EDITORIAL

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Are lasers justified in everyday clinical dental practice?

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At first sight, such a question would seem somewhat irrelevant and outdated; it is 30 years since, as a Private Practitioner I purchased the first "dental" laser in 1989 – the year of its launch. It is well-known that much of the dissatisfaction shown towards adjunctive laser technology in the 1990s was due to the fact that this pioneering laser, as a soft tissue laser drawing its pedigree from ophthalmic use, was ill-suited to perform a valued benefit to the dentist in treating dental decay and restorative treatment in general [1].

Within a General Practice setting, the challenge exists to examine, identify, diagnose and treat oral disease processes, with minimum collateral damage. Such a challenge is met often in the presence of an anxious and sceptical patient, the greater concern with whom exists the avoidance of pain, disfigurement and aesthetic acceptance of the result of treatment. From a medico-legal perspective, the potential for collateral damage – so called iatrogenic damage – is heightened when the expectations of the patient are not met, or the treatment leads to unforeseen outcomes – a fractured marginal ridge or pulp death following excessive turbine use or bleeding, swelling, infection and scarring that may compromise a soft tissue surgical event with a scalpel and sutures. Aesthetic challenges such as harmonising the upper labial gingival margins within a proportionate smile envelope or gingival de-pigmentation, may place great stress on the clinician to deliver an ideal outcome. It is with such a background that various alternative therapies and modalities have been devised and developed over the years – air abrasion, electrosurgery and cryosurgery – and the "hi-tech" impact of laser technology that may capture the attention of the clinician; such was the case that brought me into the world of laser photonic energy – laser light!

Light is a form of electromagnetic energy and the particulate representation of light is the photon. Laser photonic energy is a definitive "pure" emission, a single wavelength, coherent irradiation that confers specific interaction with a chosen target as well as benefitting from high intensity due to light wave non-interference [2].

Individual lasers are annotated in much the same way as motor cars; we intuitively qualify our chosen car in terms of make, model, engine size, colour, etc and the many types of lasers within the scope of clinical dentistry deserve similar qualification, simply to help us identify the areas of treatment where such a laser may be of benefit. At worst, we may allow ourselves to denote certain lasers by a group name or to reference the technology behind its manufacture and it is common to see the word "diode", as though such generalisation may still be too wide. Instead, it should be acknowledged that each laser has an emission wavelength, a specific emission mode (type of wave delivery) and perhaps a maximum power output value; a "5W, diode 810nm, CW" laser, or a 10W, Er:YAG 2940nm, FRP" laser – irrespective of a full explanation of terminology, allows a detailed appreciation of the laser that might be considered for soft or hard oral tissue management.

Human light appreciation is represented by a narrow band-with of wavelengths, capable of detection by the retina; from "blue" to "red" colour limits, the visible spectrum is but a tiny representation of the electromagnetic spectrum which , for our appreciation of lasers, further extends from the ultraviolet to far infra-red limits. Within such a range, the many lasers currently available for dental use occupy placings that are determined by virtue of their emission wavelength [3].

Omitting mind-numbing physics, it is sufficient to note that the discerning basis of light wavelength is its inverse proportionality to photonic energy; shorter wavelengths have higher photonic energy and there is a linear reduction in energy with ascending wavelength values. In short, blue light has higher energy than red light. Energy is fundamental to life and the component atoms and molecules of human tissue, like other non-human structures remain in a constant "ground state" energy configuration – a combination of atomic vibration and molecular spin, essentially unique for each but within the limits of normal homeostasis [4]. The basis of laser light production is that atoms of the laser host material, known as the "active medium", when energised may absorb such external energy and adopt an essentially unstable form. The applied energy will be re-emitted in the form of a photon of light, whose energy – unique for each different atom – will correspond to a unique emission wavelength. Successive photon emission with the laser active medium, amplified back and forth through further photon-atom collision, defines the coherent nature of the laser beam.

Laser-tissue interaction draws upon the concepts outlined above. Incident laser photonic energy of a chosen wavelength has a potential for absorption by a tissue component, termed a chromophore. Individual chromophores – tissue water, haemoglobin, melanin, collagen, hydroxyapatite and carbonated hydroxyapatite, represent the most common chromophores capable of interacting with the range of laser wavelengths available in dentistry. Laser energy when applied to a target tissue, may behave in one of four basic ways: there may be transmission of the beam through the tissue without any interaction; there may be reflection of the beam across the tissue surface, again without interaction; a degree of interaction may occur and the beam is scattered as it passes into the sub-surface region of the tissue; or the light may be absorbed by the tissue and photonic energy converted primarily into heat[5].

Photonic bombardment and consequent heat build-up around 60 deg. C may cause tissue protein to denature; at 100 deg. C water vaporisation may lead to tissue disruption and vaporisation and temperature rise above 200 deg. C may lead to carbonisation.

Within this range, it may be appreciated that a choice of correct laser wavelength may target specific and ideal chromophores and that the process of heat-mediated tissue change (termed photothermolysis) may be controlled to achieve a predictable surgical outcome.

