Analysis of the prospects of modern laser technologies in dentistry: The experience of the EU countries

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WORD COUNT 5606
TIME SUBMITTED 20-MAR-2024 03:33PM
PAPER ID 107706257

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Abstract

In the EU countries, modern laser technologies in dentistry have witnessed remarkable advancements, revolutionizing dental care by offering precise and minimally invasive procedures, reducing patient discomfort, and enhancing overall treatment outcomes. The aims are to explore the types of laser technologies, evaluate clinical applications, and review the experiences of EU countries. For this narrative review, the Google Scholar database was searched for works published

in the recent 2019–2023 timeframe. Keywords such as Lasers [general dentistry] OR Laser [soft tissue] OR "Germany" OR "United Kingdom" OR "France" OR "Italy" were employed and 9910 in total identified. Finally, a thorough evaluation of 14 papers was selected. European dentists use a variety of lasers for different purposes. Nd:YAG lasers for soft tissue operations and tooth whitening, diode lasers for gingival and tissue treatments, CO2 lasers for soft tissue surgery, Er:YAG lasers for precision hard tissue ablation and cavity preparation, and Er,CR:YSGG lasers for diverse soft and hard tissue procedures. European dentistry uses laser technology for several clinical objectives. It accurately removes pyogenic granulomas from the maxillary molars and premolars during surgical excisions. Lasers also perform soft tissue operations and accelerate orthodontic tooth movement by targeting oral sites in periodontal therapy and treat mucositis and early peri-implantitis. Lasers help wound healing and tissue regeneration in soft and hard dental tissues via photo- biomodulation therapy. Lasers cut tissue precisely, making them useful for minor dental operations such impacted lower third molar extractions. In conclusion, The different ways lasers are used in European dentistry show how important they are for improving precision, efficiency, and therapeutic results in a wide range of clinical applications, from soft tissue procedures to hard tissue ablation and wound healing.

Keywords: Laser Technologies, Dentistry, Prospects, EU Countries, Modern experiences

INTRODUCTION

It has been investigated in dentistry to anticipate conditions including periodontitis, gingival fibromatosis, malocclusions, and tooth caries [1]. Periodontitis is a complex illness that is primarily brought on by host response and infection from periodontal bacteria found in tooth plaque [2]. Chronic periodontitis is the most prevalent kind of periodontitis. When Porphyromonas gingivalis causes chronic periodontitis, junctional epithelium is destroyed [3]. The alveolar bone and periodontal ligament are particularly vulnerable to the gradual damage produced by the specific bacterium that causes periodontitis, a devastating inflammatory disease. Periodontitis has three clinical signs: tooth movement, pocket development, and loss of attachment. Aggressive and chronic periodontitis are the two types of periodontitis [4]. Periodontitis is a well-known inflammatory oral disease that has been linked to a number of systemic illnesses and numerous

