erbium laser can be used for fissurotomy and caries removal. On the other hand, when LF values indicate a healthy tooth (0-10), a lower wavelength erbium laser is employed for macro-roughening.

It is important to acknowledge that using lasers alone for tooth surface preparation, without acid etching, can potentially result in higher rates of microleakage (16). Laser treatment should not be considered a substitute for enamel acid etching. Some studies have indicated that when lasers are used alongside acid etching, approximately 80% of specimens may exhibit microleakage due to the development of enamel cracks and debris at the sealant-enamel interface. To address this concern, the use of an argon laser for curing the sealant material at the enamel-sealant interface has been suggested as a potential solution to enhance enamel resistance against acids. However, other studies have found no significant difference in the extent of microleakage when comparing acid etching alone to the combination of acid etching with lasers for pit and fissure preparation (15). In the case of primary teeth, the use of an Er,Cr:YSGG laser for surface preparation before applying fissure sealants has demonstrated no effect on increasing resistance to microleakage.

Endodontics

Laser technology offers an alternative to the use of formocresol, a substance with carcinogenic and mutagenic properties, for procedures such as pulpotomy, pulpectomy, and pulp coagulation. CO_2 laser has shown superior clinical outcomes in pulpotomy of primary teeth compared to formocresol. Laser therapy has been found to reduce pulpal inflammation, and the extent of inflammation is inversely correlated with the amount of laser energy applied.

Laser technology has also demonstrated efficiency in cleaning and shaping the root canal system (17). The Er,Cr:YSGG laser has been shown to have similar cleaning and shaping efficacy as rotary instruments and superior efficacy compared to hand instruments, with the added advantage of faster performance.

For pulp coagulation, the application of lasers such as Er:YAG, Er,Cr:YSGG, and CO_2 has shown more favorable results compared to the use of calcium hydroxide after a two-year follow-up. Vital pulp therapy and pulp hemostasis achieved through CO_2 laser pulpotomy have shown a clinical success rate of 98.1% and a radiographic success rate of 91.8%.

However, it is important to note that not all laser types have shown equal success in pulpotomy of primary teeth. Studies using Nd:YAG laser have reported lower clinical and radiographic success rates of 71.42% and 85.71%, respectively, after 12 months, which are comparatively lower than the success rates of formocresol at 90.47% during the same time period.

SOFT TISSUE APPLICATION OF LASER:

Laser technology presents a safe and efficient treatment option for a range of periodontal conditions in children (18). Unlike conventional methods, laser treatment eliminates the risks of allergic reactions and bacterial resistance. It can be used for procedures like gingivectomy, gingivoplasty, and operculectomy without requiring local anesthesia, resulting in minimal bleeding (3,18).

Beyond periodontal care, laser treatment offers several benefits in pediatric dentistry. It can assist in promoting tooth eruption, addressing abnormal gingival lesions caused by tooth movement, managing drug-induced gingival hyperplasia, removing fibromas, and treating various oral conditions like aphthous lesions, herpes labialis, mucoceles, and pyogenic granulomas. Laser procedures can also be utilized for aesthetic purposes.

For infants with tight maxillary frenums or severe ankyloglossia, frenectomy procedures can be performed using Er:YAG laser. Additionally, CO2 laser effectively removes vascular tumors in the oral cavity and manages cyclosporine-induced gingival enlargement. Compared to traditional surgical scalpels, CO2 laser offers advantages such as disinfection and coagulation.

In micro-gingival surgery for traumatic injuries to unerupted teeth, laser technology, particularly Erbium laser, allows for the removal of gingival tissue covering cervical carious lesions, providing an alternative to conventional methods (14).

Furthermore, researchers have discovered that low-level laser therapy (LLLT) can expedite orthodontic tooth movement. Laser or light-emitting diode (LED) treatments can also help reduce the duration of herpetic lesions and promote healing in children affected by conditions like primary herpetic stomatitis.

Overall, laser technology proves to be a versatile tool in pediatric dentistry, offering safe and effective treatment options for various oral and periodontal conditions in children.

Trauma and Vitality Testing

Injuries to the teeth can have detrimental effects on pulp vitality, both in the short and long term (14, 19). Laser doppler flowmetry (LDF) provides a noninvasive and accurate method for assessing pulp blood flow (PBF) and evaluating pulp vitality. This painless procedure is well-tolerated by children. LDF is also useful in monitoring revascularization processes and evaluating mobile teeth.

Laser technology finds diverse applications in the treatment of traumatized teeth (20). It can be utilized for preparing fractured tooth edges prior to restoration. Laser treatment is effective for coagulating exposed pulp, performing pulpotomy, and pulpectomy (using erbium lasers) when necessary following dental trauma. Moreover, Er:YAG and Er,Cr:YSGG lasers can be employed to fuse and seal dentinal tubules in cases of fractured teeth or open tubules, thereby reducing tubule permeability and alleviating tooth hypersensitivity.

