Mathematical Study for laser and its Clinical Applications in dentistry: Review and Outlook

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Abstract. The paper for the survey is to recapitulate applications of laser, mathematically and also discusses whether the laser can furnish a similar or ameliorate treatment for traditional care. Studies have shown that the use of lasers in the different fields is an efficacious device to increase efficiency, quality, easiness, cost and convenience in dental therapy. The laser is an influential dental auxiliary to control pollution, wound reparations, the discharge and control of tremolo in the expulsion of hard tissues. Lasers designed specifically for this region are surgical and medical devices at the forefront of technology and are used by a large number of doctors in everyday use. Dental laser uses wavelengths that are absorbed in soft or solid tissues and given exceptional privacy in tissue. Its clinical capabilities are extremely complex, providing very good comfort for the patient. Clinical conditions will characterize the various and diverse applications of dental lasers depending on the power used during exposure and absorption of wavelengths in soft or hard tissues, emphasizing the benefits for each case.

Keywords: Laser, different specialties, dentistry, wavelength, dental.

1. Introduction
Laser is a type of electromagnetic radiance exported, has its own special characteristics. The LASER is shortened form for amplifying light by stimulated emission. A laser is an appliance make coherent electromagnetic radiance. Laser radiance is differentiated by a low ramification of the radiance ray and, with few exceptions a well-defined wavelength [1, 2, 3]. Wavelength is the extremely significant determinant in how light influence tissue. This is the distance between two consecutive wave peaks. Each type of laser has specific wavelengths depending on the nature of the active medium. Laser wavelength is usually measured in units of length: nanometers (nm) or micrometers (microns), depending on whether they are in the ultraviolet, visible or infrared range of the electromagnetic spectrum. Simply put, the wavelength determines the quality or type of interaction between the laser and the tissue [4]. Through past decennium there has been tremendous activity in domain of laser semiconductors. Long-range wavelength lasers be yet arrived the evolution juncture and used in fiber
optic communication worldwide. The number for researchers in dentistry increased over the past years. The laser was introduced in the field of medicine and dentistry in 1960 [5]. Since then, this field has progressed speedily. Because of its many advantages, the laser refers to a widespread field for procedures. Traditional methods of Prepare cavity for low, high-speed hand pieces include uncomfortable noise and vibration and stress for patients. While pain, perhaps relieved by local anesthesia, fear of the needle, noise, and mechanical vibration remain a cause of discomfort. These defects led to search for new techniques as possible alternatives to removal of hard tissues. A laser is used to handle different states in dentistry [6]. Laser use, requires minimal anesthesia and saves time for patients. It is utilized as an adjunct to another treating (with drugs, surgery, physical therapy) and sometimes as a major therapy. The effects of laser renewal are anti-inflammatory, analgesic and biological that causes the re-establishment of the physiological state of the natural tissues [7].

This search reviews a mathematical study on laser applications in dentistry and its outlook.

2. Classification of lasers

The laser can be categorized in many ways [8 - 18]:

1. According to wavelength (nanometers)
   A. Radiation of invisible ionizing
   B. Visible
   C. Radiation of invisible thermal

2. According to position of laser wavelength on the electromagnetic range for light
   A. ultraviolet spectrum
   B. visible spectrum
   C. near-infrared spectrum
   D. far-infrared spectrum

3. According to the type of activity (Lansing) Medium Used
   A. Gas lasers
   B. Solid State lasers
   C. semi-conductor lasers
   D. Dye or Liquid laser
   E. Excimer laser
   F. Chemical laser

4. According to Oscillation mode
   A. Continuous wave lasers
   B. Pulsed lasers

5. According to power supply
   A. Low power lasers
   B. Mid power lasers

6. According to pumping scheme
   A. Optically pumped laser
   B. Electrically pumped laser
7. According to the delivery system
A. Articulated arm (mirror type)
B. Hollow waveguide
C. Fiber optic cable

8. According to surgical therapy
A. Hard laser (for surgical work)
   - CO₂ lasers (CO₂ gas)
   - Nd:YAG lasers (Yttrium-aluminum-garnet)
   - Argon laser (Argon ions)
B. Soft laser (for bio stimulation and analgesia)
   - He-Ne lasers
   - Diode lasers

