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Laser Technology in Dentistry: Clinical Applications and Emerging Trends

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Abstract:

Laser technology has emerged as an important advancement in modern dentistry, offering greater precision, improved tissue management, and minimally invasive alternatives across several clinical procedures. The present study evaluated the clinical applications, perceived effectiveness, and factors influencing the adoption of laser technology among 150 dental practitioners using a quantitative cross-sectional analytical design. Data were collected through a structured questionnaire and analyzed using descriptive statistics, Chi-square test, independent-samples t-test, one-way ANOVA, and multiple regression analysis. Diode lasers were the most commonly utilized system (42.0%), while periodontal procedures (26.0%) and soft-tissue surgery (24.0%) were the leading clinical applications. Bleeding control showed the highest perceived outcome score (4.34 ± 0.58). Professional specialization was significantly associated with regular laser use ($p = .027$), while regular users reported significantly greater clinical effectiveness than non-regular users ($p < .001$). Clinical effectiveness also differed significantly across laser types ($p = .029$). Regression analysis identified frequency of laser use, formal training, and perceived ease of use as significant predictors of clinical effectiveness, with the model explaining 38.6% of the variance. The study concludes that laser technology represents a valuable adjunct in contemporary dentistry, although its effective integration depends substantially on appropriate training, regular clinical exposure, and procedure-specific selection of laser systems.

Keywords: Laser dentistry; Diode laser; Clinical effectiveness; Periodontal therapy; Soft-tissue surgery; Dental technology

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1. INTRODUCTION

The continuing advancement of dental technology has transformed conventional approaches to diagnosis, treatment, and patient care, with laser technology emerging as an important component of modern clinical dentistry[1]. Dental lasers provide controlled interaction with both hard and soft tissues and have been increasingly applied in periodontics, endodontics, oral surgery, restorative dentistry, prosthodontics, and pediatric dentistry[2]. Depending on the wavelength and clinical indication, laser-assisted procedures may offer advantages such as precise tissue ablation, improved hemostasis, reduced operative trauma, microbial reduction, and greater postoperative comfort. Various systems, including diode, Nd, Er, Er,Cr, and CO_2 lasers, have consequently expanded the therapeutic possibilities available to dental practitioners[3]. Despite these developments, their routine adoption remains influenced by factors such as equipment cost, practitioner training, technical competence, clinical indications, and availability of standardized protocols[4]. Evaluating current applications, clinical effectiveness, and emerging trends is therefore important for understanding the evolving role of laser technology in contemporary dental practice[5].

1.1.Statement of the Problem

Despite the expanding applications of laser technology in dentistry, its integration into routine clinical practice remains uneven due to variations in practitioner training, technological accessibility, equipment costs, clinical experience, and understanding of wavelength-specific applications. Although dental lasers have been associated with advantages such as improved hemostasis, precise tissue management, reduced postoperative discomfort, and favorable healing, their perceived effectiveness may differ across laser systems, dental specialties, and patterns of clinical use[6].

Moreover, the availability of multiple laser technologies creates uncertainty regarding their appropriate selection for specific procedures and their comparative clinical value[7]. There is therefore a need to systematically examine current utilization patterns, major clinical applications, perceived treatment outcomes, and factors influencing the adoption and effectiveness of laser technology in dentistry.

1.2.Background of the study

The application of lasers in dentistry has evolved considerably since their introduction into clinical practice, progressing from limited soft-tissue procedures to broader applications in periodontics, endodontics, oral surgery, restorative dentistry, prosthodontics, and pediatric dentistry[8]. Different laser systems, including diode, Nd, Er, Er,Cr, and CO_2 lasers, interact with oral tissues according to their specific wavelengths and absorption characteristics, allowing clinicians to select appropriate systems for particular therapeutic purposes[9]. Advances in laser technology have contributed to

improved tissue precision, hemostasis, microbial control, and minimally invasive treatment approaches, with potential benefits for postoperative comfort and healing.