unfavorable reproductive outcomes, such as low birth weight, preeclampsia, premature labor, restricted fetal development, and perinatal mortality. According to research, mouth infections and decreased fertility are related [5]. The deterioration of the supporting components of the teeth caused by periodontal disease affects people of all ages, genders, and races. The sick state is treated with systemic antibiotic treatment, but its effectiveness is limited by the periodontopathic organisms' inaccessibility in the periodontal pocket. Additionally, these monitored intra-pocket devices aid in preserving therapeutic medication concentration for the optimum amount of time [6]. The health of the whole body is critically impacted by oral hygiene. A persistent inflammatory condition called periodontitis affects soft tissue and kills the bone that supports your teeth. Periodontitis may result in tooth loss or tooth loosening. Numerous clinical research have shown clear connections between chronic periodontitis, increased blood C- reactive protein (CRP), and cholesterol levels. Periodontitis is one of the key risk factors for cardiovascular disease since it is linked to chronic infections like periodontitis, which have elevated CRP levels [7]. Laser technology, short for "Light Amplification by Stimulated Emission of Radiation," has changed health, communications, and business. Lasers began with Albert Einstein's stimulated emission theory in the early 20th century. Einstein proposed in 1917 that an excited atom may generate a photon when it returned to its lower energy state. In the 1950s, Charles Townes and Arthur Schawlow invented masers, which enabled stimulated emission [8]. First practical laser by Theodore Maiman in 1960 revolutionized laser history. Maiman invented the "LASER" red-light laser using a synthetic ruby crystal. After the ruby laser, various materials were used to make visible, infrared, and ultraviolet lasers. Lasers were first employed in ophthalmology for retinal treatments and dermatology for skin lesion elimination and aesthetics in the 1960s. Late 20th-century medical and dental CO2 and Nd:YAG lasers were introduced [9]. Precision in cutting and coagulating tissues makes this laser valuable for soft tissue surgery and dentistry. Conservative cavity preparations and patient comfort using Er:YAG and Er,Cr:YSGG lasers changed dentistry in the 1990s. Diode lasers for soft tissue surgery and photobiomodulation for pain and tissue repair sophisticated lasers. Another use of laser technology is Confocal Laser Scanning Microscopy that allows researchers to visualize, quantify, and analyze the structural and chemical characteristics of Aggregatibacter actinomycetemcomitans biofilms induced by various substances, improving biofilm formation and oral health detection, prevention, and treatment [10]. Finally, laser technology's history shows scientific curiosity, invention, and pragmatism. Lasers enhance

medical and dental operations' accuracy, invasiveness, and patient comfort. Laser technology's use in healthcare and beyond is promise as research and innovation continue [11]. Based on existing protection systems, limitations of harmful emissions and hazardous chemicals, and their effects on people and the environment, there are safety guidelines for the general public [12].Technology has improved patient care, treatment outcomes, and procedural comfort in dentistry in recent years. Lasers in dentistry are a technological development that has garnered attention. Laser technology's precision, minimally invasiveness, and versatility have changed dentistry [13]. Europe leads the world in dentistry technology adoption. Dental lasers have made dentistry faster, more pleasant, and more effective throughout Europe. However, the lack of regulatory body approvals for the allowed use of dental lasers in operations or treatments and the availability of drill instruments and hand tools limit the European dental lasers market [14]. The preceding experiences and studies provide a comprehensive picture of laser technology's evolving significance in European dentistry. Laser use in dentistry has beneficial effects, but more research and protocol optimization are needed to fully realize its potential. From experimental use to mainstream dental treatment, laser technology has been shaped by rigorous study, innovation, and regulation. The European Union, recognized for its emphasis on healthcare regulations and patient safety, is a good example of laser dentistry usage and ramifications. This report sheds light on laser technology integration and dental care's future [15]. Dental procedures have traditionally been intrusive, causing pain and long recuperation times. Lasers in dentistry have transformed oral health diagnosis and treatment. Lasers target tissue precisely, reducing pain, hemorrhage, and healing time. The EU's dynamic healthcare sector and evidence-based methods make it an ideal context for analyzing current laser technology uptake [16].Because life expectancy is increasing in the modern day, technological development is also necessary to address the issues associated with aging. This demand to investigate potential novel therapies and technology developments that can enhance the health of elderly persons [17]. Lasers in dentistry have been pioneered in the EU. This section discusses EU countries' laser dentistry regulatory frameworks, training programs, and clinical guidelines. Other locations considering laser technology integration can learn from the emphasis on practitioner training, patient safety, and evidence-based practice [18]. Laser technology in dentistry have perks and cons to consider. Positives include better patient experience, faster healing, and better treatment outcomes. However, cost, practitioner training, and the need for long-term effectiveness research must be addressed [19]. The European Union's laser dentistry research can inform future

directions. These insights include laser system technological developments, treatment protocol refinement, broader integration into general and specialized dental clinics, and possibilities for practitioner and patient acceptability. This extensive evaluation covers diode, erbium, and CO2 dental lasers. It evaluates their distinctive properties, uses in soft and hard tissues, and pros and cons. This narrative study examines how laser technology is used in oral surgery, periodontics, endodontics, and tooth whitening. The focus is on how these technologies have improved results and procedural efficiency over conventional procedures. The narrative study also examines modern healthcare systems in EU countries including Germany, France, Sweden, and the UK. This involves assessing regulatory clearances, adoption rates, and impediments to determine patterns and best practices.

