Introduction to laser dentistry: part one

In the first of a series of articles, Arun and Rita Darbar explain how lasers can be used beneficially in many aspects of dentistry.

Lasers in dentistry today create unique opportunities for the development and application of new technologies. It is hard to imagine that simple photons can change the way in which we practice, from diagnosis and treatment to pain management. The many advantages of using lasers are hard to ignore, such as precision, ease of use and improved outcomes over conventional methods. However, a comprehensive understanding of the modality is imperative to avoid damage and reap the benefits of this technology. There is abundant evidence based research that supports this article. We would encourage any dentist interested in introducing a laser into their practice for the first time, to read this research to help better integrate this new technology into their offices.

Background
Lasers are used today in everyday life from barcode readers, to robotic surgery, to detection of life on Mars. The word laser is an acronym for ‘Light Amplification of Stimulated Emission of Radiation’. Laser light does not exist in nature and is man made. In 1905, Albert Einstein wrote his first paper describing the photoelectric effect where he came up with the idea of a photon that creates laser light. The main difference between ordinary and laser light is that laser light is monochromatic, coherent and collimated whereas ordinary light is multicoloured, the waves are not synchronized and is scattered.

History of dental lasers
In 1960 Theodore Maiman built the first functioning laser using a synthetic ruby crystal medium to produce laser light at 694 nanometers (nm) wavelength in the red region of the electromagnetic spectrum. Even though many physicists were skeptical of his discovery it did however escalate the development of lasers with varying wavelengths, most of which are currently used in dentistry today. Dr Goldman was the first physician to report laser exposure to a vital human tooth and this was used on his brother who was a dentist! A pulsed ruby laser was used (Goldman et al, 1965). All the earlier experiments were with the ruby lasers, Stern 1974, observed that under specific parameters of exposure with a ruby laser there occurred an increased resistance to acid penetration into...
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enamel and suggested a possible role in caries prevention. Unfortunately, the rise in pulpal temperature led to pulp necrosis which was unacceptable. The first dedicated dental laser was developed by Terry Myers in 1989, an Nd: Yag with a wavelength of 1064nm. It is believed that if this was the first wavelength used in dentistry we would now be using lasers routinely.

Numerous lasers have come on the market since and whereas the earlier units were expensive, bulky and had one dedicated wavelength, today they are affordable, small, portable, mains and battery operated and can have dual wavelengths. Almost a decade ago we were invited to work with the research and development team to convert a soft tissue laser for use as a low level unit with diffusers thereby widening the scope of a diode laser for the relief of pain and for regeneration (Mester et al 1971).

Optical properties
The wavelength of laser light is measured in nanometres (nm). The wavelength is tissue specific and the tissue interaction is dependent on the reaction between the specific wavelength and the optical properties of the tissue. In human tissue the laser light is absorbed by components such as water, hemoglobin, melanin, hydroxypatite, porphyrins, flavins etc. When a laser light contacts tissue it can be reflected, absorbed, transmitted or scattered. Depending on the photon density used lasers can be photodestructive, photothermic or photobiomodulative. Hence, with the lasers available today we are not only able to diagnose disease (Alfano 2002, Brancoleon et al 2001), remove diseased tissue, but to weld tissue (Bass and Treat 1996, Reiss 2001) and help with the regeneration. Currently, lasers in dentistry are widely used in Diagnosis and Treatment, which can be all laser or laser assisted.

Diagnosis
Optical imaging is fast becoming a reliable tool for diagnosis and utilises these properties and that of fluorescence for diagnosis and treatment of disease. Most imaging techniques used today are focused on anatomical structures whereas biomedical imaging focuses on the cellular level making it possible to detect disease in the early stages (Gillenwater et al 1998). An example is the use of blue light by the Velescope to improve visualisation of the oral mucous membrane to detect early signs of dysplasia. A red light 690nm laser is used with a feedback mechanism, using fluorescence through enamel and dentine and with a reflective probe giving an analog or digital score, for dental caries detection e.g. Diagnodent.

Therapeutics
Recent developments in Photodynamic Therapy uses a laser light with a photosensitive dye to activate the formation of singlet oxygen for its bactericidal effect (Henderson 1992) in peri-odontal pockets and in the root canals. This has now been extended for use in peri-implantitis.