At the same time, successful clinical application depends on appropriate case selection, operating parameters, practitioner competence, safety protocols, and specialized training[10]. With continued technological development and increasing interest in digitally integrated and minimally invasive dental care, evaluating the clinical applications, effectiveness, adoption patterns, and emerging trends of laser technology has become increasingly relevant to contemporary dental practice.

1.3.Objectives

The objectives of the study are:

- To assess the patterns of utilization and major clinical applications of laser technology across different dental specialties.
- To evaluate the perceived clinical effectiveness of laser-assisted dental procedures in terms of procedural efficiency, bleeding control, postoperative discomfort, and healing response.
- To examine the association between professional characteristics, laser type, and regular utilization of laser technology in dental practice.
- To determine the influence of laser-use frequency, professional training, clinical experience, and perceived ease of use on the overall clinical effectiveness of laser technology.

2. RESEARCH METHODOLOGY

The study was conducted to analytically evaluate the clinical applications, effectiveness, and emerging trends of laser technology in dentistry. A quantitative, cross-sectional analytical approach was adopted to examine patterns of laser utilization across dental specialties, perceived clinical benefits, treatment outcomes, and barriers to adoption. Standardized data collection procedures were followed to ensure consistency and facilitate statistical comparison among the study variables.

2.1.Description of Research Design

A quantitative, cross-sectional analytical research design was employed. The study assessed the association between the use of dental lasers and selected clinical parameters, including procedural efficiency, postoperative discomfort, healing response, and practitioner-reported treatment effectiveness. Differences in laser utilization across dental specialties and practitioner characteristics were also analyzed.

2.2.Participants and Sample Details

The study included a sample of 150 dental practitioners selected from dental hospitals, clinics, and academic institutions. Participants included general dentists and specialists in periodontics, endodontics, oral surgery, prosthodontics, and pediatric dentistry. Dentists with at least one year of clinical experience were included. Participants who did not provide complete responses were excluded from the final analysis.

2.3.Instruments and Materials Used

Data were collected using a **structured questionnaire** developed from relevant literature on laser-assisted dentistry. The instrument included sections covering demographic and professional characteristics, types of lasers used, frequency and areas of clinical application, perceived effectiveness, clinical advantages, complications, training, cost considerations, and barriers to adoption. Information regarding commonly used systems, including **diode, Nd:YAG, Er:YAG, Er,Cr:YSGG, and CO_2 lasers**, was recorded where applicable.

2.4.Procedure and Data Collection Methods

Eligible dental practitioners were approached after obtaining the necessary institutional permission and informed consent. The questionnaire was administered electronically or in printed form according to participant accessibility. Respondents reported their experience with laser-assisted procedures, commonly treated conditions, perceived clinical outcomes, and adoption-related challenges. Completed questionnaires were reviewed for completeness, coded, and entered into a structured database for analysis.

2.5.Data Analysis Techniques

SPSS was used to examine the data. To summarize the participant characteristics and patterns of laser consumption, we calculated frequencies, percentages, means, and standard deviations. When looking for correlations between categories, we utilized the Chi-square test; when comparing groups based on relevant practitioners or laser use, we used either independent-samples t-tests or one-way ANOVA. A more positive impression of the laser's therapeutic efficacy and its subsequent widespread use were both sought after by conducting a multiple regression analysis. The threshold for statistical significance was set at $p < 0.05$.

3. RESULTS

The study analyzed responses from 150 dental practitioners to determine patterns of laser technology utilization, its clinical applications, perceived treatment effectiveness, and factors influencing its adoption in dental practice. The findings indicated considerable variation in laser use according to professional specialization, clinical experience, and type of laser system. Diode lasers were the most frequently reported systems, while soft-tissue procedures and periodontics represented the predominant areas of application. Practitioners using laser technology more

frequently reported higher perceived clinical effectiveness, particularly in relation to procedural efficiency, postoperative comfort, and healing response.

To further comprehend the study's sample composition, researchers looked at the demographic and occupational details of the participants.