The aims and objectives of this narrative review are to:

1. Exploring the Types of Lasers Technologies.
2. Evaluating Clinical Applications.
3. Reviewing EU Countries' Experiences.

MATERIALS AND METHODS

A narrative review of scholarly literature was conducted to assess the utilization of modern laser technologies in dentistry across EU countries. Google Scholar database was searched for articles published in the past 2019-2023 period. Keywords such as Lasers [general dentistry] OR Laser [soft tissue] OR "Germany" OR "United Kingdom" OR "France" OR "Italy" were employed to identify relevant studies. Only studies conducted in five European countries were selected.

Database Search Results

A total of 9910 was identified using our search strategy. Those articles were screened to choose the articles pertinent to our topic. Finally, 14 articles [15,20–32] were comprehensively reviewed to collect information about our topic and compile this study as in Figure 1.

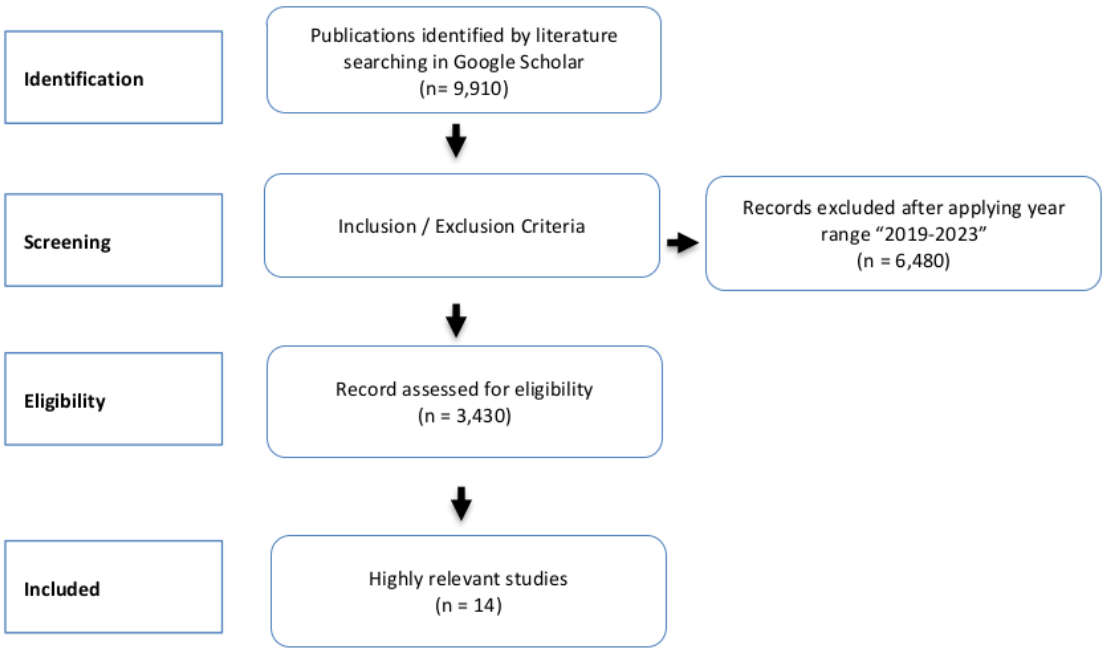

Figure 1. A Four-Phase Flow Diagram

RESULTS

Exploring the Types of Lasers Technologies in Europe

Results in Table 1 showed that diverse lasers are employed in European dentistry, including Nd:YAG, diode, CO2, Er:YAG, and Er,CR:YSGG lasers for various applications such as soft and hard tissue treatments, while newer technologies reshape practices based on regulatory factors, practitioner choices, and patient demands.