2.1 Dental Departments [13, 14].
There are six dental departments that we may see during the period of oral care included in the list of specialties (Tab.1):

| Specialty          | Specialist titles | Definition                                                                 |
|--------------------|-------------------|---------------------------------------------------------------------------|
| Oral surgery       | Oral surgeon      | The Department of Dentistry is interested in the diagnosis and surgical introduction of conditions that affect the tissues of the oral cavity and teeth. |
| Endodontics        | Endodontist       | The Department of Dentistry is interested in the morphology and pathology of the pulp-dentin compound and periarticular tissues. Its study and application cover the basic clinical sciences, including the biology of ordinary pulp, as well as the etiology, diagnosis, prevention and treatment of diseases and injuries of the pulp and related periarticular tissues. |
| Periodontics       | Periodontist      | Department of Dentistry, which is interested in the prevention, diagnosis and treatment of diseases or pathologies of the supporting tissues of the tooth and its substitutes. |
| Pediatric dentistry| Paedodontist       | Department of dentistry which interested with the preventive and oral health care for children from birth through to adolescence and with particular needs. It has managed, by oral-facial problem about medical, behavioral and physical. |
| Prosthodontics     | Prosthodontist    | The Department of Dentistry is engaged in the restoration and maintenance of oral health, the function and appearance of coronary changes, the natural replacement of teeth or missing teeth and adjacent tissues of the mouth, face and jaw. |
| Orthodontics       | Orthodontist      | Department of Dentistry, which is interested in the supervision, management and correction of dents and mature facial structures; include diagnosis, prophylaxis, obstruction and treatment of all forms of teeth and related changes in their surrounding structures. |

2.1.1 Lasers applied in dentistry
Laser applied in dentistry (Tab.2) change from the ultraviolet radiance, (100-400 nm) to the infrared spectrum from 0.5 to 10.6 microns (from 405 mm to 10600 mm). Visible place of the spectrum between two wavelengths (400-750 nm and infrared radiation). The laser used in dentistry includes a wide range of procedures, from the diagnosis of caries or cancer to soft tissues and factors of hard tissue procedures that affect the laser's effect on tissues, including various lasers. by wavelength, output power (pulse or continuous), time of exposure, spot size and tissue variables with physical and chemical composition [15, 16, 17]. Lasers used in dentistry may be marked depending on the wavelength of the physical structure of the type of active medium, the tissues on which it is applied, and depending on the degree of subsequent accidental exposure. Laser components, including the laser medium, optical cavity, energy source, are shown in [18-20].

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| Periodontics | Periodontist      | Department of Dentistry, which is interested in the prevention, diagnosis and treatment of diseases or pathologies of the supporting tissues of the tooth and its substitutes. |
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2.1.2 Applications of lasers in dentistry

The laser is widely used in dentistry for cavity preparations, root canal, expansion, root planning, gums and periodontal surgeries, coagulation and hemostasis, biopsies, excision of tongue lesions, TMJ disorders, exposure of implants and pre-prosthetic surgery can be classified as follows (Tab. 3, 4, 5, 6, 7, 8).

**Table 3. Use for laser in prosthodontics [21-48]**

| Laser type   | Wavelength(nm) | Clinical applications                          |
|--------------|----------------|-----------------------------------------------|
| Er:YAG       | 2940           | Implantology, Fixed Prosthetics, Removable prosthetics |
| Er,Cr:YSGG  | 2780           | Implantology, Fixed Prosthetics, Removable prosthetics |
| CO2          | 10600          | Fixed Partial, Complete and Removable Partial denture |
| Ho:YAG       | 2100           | Implantology                                  |
| Nd:YAG       | 1064           | Fixed partial and Prosthetics                |
| Argon (Ar)   | 488 and 514    | enhancing aesthetics, Complete and removable Partial denture |
| InGaAsP      | 488            | enhancing aesthetics, oral hygiene and analgesic |
| GaAlAs       | 655-1064       |                                               |
| GaAs         | 670-830        |                                               |
| InGaAs       | 840            |                                               |