Table 1. Demographic and Professional Characteristics of Participants (N = 150)

Characteristic	Category	F	%
Gender	Male	86	57.3
	Female	64	42.7
Clinical experience (Years)	1–5	48	32.0
	6–10	45	30.0
	11–15	32	21.3
	>15	25	16.7
Professional category	General dentist	52	34.7
	Periodontist	24	16.0
	Endodontist	22	14.7
	Oral surgeon	20	13.3
	Prosthodontist	18	12.0
	Pediatric dentist	14	9.3
Practice setting	Private clinic	68	45.3
	Dental hospital	47	31.3
	Academic institution	35	23.3

General dentists constituted the largest professional group (34.7%), followed by periodontists (16.0%) and endodontists (14.7%). Nearly two-thirds of the respondents had up to 10 years of clinical experience, indicating substantial representation of early- and mid-career dental practitioners.

The pattern of laser utilization was evaluated according to the type of laser system most commonly used by participating dental practitioners.

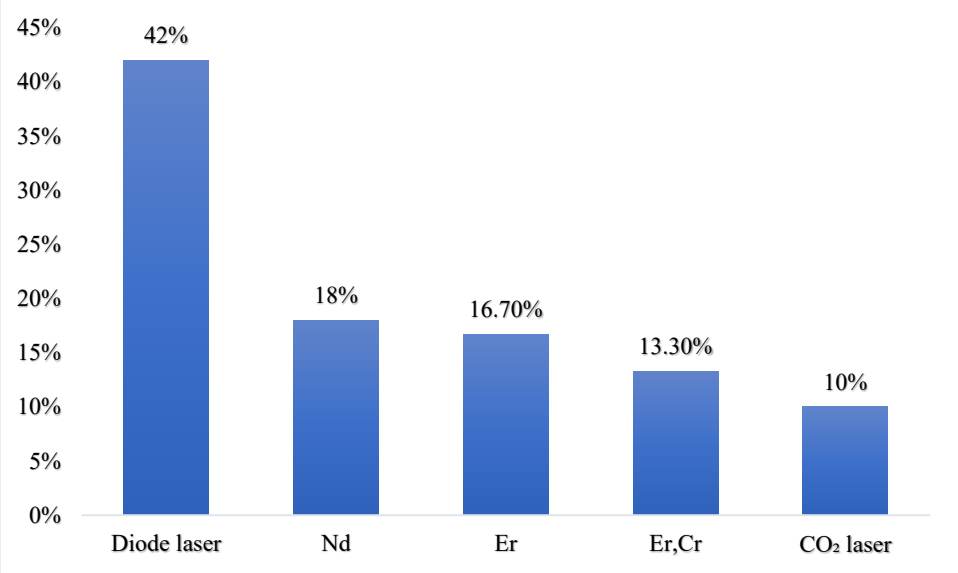

Figure 1. Types of Dental Lasers Used by Participants

Diode lasers were the most commonly reported laser systems, accounting for 42.0% of utilization. Nd and Er lasers accounted for 18.0% and 16.7%, respectively, whereas CO_2 lasers represented the least frequently reported system.