Apart from dental applications, lasers can also be advantageous in managing soft tissue trauma, facial wounds, and swelling. The application of laser or LED therapy to these areas can alleviate symptoms and promote healing. Laser therapy can also be employed in severely traumatized regions to reduce post-traumatic discomfort.

Overall, laser technology provides valuable options for assessing and treating traumatized teeth, offering accurate diagnostic capabilities, effective treatment methods, and improved patient comfort, especially in pediatric cases.

Preservation of Pulp Vitality

Laser irradiation has shown potential for preserving pulp vitality. Specific parameters should be considered when using laser therapy for this purpose. This includes using different wavelengths with a power of 0.5-1 W, employing a non-concentrated beam, utilizing low frequency and pulse mode, avoiding the use of water, and keeping the duration of irradiation under 10 seconds to prevent coagulation. Additionally, applying laser therapy with 30-second intervals helps prevent overheating of the pulp.

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A successful treatment approach entails utilizing an 808 nm probe in the vicinity of the root area of central and lateral incisors affected by trauma in children(3). This treatment modality has demonstrated effectiveness in preventing pulp necrosis and promoting pulp vitality. By carefully applying laser therapy within the appropriate parameters, it is possible to enhance the chances of preserving the health and vitality of the dental pulp.

Disinfection and Decontamination

Laser technology has proven to possess beneficial antimicrobial properties, as supported by several studies (21). One notable application is the utilization of diode lasers with the photo-activated bacterial disinfection (PAD) method. Laboratory studies have shown that this technique effectively eliminates 99% of bacteria within a collagen matrix during root canal therapy and caries removal. These findings highlight the potential of lasers to improve disinfection protocols and enhance treatment outcomes.

The cleaning and disinfection of the primary root canal system, especially considering its complex anatomy at the apex, requires meticulous precision. The penetration depth of the laser, which typically operates in the infrared light range, needs to be carefully controlled to ensure effective treatment and avoid any potential complications.

Furthermore, the documented antimicrobial effect of erbium laser on the root canal system provides an alternative approach to enhance disinfection during endodontic procedures.

Another application of lasers in dentistry is alveolar socket decontamination following tooth avulsion, further highlighting their antimicrobial capabilities (22).

Overall, lasers offer a promising means of achieving effective antimicrobial effects, contributing to improved treatment outcomes in endodontic treatment and the removal of dental caries, and other dental procedures.

The analgesic effects and relief of pain and discomfort

Laser technology offers advantages in pain management for dental patients, leading to a reduced reliance on local anesthetics (23). Studies have shown that laser application in near-infrared wavelengths (803-980 nm) with a non-concentrated mode can induce anesthesia. This is achieved by hyperpolarizing the nerve fiber membranes and can provide anesthesia for approximately 15 minutes. For instance, a 660 nm probe has demonstrated a success rate of 50%-75% in achieving anesthesia during the preparation of class II cavities in primary molar teeth without the need for anesthetic injection.

In the context of orthodontics, CO2 laser can be used locally to alleviate pain caused by orthodontic forces, offering relief to patients. Additionally, low-level laser therapy (LLLT) has been found to expedite orthodontic tooth movement without adverse effects. Laser or LED irradiation near the orthodontic site or temporomandibular joint has proven successful in pain relief.

LLLT can also be utilized for pain management during the eruption of primary or permanent teeth by targeting lymph nodes (24). Laser irradiation (4 to 6 J) of exposed primary teeth has been effective in reducing pain. Furthermore, LLLT can effectively reduce the initial inflammatory response, with a dosage of 3 to 4 J being suitable for alleviating pain and swelling in cases of lip and anterior teeth trauma.

In summary, laser therapy presents a valuable approach to pain management in dentistry, providing alternatives to local anesthetics and promoting patient comfort during various dental procedures.

Exposing unerupted teeth for orthodontic purposes

To remove soft tissue and expose unerupted teeth in orthodontic procedures, various lasers can be utilized, including Er,Cr:YSGG, Er,YAG, diode, and Nd:YAG lasers (25). Among these lasers, erbium lasers are known for their efficiency in ablating both soft and hard tissues.Nevertheless, the use of erbium lasers in exposing unerupted teeth for orthodontic purposes carries a potential risk of enamel damage at the surgical site. In contrast, diode and Nd:YAG lasers, with their specific wavelengths, eliminate the risk of enamel damage, making them safer options for such procedures.

Conclusion

Laser technology presents numerous advantages and applications in the field of pediatric dentistry, offering a viable alternative to traditional procedures. It finds utility in various dental purposes such as caries diagnosis and removal, pulp therapy, infection control, reduction of swelling and inflammation, minimal bleeding, promotion of soft tissue healing, pain relief, and even mitigating the gag reflex in children. The minimally invasive nature of laser treatments often improves children's cooperation, resulting in higher satisfaction levels for both children and their parents. Additionally, the use of lasers has the potential to enhance the overall quality of dental services provided. However, further studies are necessary to explore the effectiveness of laser applications across diverse dental procedures, particularly within the realm of pediatric dentistry.

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