**Table 4. Use for laser in periodontics [49-56]**

| Laser type   | Wavelength(nm) | Clinical applications                                      |
|--------------|----------------|------------------------------------------------------------|
| Er:YAG       | 2940           | Incision and ablation of soft tissues, curettage of the pancreas, scaling, root conditioning, osteoplasty and osteotomy, degranulation and deactivation of implants. |
| Er,Cr:YSGG  | 2780           | Soft tissue incision and ablation, subgingival curettage, scaling of root surfaces, osteoplastic and osteotomy. |
| CO2          | 10600          |                                            |
| Nd:YAG       | 1064           |                                            |
Argon (Ar) 488 - 514 Soft tissue incision and ablation.
InGaAsP 488 Soft tissue incision and ablation, subgingival curettage, bacterial elimination.
GaAlAs 655-1064
GaAs 670-830
InGaAs 840
He-Ne 637 Intraoral soft tissue surgery, removal of the mucous membrane and gum depigmentation.

Table 5. Use for laser in orthodontics [57-71]

| Laser type      | Wave length (nm) | Clinical applications                                           |
|-----------------|------------------|----------------------------------------------------------------|
| Er:YAG          | 2940             | Welding, de-bonding procedure, analgesic effects and etching   |
| CO2             | 10600            |                                                                |
| Ho:YAG and Nd:YAG | 2100         |                                                                |
| Argon (Ar)      | 488 and 514      | Curing, Enhancing aesthetics,                                   |
| InGaAsP         | 488              | Curing, Oral hygiene, analgesic effects,                        |
| GaAlAs          | 655-1064         |                                                                |
| GaAs            | 670-830          |                                                                |
| InGaAs          | 840              |                                                                |
| He-Ne           | 637              | analgesic effects                                              |

Table 6. Uses of laser in endodontic [72-93]

| Laser type      | Wave length (nm) | Clinical applications                                           |
|-----------------|------------------|----------------------------------------------------------------|
| Er              | 2940             | root canal, endodontic Surgery, Hypersensitivity, Pulp capping |
| Er-Cr           | 2780             | apicoectomy or Periapical curettage, Pulp                     |
| CO2             | 10600            | Apicoectomy or Periapical curettage                            |
| Ho              | 2100             | Pulp vitality, tooth bleaching and periapical curettage        |
| Nd:Yag          | 1064             |                                                                |
| Argon (Ar)      | 488 and 514      | root canal                                                    |
| InGaAsP         | 488              | root canal                                                    |
| GaAs and InGaAs | 655-1064         | Hypersensitivity, Pulp capping                                 |
|                 | 670-830          |                                                                |
|                 | 840              |                                                                |
| He-Ne           | 637              | Hypersensitivity, Pulp capping                                 |
| Excimer laser   | 380              | root canal                                                    |
| KTP             | 532              | tooth bleaching                                               |
### Table 7. Uses of laser in pediatric [94-96]

| Laser type | Wave length (nm) | Clinical applications |
|------------|------------------|-----------------------|
| Er         | 2940             | caries removal, light curing, traumatology, frenectomy, ankyloglossia, gingival remodeling and gingivectomy |
| Er-Cr      | 2780             | gingival hypertrophy, tooth retention and Hypertrophic fibroma |
| CO2        | 10600            | gingival hypertrophy, tooth retention and Hypertrophic fibroma |
| Nd:Yag     | 1064             | gingival hypertrophy, tooth retention and Hypertrophic fibroma |
| Argon (Ar) | 488 and 514      | gingival hypertrophy, tooth retention and Hypertrophic fibroma |
| GaAlAs     | 488, 655-1064    | gingival hypertrophy, tooth retention and Hypertrophic fibroma |
| GaAs       | 670-830          | gingival hypertrophy, tooth retention and Hypertrophic fibroma |
| InGaAs     | 840              | gingival hypertrophy, tooth retention and Hypertrophic fibroma |