The most commonly used lasers in dental practice today are diodes. These are soft tissue only lasers and generally have wavelengths between 810nm-1064nm. They can be used for haemostasis, incision and excision of soft tissue for indications including crown lengthening, sulcular debridement, troughing before taking an impression, fraenectomy and implant recovery. Due to their high absorption in haemoglobin it makes them very effective for coagulation. Their affinity for water also makes

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Other Rod lasers:
- Ruby
- Alexandrite

Figure 3: Types of lasers in dentistry

Figure 4: Schematic representation of tissue fluorescence
Normal (healthy) tissue fluorescence
• Shining an excitation light on the tissue causes it to emit fluorescence
• Colour is characteristic of the combination of the fluorophores in the tissue

Figure 5: Schematic representation of tissue fluorescence
Abnormal tissue fluorescence
• Changes in tissue fluorescence can help determine areas where molecular/structural changes have occurred
them effective for tissue ablation. The diode is set to compete with the electro-surgery unit as it has the additional benefits of being compatible to use around metal and the additional uses such as periodontal application (Aoki et al 2008), desensitisation (Ladalardo et al 2004), tooth whitening, treatment of TMD (Pinheiro et al 1998) and ulcers. The flexibility of the fibre also makes it useful for those hard to reach areas like the root canal (Gutknecht et al 2004) and periodontal pockets. We must not forget the advantages for the patients experiencing less pain and better healing compared to purely a hot knife.

There is a paradigm shift when using the diode laser as the tip can be in contact or non-contact. The laser can be initiated or uninitiated depending on the procedure to be performed. The beam can be focused or defocused, it can be in a continuous mode or a pulsed mode (and/or gated modes) and today we are looking...
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Figure 18: Crown lengthening or gingival recontouring preop

Figure 19: Temporary crown in place

Figure 20: Tissue at prep site well maintained

Figure 21: Definitive long-term restorations in place at fit appointment

Figure 22: Unerupted canine soft tissue exposure preop

Figure 23: Soft tissue exposure immediate postop

Figure 24: Canine eruption at 10 day review. Post op

Figure 25: Irritation fibroma preop

Figure 26: Fibroma stabilisation

Figure 27: Fibroma excision site immediate post op

Figure 28: Painful traumatic ulcer pre op

Figure 29: Healed ulcer site

at super pulsed and micro second pulsing. A clear understanding of the effects of each will determine the energy delivered to the tissue.

‘The Erbium family’
These include the Er:Yag-2940 nm and ER,Cr:Y.S.G.G. 2780 nm—both are typical hard tissue lasers with a high affinity for water and hydroxyapatite. They can also be used as soft tissue lasers. They are similar in action with slight variation in absorption characteristics but in practical terms appear to have similar properties. The concentrated laser energy in the water content leads to mini explosions thereby ablating hard tissue like enamel and dentine. As the tips are end cutting, the most efficient cut is at about 90 degrees to the tooth surface to be removed.

Another added benefit is that the smear layer is removed (Takeda et al 1999) which would increase the bond strength to the tooth structure and the cavity preparation is disinfected. Patients also report less or no pain during the procedure which reduces the need for a local anaesthetic which could be attributed to the non contact mode as pressure from the high speed turbine affects the hydrostatic pressure in the dentinal tubules resulting in pain (Charoenlarp et al 2007).

This wavelength is also suitable for soft tis-
Dermatology the uptake in Dentistry remains slow. This could be attributed to the cost, however this is now comparable to other technologies used in dental practices and since the development of diode lasers a very affordable entry-level option. Adequate training is the key for successful integration of lasers into any general or specialist dental practice.

The next article will discuss the properties of light and how low level lasers are used today in medicine and dentistry. This will be followed by hard and soft tissue applications with tips on how to adjust parameters to get consistent and predictable results.

References
Reiss, S. M., Laser Tissue Welding: The leap from Lab to the Clinical Setting. Biophotons Int. 2001:36-41

Figure 30: Herpetic cold sore chronic sufferer
Figure 31: Herpetic lesion two days later
Figure 32: Healed site few weeks later