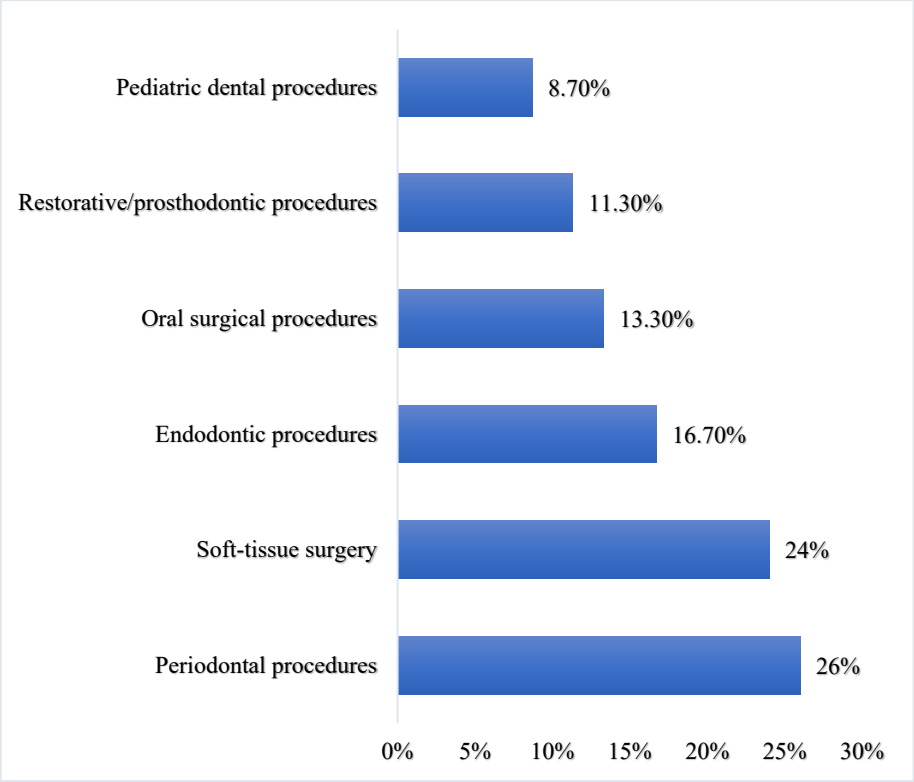

Figure 2. Principal Clinical Applications of Laser Technology

Periodontal procedures constituted the most frequent clinical application (26.0%), closely followed by soft-tissue surgery (24.0%). Together, these applications accounted for half of the reported principal uses, demonstrating a greater concentration of laser technology in procedures involving periodontal and soft tissues.

Table 4. Descriptive Statistics for Clinical Outcome Measures

Clinical outcome	N	Min	Max	Mean	Std. Deviation
Procedural efficiency	150	2.00	5.00	4.12	0.68
Reduction in postoperative discomfort	150	2.00	5.00	4.21	0.64
Healing response	150	2.00	5.00	4.18	0.61
Bleeding control	150	2.00	5.00	4.34	0.58
Overall clinical effectiveness	150	2.00	5.00	4.16	0.62

Scores were measured on a five-point scale, with higher scores representing more favorable perceived outcomes.

The highest mean score was observed for bleeding control (M = 4.34, SD = 0.58), followed by reduction in postoperative discomfort (M = 4.21, SD = 0.64). Overall clinical effectiveness also received a relatively high mean score of 4.16 ± 0.62, indicating favorable practitioner perceptions of laser-assisted dental treatment.

3.1.Statistical Analysis

Inferential statistical analysis was performed to determine whether laser utilization differed according to professional specialization and whether clinical effectiveness varied according to the frequency of laser use.

Association Between Professional Specialization and Regular Laser Use

Table 5. Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson χ^2	12.684[a]	5	.027
Likelihood Ratio	13.146	5	.022
Linear-by-Linear Association	1.328	1	.249
N of Valid Cases	150		

[a] 0 cells (0.0%) had an expected count less than 5.

The Pearson Chi-square test demonstrated a statistically significant association between professional specialization and regular use of dental lasers, $\chi^2(5) = 12.684$, $p = .027$. Periodontists showed particularly high regular utilization, suggesting that professional specialty was associated with the likelihood of incorporating laser technology into routine practice.

Table 6. Independent Samples Test

	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI Lower	95% CI Upper
Equal variances assumed	7.214	.008	4.138	148	<.001	.390	.094	.204	.576
Equal variances not assumed			3.871	91.64	<.001	.390	.101	.189	.591

Practitioners who regularly used laser technology reported significantly greater overall clinical effectiveness (M = 4.31, SD = 0.48) than those who did not regularly use lasers (M = 3.92, SD = 0.68). The difference was statistically significant, $t(91.64) = 3.871$, $p < .001$, indicating that greater practical exposure to laser technology was associated with more favorable evaluations of its clinical effectiveness.

Table 7. ANOVA – Overall Clinical Effectiveness

	SoS	df	Mean^2	F	Sig.
Between Groups	4.083	4	1.021	2.793	.029
Within Groups	53.017	145	.366		
Total	57.100	149			

One-way ANOVA demonstrated a statistically significant difference in perceived clinical effectiveness among the five laser categories, $F(4,145) = 2.793$, $p = .029$. Diode laser users reported the highest mean effectiveness score (4.28 ± 0.54), whereas CO_2 laser users demonstrated the lowest mean score (3.76 ± 0.70). The finding indicated that perceived clinical effectiveness varied according to the type of laser technology used.