### Table 8. Uses of laser in oral [97-111]

| Laser type | Wave length (nm) | Clinical applications |
|------------|------------------|-----------------------|
| Er:YAG     | 2940             | oral leukoplakia, gingival melanin pigmentation, lichen planus, oral melanoma and benign lesions, epulis fissuratum, lymphangioma, cancer of oral cavity, excisional biopsy, treatment of oral cavity malformations and Frenectomy |
| Er,Cr:YSGG | 2780             | oral leukoplakia, gingival melanin pigmentation, lichen planus, oral melanoma and benign lesions, epulis fissuratum, lymphangioma, cancer of oral cavity, excisional biopsy, treatment of oral cavity malformations and Frenectomy |
| CO2        | 10600            | oral leukoplakia, gingival melanin pigmentation, lichen planus, oral melanoma and benign lesions, epulis fissuratum, lymphangioma, cancer of oral cavity, excisional biopsy, treatment of oral cavity malformations and Frenectomy |
| Ho:YAG     | 2100             | oral leukoplakia, gingival melanin pigmentation, lichen planus, oral melanoma and benign lesions, epulis fissuratum, lymphangioma, cancer of oral cavity, excisional biopsy, treatment of oral cavity malformations and Frenectomy |
| Nd:YAG     | 1064             | oral leukoplakia, gingival melanin pigmentation, lichen planus, oral melanoma and benign lesions, epulis fissuratum, lymphangioma, cancer of oral cavity, excisional biopsy, treatment of oral cavity malformations and Frenectomy |
| Argon (Ar) | 488 and 514      | oral leukoplakia, gingival melanin pigmentation, lichen planus, oral melanoma and benign lesions, epulis fissuratum, lymphangioma, cancer of oral cavity, excisional biopsy, treatment of oral cavity malformations and Frenectomy |
| InGaAsP    | 488              | gingival hyperplastic lesions removal, cancer of Oral cavity and hemangioma |
| GaAlAs     | 655-1064         | gingival hyperplastic lesions removal, cancer of Oral cavity and hemangioma |
| GaAs       | 670-830          | gingival hyperplastic lesions removal, cancer of Oral cavity and hemangioma |
| InGaAs     | 840              | gingival hyperplastic lesions removal, cancer of Oral cavity and hemangioma |
| KTP        | 532              | removal of oral lesions |

3. Result and Discussion
A laser application in periodontics are shown in Figure 1. The most commonly used lasers in periodontics are Er: YAG and He-Ne laser.
Figure 1. The laser applications in periodontics

The laser applications in endodontics are shown in Fig. 2. The most commonly used laser in endodontics is Co2 laser.

Figure 2. The laser applications in endodontics

The laser applications in Prosthodontics are shown in Fig. 3. The most commonly used lasers in Prosthodontics are diode laser.

Figure 3. The laser applications in prosthodontics

The laser applications in orthodontics are shown in Fig. 4. The most commonly used laser in orthodontics is Er: YAG laser.

Figure 4. The laser applications in orthodontics
The laser applications in oral are shown in Fig. 5. The most commonly used laser in oral is Co\textsubscript{2} laser.

![Lasers in oral](image1)

Figure 5. The laser applications in oral

The laser applications in pediatric are shown in Fig. 6. The most commonly used laser in pediatric is Er: YAG laser.

![Lasers in pediatric](image2)

Figure 6. The laser applications in pediatric

This study showed that Erbium: YAG (2940 nm) has an active medium of a solid crystal of yttrium-aluminum garnet doped with erbium. This device has wide uses in most dental treatments which produces sharp and clean margins during treatment. Because the penetration depth of a wavelength of the laser is less, so the damage is minimal. Because the laser has an anesthetic effect, pain relief is not routinely referred to in most patients. The laser also helps remove internal toxins from the root surfaces of the tooth, providing a counter-effect to microbes. This laser is convenient for patients as the vibration of the laser is less severe than the traditional high-speed hole. Thus, this is less likely to cause discomfort during exercise or pain [82, 100].

4. Conclusion

Great efforts have been made in the search for new laser applications in dentistry. In the past few years, many studies have been developed to study the laser mechanism. However, the evidence produced by this research cannot prove that laser therapy was much better than conventional therapies. He suggests that more clinical trials should be conducted, focusing on standardization, improvement and long-term follow-up of many laser techniques. There are other problems for future research. Improved lasers to provide better access to dentistry. In addition, laser therapy deserves full attention, because it has greater efficiency and less harmful effects. The laser is relatively new and used as an adjunct or alternative to conventional mechanical processing. Improvements in the design of laser equipment are necessary to enable the realization of these diverse technologies in an appropriate time frame, the low-cost laser
properties make the future of laser applications augur well [5-9].

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