Table 1. Exploring the Types of Lasers Technologies in Europe

Study	Study Design	Sample Size	Laser Type
Andreadis et al 2019 [20]	CR	1	Diode laser
Diebolder et al. 2019 [21]	ES	24	Nd:YAG laser and Diode lasers
Isola et al. 2019 [22]	RCT	41	Diode laser, Wiser Laser Doctor Smile
Tenore et al. 2020 [23]	RCT	23	Diode laser
Chala et al 2020 [24]	SLR	9	Various wavelengths/applications of lasers
Parker et al. 2020 [25]	SLR	25	Dental laser wavelengths shorter than 650
Bawazir et al. 2020 [26]	SLR	-	Various laser types
Pisano et al. 2021 [27]	SLR	14	Diode lasers and Yttrium Aluminum Garnet, CO2
Laky et al. 2021 [28]	RCT	22	Nd:YAG and Er:YAG lasers

EO Amaral et al. 2022 [29]	SLR	25	surgical laser
Aria et al. 2022 [15]	RCT	35	Er,CR:YSGG laser (2780 nm).
Nemeth et al. 2022 [30]	CSO	15	Laser-Doppler fluxmetry
Sorrentino et al. 2022 [31]	NR	25	-
Malcangi et al. 2023 [32]	SLR	16	Diode lasers, CO2 lasers, Nd YAG lasers, Er: YAG lasers, Argon lasers, Erbium lasers.

Evaluating Clinical Applications of Laser Technology in Europe

Table 2 reveals the extensive applications of laser technology in European dentistry, encompassing precise surgeries, periodontal therapy, orthodontic support, peri-implant care, wound healing, and enhanced bonding for stable restorations. Lasers seamlessly integrate across oral surgery, periodontics, implantology, orthodontics, and restorative dentistry, enhancing overall dental care in Europe.

Table 2. Evaluating Clinical Applications

Study	**Clinical Applications**
Andreadis et al 2019 [20]	utilized for complete surgical excision of maxillary molar-premolar buccal gingiva pyogenic granulomas.
Diebolder et al. 2019 [21]	Periodontal therapy and soft tissue surgery
Isola et al. 2019 [22]	The diode laser was applied to the test side of the mouth on three points/side (distal, medial, and mesial) in order to accelerate orthodontic tooth movement.
Tenore et al. 2020 [23]	As an adjuvant to non-surgical conventional therapy for peri-implant mucositis and initial peri-implantitis.

Chala et al 2020 [24]	Adjuvant therapy for implant mucositis and peri-implantitis in non-surgical and surgical techniques.
Parker et al. 2020 [25]	Photobiomodulation therapy in clinical dentistry.
Bawazir et al. 2020 [26]	Bond strength.
Pisano et al. 2021 [27]	Peri-implantitis.
Laky et al. 2021 [28]	Periodontal treatment.
EO Amaral et al. 2022 [29]	Soft tissue adjunctive periodontal procedures.
Aria et al. 2022 [15]	Soft tissue and bone cutting
Nemeth et al. 2022 [30]	To measure pulpal LD flux values in both carious and non-carious teeth.
Sorrentino et al. 2022 [31]	Gingival retraction procedures.
Malcangi et al. 2023 [32]	Soft tissues (oral surgery), periodontics, implantology, orthodontics, and restorative dentistry.

EU Countries' Experiences Regarding Use of Modern Laser Technology in Dentistry

Results in Table 3 showed that EU countries extensively utilize modern lasers in dentistry, benefiting orthodontics, periodontal treatments, and restorative dentistry, while emphasizing risk assessment, standardized protocols, and further research for optimal application.