Table 8. Model Summary[b]

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	.621[a]	.386	.369	.493

[a] Predictors: (Constant), Frequency of laser use, laser training, clinical experience, perceived ease of use.

[b] Dependent Variable: Overall clinical effectiveness.

Table 9. ANOVA[a]

Model	SoS	df	Mean Square	F	Sig.
Regression	22.041	4	5.510	22.783	<.001[b]

Residual	35.079	145	.242		
Total	57.120	149			

[a] Dependent Variable: Overall clinical effectiveness.

[b] Predictors: (Constant), Frequency of laser use, laser training, clinical experience, perceived ease of use.

Table 10. Coefficients[a]

Model	Unstandardized B	Std. Error	Standardized β	t	Sig.
(Constant)	1.482	.328		4.518	<.001
Frequency of laser use	.286	.067	.342	4.269	<.001
Laser training	.241	.073	.264	3.301	.001
Clinical experience	.074	.041	.137	1.805	.073
Perceived ease of use	.219	.064	.271	3.422	.001

[a] Dependent Variable: Overall clinical effectiveness.

The multiple regression model was statistically significant, $F(4,145) = 22.783$, $p < .001$, and explained approximately **38.6% of the variance** in perceived clinical effectiveness ($R^2 = .386$). Frequency of laser use ($\beta = .342$, $p < .001$), formal laser training ($\beta = .264$, $p = .001$), and perceived ease of use ($\beta = .271$, $p = .001$) emerged as significant positive predictors. Clinical experience alone did not independently predict effectiveness at the 5% significance level ($\beta = .137$, $p = .073$). Collectively, the findings suggested that practical exposure, appropriate training, and usability were more influential in shaping favorable assessments of laser technology than the general duration of dental practice.

4. DISCUSSION

The present study evaluated the clinical applications, effectiveness, and adoption of laser technology among 150 dental practitioners. Diode lasers were the most commonly used, while periodontal and soft-tissue procedures represented the major clinical applications. Favorable outcomes were reported for bleeding control, postoperative discomfort, and healing. Statistical findings further demonstrated that specialization, frequency of laser use, formal training, and ease of use were important factors associated with laser adoption and perceived clinical effectiveness.

4.1.Interpretation of Results

The findings demonstrated that laser technology was particularly valued for soft-tissue management and periodontal applications. Bleeding control recorded the highest clinical outcome score (4.34 ± 0.58), while regular laser users reported significantly greater clinical effectiveness than non-regular users ($p < .001$). Effectiveness also differed significantly across laser types ($p = .029$). Regression analysis showed that frequency of use, laser training, and perceived ease of use significantly predicted clinical effectiveness, whereas general clinical experience was not independently significant ($p = .073$).

4.2.Comparison with Existing Studies

The findings of the present study were broadly consistent with existing literature regarding the expanding clinical importance of laser technology in dentistry. Sachelarie et al. (2024)[11] highlighted the growing application of dental lasers across soft-tissue procedures and other therapeutic areas, supporting the present finding that periodontal procedures and soft-tissue surgery represented the predominant applications. Similarly, Zhang et al. (2025)[12] emphasized the clinical versatility of advanced laser systems and their potential benefits for precise tissue management, which corresponds with the favorable effectiveness outcomes observed in the present study. Rolek and Pławecki (2024)[13] reported that modern laser technologies could contribute to improved procedural precision, hemostasis, healing, and patient comfort; comparable findings were obtained in the current study, where bleeding control achieved the highest mean score (4.34 ± 0.58), alongside favorable scores for postoperative discomfort and healing response. Liaqat et al. (2022)[14], through a systematic review, also demonstrated the increasing importance of lasers as innovative tools across multiple areas of dentistry, reinforcing the present observation of their multidisciplinary clinical application. Furthermore, Huang et al. (2023)[15] emphasized that successful laser application depends on appropriate technological selection and clinical protocols, which aligns with the present regression findings showing that frequency of laser use, formal training, and perceived ease of use significantly predicted clinical effectiveness. Collectively, these comparisons indicate that the present findings are consistent with existing evidence while further highlighting practitioner training and regular clinical exposure as important determinants of effective laser integration.