Table 3. EU Countries' Clinical Experiences

Study	**Clinical Experiences**

Andreadis et al 2019 [20]	The study used an 840nm diode laser to remove a large buccal gingiva lobulated pyogenic granuloma. The surgery minimized tooth mobility and recovered in two weeks. Gingival inflammation resurfaced after 4 months.
Diebolder et al. 2019 [21]	The maximum transmitted light intensities were in composite specimens. Glass ionomer cement and other materials transmitted near-zero light at laser wavelengths tested. Material classes and wavelengths affected absorption lengths. Composite surfaces are least laser-damaged.
Isola et al. 2019 [22]	Low-level laser therapy with the diode laser increased orthodontic tooth movement and decreased discomfort. Laser treatment significantly reduced space closure time compared to orthodontic traction alone. At 3, 7, and 14 days following treatments, the laser-treated group had less dental discomfort than the control group.
Tenore et al. 2020 [23]	In the test group having non-surgical conventional therapy and diode laser application, the average probing pocket depth dropped from 4.04 mm to 2.98 mm at T1. The test group had 6 bleeding on probing locations at T1 compared to 44 at T0. The control group got only non-surgical conventional therapy, and the average PPD dropped from 3.8 mm to 3.54 mm at T1 and the BOP-positive sites fell from 52 to 28.
Chala et al 2020 [24]	Laser adjunctive therapy of peri-implant inflammation is helpful for up to three months, but there is no convincing evidence of long-term advantages compared to traditional treatment.
Parker et al. 2020 [25]	Positive or neutral results when comparing laser wavelengths to scalpel therapy. The laser wavelengths (808-980 nm) showed positive results when compared to other diodes. Overall, a laser wavelength system may have good or neutral results compared to other control therapies.
Bawazir et al. 2020 [26]	Adhesive kind, resin composite type, laser settings, substrate, and bond strength test technique affected bond strength results. Laser surface treatment has no evident bond strength advantage over traditional surface treatment, according to the abstract.

Pisano et al. 2021 [27]	Lasers and conventional treatment had similar effects. The authors also note that the research did not agree on the optimum peri-implantitis therapy.
Laky et al. 2021 [28]	The use of Nd:YAG and Er:YAG laser irradiation to non-surgical periodontal therapy improved outcomes.
EO Amaral et al. 2022 [29]	The research found no significant differences between laser and scalpel for probing pocket depth, clinical crown length, gingival index, and relapse rate. Lasers reduced pain and bleeding more than scalpels.
Aria et al. 2022 [15]	The photonics protocol (Er,CR:YSGG laser + PBMT) for impacted lower third molar extraction prevented maximum mouth aperture impairment.
Nemeth et al. 2022 [30]	Pulpal LD flux levels were substantially lower for teeth with an ICDAS score of 6 than 1. Teeth with active caries demonstrated considerably lower pulpal LD flux than teeth with only inactive caries.
Sorrentino et al. 2022 [31]	Gingival retraction using lasers improves hemostasis and patient comfort. Safety was observed with thick gingival biotype.
Malcangi et al. 2023 [32]	Lasers in dentistry have several therapeutic benefits but also hazards. Laser usage can cause cracks and fractures in restorative dentistry, thermal damage to pulp tissue in periodontal treatments, and bleeding, post-operative discomfort, and burning in surgical treatments.

DISCUSSION

Exploring the Types of Lasers Technologies in Europe

The collection of research studies conducted in Europe explores a wide array of laser technologies and their applications in diverse medical and dental contexts. In 2019, Andreadis et al. [20] presented a case report that delved into the usage of an 840nm diode laser in a specific clinical scenario. Around the same time, Diebolder et al. [21] conducted an experimental study involving 24 participants, investigating the efficacy of diode lasers and Nd:YAG lasers with varying wavelengths (810 nm, 940 nm, 980 nm, 1,064 nm). Continuing this trend, Isola et al. conducted a randomized controlled trial (RCT) with 41 participants, focusing on the performance of a 810 nm

diode laser, specifically the Wiser Laser Doctor Smile, in continuous wave mode. These findings are in line with the development of dental lasers in the region and the European dental lasers industry, which, according to a study by iData Research, is anticipated to reach over $60 million by 2023. Additionally, it emphasizes the market for dental lasers in Europe as having room to develop, but it also makes mention of the present economic climate and reimbursement practices in several European nations as impeding this expansion [33]. The use of laser technology is also anticipated to increase significantly in the European region as the dental sector adopts technological advancements, and the rise in the number of dental professionals and their preference for dental lasers is greatly boosting the European dental lasers market growth [34]. Another scoping study that supports this technology-based approach claims that laser surgery is a secure surgical technique that might improve both the clinical result and the quality of life of dental patients [35]. A recent article published in the journal MDPI presents the findings of a systematic study on the therapeutic and harmful effects of lasers in dentistry [36]. Europe is dominant in high-tech sectors and high-value-added products. This suggests that Europe has a strong presence in the development and export of laser machines and related technologies [37]. Another study conducted in Syria examined carbon dioxide laser, diode laser, and erbium: yttrium-aluminum-garnet laser applications on Streptococcus mutans-contaminated sandblasted surface titanium implants and performed a comparative evaluation of the bactericidal effects. The bactericidal activity was assessed in relation to colony counts, and the Er: YAG laser reduced the bacterial count [38].

In conclusion, the extensive collection of European research papers on laser technology and their medical and dental applications shows that lasers are poised to transform clinical procedures. These research, which range from diode laser use in clinical settings to laser wavelength efficacy, illuminate the tremendous rise of the European dental lasers sector. Europe is a dominant force in high-tech sectors, poised to lead in the development and export of laser machinery and related innovations, driven by substantial growth and dental professionals' preference for laser tools. These studies also show that laser surgery is safe and can improve dental patient outcomes and quality of life, demonstrating lasers' potential to revolutionize healthcare.

Evaluating Clinical Applications of Laser Technology in Europe

European dentistry uses laser technology for several therapeutic objectives. It is used for precise pyogenic granuloma removal from the maxillary molar-premolar region in surgical excisions.

Lasers also perform soft tissue operations and accelerate orthodontic tooth movement by targeting oral sites in periodontal therapy. Lasers help cure mucositis and early peri-implantitis. Lasers help wound healing and tissue regeneration in soft and hard dental tissues via photobiomodulation treatment. Lasers' precise tissue cutting benefits minor oral operations such impacted lower third molar extractions. Lasers strengthen bonding between dental substrates and adhesive solutions, ensuring durable restorations. Nd:YAG and Er:YAG lasers improve periodontal therapy, whereas Laser-Doppler fluxmetry analyzes pulpal blood flow. Lasers enable soft tissue adjunctive operations in orthodontics, aligning with oral surgery, periodontics, implantology, orthodontics, and restorative dentistry, improving European dental care. While some studies have shown promising results, others have suggested that more clinical trials should be conducted to standardize and improve laser techniques [39].

Other research have shown that lasers have become an indispensable instrument in a variety of treatments, such as the elimination of caries, the decontamination of caries, the prevention of caries, the preparation of cavities, soft tissue surgery, and periodontal therapy [40]. Further studies showed that laser technology has been an effective tool for increasing bond strength of dental substrates with various adhesive systems. It has been demonstrated that focusing the energy of a laser to particular spots on the test side of the mouth can speed up the movement of teeth during orthodontic treatment. Both non-surgical and surgical methods have been demonstrated to be helpful in treating implant mucositis and peri-implantitis. Laser technology has been used as an adjuvant to standard non-surgical treatment for peri-implant mucositis and early peri-implantitis [39]. Even though dental laser therapy is gaining a lot of interest in both basic and clinical research, there have only been a relatively small number of clinical applications that have been acknowledged as standard treatments. The data that has been developed by research on laser treatment is not sufficient to indicate that laser therapy is significantly superior than traditional therapies. It is recommended that more clinical studies be carried out, the primary focus of which should be on the standardization, improvement, and long-term follow-up of various laser procedures [39]. Another study reached a similar conclusion, finding that silica nanoparticles consolidate the optical characteristics for dental fillings while increasing laser power and exposure time results in the induction of more optical qualities. This behavior can be linked to the most absorbent components of nanoparticle fillings and the enormous rise in molecular excitation that happened during laser treatment of dental fillings [41]. Overall, despite the fact that laser

technology has demonstrated some potential in a variety of dental specialties, further study is required to standardize and advance laser procedures.