4.3.Implication of Existing Studies

The findings were broadly consistent with existing evidence on the clinical utility of dental lasers:

- Diode lasers showed greater utilization, reflecting their versatility in soft-tissue and periodontal procedures.
- Favorable bleeding control supported the recognized hemostatic benefits of laser-assisted treatment.
- Improved postoperative comfort and healing reflected the potential advantages of minimally invasive laser procedures.
- The importance of training and regular use highlighted the role of practitioner competency in achieving effective outcomes.
- Variation across laser types indicated the need for procedure-specific selection of appropriate wavelengths and parameters.

4.4.Limitations of the Study

Several limitations should be considered while interpreting the findings:

- The cross-sectional design did not permit assessment of causal relationships.
- Clinical outcomes were mainly based on practitioner-reported perceptions.
- The sample of 150 practitioners may limit wider generalization.
- Patient-level outcomes and long-term treatment results were not directly evaluated.
- Differences in laser parameters, equipment, and treatment protocols were not fully controlled.

4.5.Suggestions for Future Work

Future studies should strengthen the clinical evidence through broader and more objective investigation:

- Conduct multicenter studies with larger and more diverse samples.
- Compare laser-assisted and conventional treatments using standardized clinical outcomes.
- Investigate differences among individual laser wavelengths and systems.
- Examine long-term outcomes, patient satisfaction, and cost-effectiveness.
- Explore emerging applications involving digitally controlled and AI-assisted laser technologies.

5. CONCLUSION

The present study concluded that laser technology has considerable clinical value in contemporary dentistry, particularly in periodontal and soft-tissue procedures. Diode lasers emerged as the most frequently utilized system, while bleeding control, reduced postoperative discomfort, and favorable healing responses were among the major perceived clinical benefits. Statistical analysis further demonstrated that regular laser utilization, professional training, and perceived ease of use significantly contributed to clinical effectiveness. These findings suggest that successful integration of laser technology depends not only on technological availability but also on appropriate practitioner training and consistent clinical exposure.

5.1.Summary of Key Findings

The major findings of the study can be summarized as follows:

- Diode lasers were the most commonly utilized laser system, reported by 42.0% of practitioners.
- Periodontal procedures and soft-tissue surgery were the leading clinical applications.
- Bleeding control recorded the highest perceived clinical outcome score (4.34 ± 0.58).
- Professional specialization was significantly associated with regular laser utilization ($p = .027$).
- Regular laser users reported significantly higher clinical effectiveness than non-regular users ($p < .001$).
- Clinical effectiveness differed significantly across laser types ($p = .029$).
- Frequency of use, laser training, and perceived ease of use significantly predicted clinical effectiveness, with the regression model explaining 38.6% of the variance.

5.2.Significance of the Study

The study provides useful evidence regarding the expanding role of laser technology across different areas of dental practice. By examining utilization patterns alongside perceived clinical outcomes and adoption-related factors, the findings highlight the importance of selecting appropriate laser systems and strengthening practitioner competency. The study particularly demonstrates that technology-specific training and regular clinical exposure may be more influential in achieving favorable outcomes than general professional experience alone. It therefore contributes to understanding both the clinical and professional factors underlying effective laser integration in dentistry.

5.3.Recommendations

Based on the findings, the following recommendations are proposed:

- Dental practitioners should receive structured theoretical and practical training before routinely performing laser-assisted procedures.
- Dental institutions should incorporate evidence-based laser dentistry into clinical education and continuing professional development.
- Laser systems should be selected according to wavelength, tissue characteristics, and specific clinical indications.

- Standardized clinical protocols should be followed to improve treatment effectiveness and patient safety.
- Greater emphasis should be placed on patient-centered outcomes, including postoperative pain, healing, satisfaction, and long-term treatment success.
- Further clinical and economic evaluation should be encouraged before large-scale adoption of emerging laser technologies.

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