In conclusion, laser technology has revolutionized European dentistry, providing precise solutions for various therapeutic goals. Lasers have shown promise in soft tissue procedures, periodontal treatment, orthodontic tooth movement acceleration, and wound healing. The discipline recognizes the need for more clinical trials to standardize and optimize laser procedures despite encouraging outcomes. Lasers have proven useful in several treatments, although their superiority over traditional approaches is still debated. Thus, laser research on refinement, standardization, and long-term efficacy is necessary to maximize their usage in dentistry and improve patient care.

EU Countries' Experiences Regarding Use of Modern Laser Technology in Dentistry

EU dentistry fields have widely used current laser technologies. Low-level laser therapy (LLLT) with diode lasers improved tooth mobility and reduced discomfort in orthodontic treatments. Laser-assisted periodontal therapies may reduce peri-implant inflammation in the near term. Lasers for gingival retraction offered hemostasis control, but restorative dentistry worried about hazards. Lasers showed potential for diagnosing carious and non-carious tooth pulp viability. These applications emphasize risk assessment and protocol standardization notwithstanding advantages.

The material in the search results is mostly focused on the European dental lasers market and dental lasers' acceptance there. However, it is crucial to remember that the dental community has conducted research on and had discussions on the use of lasers in a number of dental specialties, including orthodontics, periodontics, restorative dentistry, and diagnostics. Low-level laser therapy with diode lasers has shown promise in enhancing tooth movement speed and reducing pain in orthodontic treatments. Laser-assisted periodontal interventions have demonstrated potential for short-term improvements in peri-implant inflammation treatment. Lasers have been used in restorative dentistry for gingival retraction, offering advantages such as hemostasis control. Laser diagnostics have shown promise in assessing pulp vitality in carious and non-carious teeth [34]. Concerns have been made in reference to the feasible dangers that are connected to the utilization of lasers in the field of restorative dentistry. It is necessary to conduct more studies in order to develop standardized protocols for the use of lasers in a variety of dental applications [34].

The use of laser technology in dentistry is gaining popularity in European nations, and the market for dental lasers there is anticipated to grow at a rate of 5.8% from 2022 to 2029, with Germany dominating the market as a result of the expansion of the patient base [42]. In a similar vein, the 8th Congress of the World Federation for Laser Dentistry European Division was held in Montpellier, France in October 2021. The primary focus of this gathering was the use of lasers in the treatment of oral soft tissue diseases [43].

In conclusion, laser technologies in dentistry in Europe have shown great potential across several fields. Low-level laser treatment (LLLT) using diode lasers has shown promise in speeding tooth movement and reducing orthodontic pain. Initial laser-assisted periodontal treatments have reduced peri-implant inflammation. Lasers have been used in restorative dentistry for gingival retraction and hemostasis management, but safety issues remain. Lasers are promising for identifying carious and non-carious tooth pulp. These advances emphasize the necessity of risk assessment and procedure standardization, but further study is needed to produce safe and effective laser usage standards for dental applications.

CONCLUSION

The extensive research conducted across Europe underscores the transformative potential of laser technology in medical and dental applications. From diode lasers to Nd:YAG lasers, a plethora of studies has illuminated the versatility and efficacy of lasers across various clinical scenarios. The European dental lasers market is poised for significant growth, driven by the preference of dental professionals for laser tools and the adoption of technological advancements. Laser surgery has shown to be safe and capable of enhancing patient outcomes and quality of life, indicating its potential to revolutionize healthcare. Laser technology has revolutionized European dentistry by offering precise solutions for therapeutic goals, including soft tissue procedures, periodontal treatment, orthodontic acceleration, and wound healing. However, the standardization and improvement of laser techniques require more clinical trials and rigorous research to ensure their efficacy and safety.

Conflict of interest: none declared.

Financial support: none declared.

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