Exposure of oral and dental tissue to laser energy will offer a potential mixture of interaction, owing to the complex and anisotropic nature of the tissue. Notwithstanding, such potential for any absorption will result in energy conversion to heat and some thermal rise. The greater the incident laser power, the higher the temperature rise and, considering the level of thermal rise above which some permanent disruption of the tissue will occur, such a level can be seen as the ablation threshold for that tissue. In applying incident laser photonic energy that exceeds the ablation threshold, the resulting change may include protein denaturation, water vaporisation and tissue carbonisation – all examples of photo-thermolysis [6]. At a molecular level this may induce effects including photoelectrical, photomechanical, photofluoresecent, photo-magnetic, photochemical and photothermal change. Such action may be utilised as an adjunct to tissue cutting, heat-induced blood coagulation and, with bone and dental hard tissue an explosive dislocation of the crystalline structure due to water vaporisation and consequent bone removal and dental cavity preparation.

Where a laser photonic energy level is of a lower level, the tissue ablation threshold may not be reached; in consequence, a lesser amount of tissue warming may occur and the penetration of photons deep into the soft tissue – a phenomenon readily seen with near infra-red and some visible wavelengths – may stimulate cellular and intracellular structures as well as biochemical and immune pathways associated with tissue repair and healing [7]. Stimulation of these structures by sub-ablative laser photonic energy constitutes a wide-ranging combination of some stimulation (endothelial cellular budding associated with healing), some inhibition (suppression of pain pathways) and overall a promotion of "feel good" factors that collectively is known as photobiomodulation (PBM) [8] .

In addressing the question of justified use, it may be intuitive to compare laser-mediated soft tissue management with a scalpel and hard tissue lasers with a rotary handpiece. Without doubt, dentistry is evolving from gross tissue management to more interceptive micro-management, from multi-surface tooth cavity preparation and potentially weakened support for extensive restoration, to small, non-Blacks non-classical cavity design, utilising micro-retention techniques and bonded composite restoratives. Laser-assisted tooth cavity preparation may be judged as less injurious to the tooth compared to the gross cutting and vibration of high-speed rotary instruments and the less-aggressive interaction may pre-dispose to less discomfort and a pain-less experience for the patient. Equally, soft tissue management, either as an adjunct to tooth restoration or as a basis for aesthetic improvement of the "smile line", can prosper through the capacity of laser photonic energy to create incisional haemostasis, to obviate the need for sutures and dressings and even harmonise surgical hard and soft tissue management within the same appointment. With such advantage, the repertoire of minor soft tissue surgery may be greatly expanded to include fibroma removal, frenectomy, gingival de-pigmentation and benign pathology.

Increasing investigation into the effects of photobiomodulation as induced by sub-ablative laser irradiation – either as a by-product of a laser-assisted surgical procedure or as a monotherapy to address and influence surface or deep tissue inflammation, neuropathy or pathology – has greatly extended the usefulness and potential for laser use in dentistry [9-13]. Photobiomodulation has been shown to reduce post-surgical pain and influence the speed and acceptance of orthodontic tooth movement. With growing awareness of this significant benefit of non-surgical laser use, the ability of the dental clinician to expand and develop new areas of therapy may be augmented [14-15].

Laser-induced photochemistry has allowed the clinician to expand tooth-bleaching techniques and laser photodynamic therapy, matching suitable photosensitisers to chosen incident laser wavelengths has greatly influenced the antibacterial offence within the periodontal pocket and peri-implant soft tissue defect [16].

Throughout the 1990s the "turf wars" of competing laser manufacturers spawned research into areas such as significant microbial reduction, uneventful healing, reduced para- and post-operative discomfort and operating speed and precision, each claiming superiority of their laser wavelength; unfortunately, a woeful lack of laser operating parametry and technique together with a predominance of case reports and in-vitro studies, introduced a significant lack of consistency and reproducibility, resulting in disappointment within the clinical setting. The paucity of structured education and certification meant that often the new laser user was condemned to self-teach – a necessity that greatly affected the progress along a learning curve and often led to discontinued use or instances of avoidable clinical negligence.

In latter years, the access to accredited education in laser dentistry has undergone considerable improvement. Organisations and societies have drawn upon the expertise of notable opinion-makers to deliver lectures and practical experience. A few universities in Europe – private as well as public universities – have developed structural and modular courses, leading to post-graduate Master-level degree courses during the past 10 years and the over-riding influence of the Internet in bringing research and distance-learning facilities, has greatly enlightened the first few steps that the new laser-user needs to take in acquiring the skills to fully integrate laser technology into their everyday clinical practice.

Above all, structured and meaningful evidence-based research into procedures and applications of laser photonic energy has undergone great improvement and direction; the acceptance of an ascending hierarchy of randomised clinical investigations, systematic reviews and meta-analyses over anecdote and case reports, is leading to a greater significance being offered through investigation standardisation among peer-reviewed publications [17].

Through this new-found discipline, the many claims of laser influence in clinical dentistry may re-establish reality over hyperbole and enable the clinician to fully-appreciate the wide usefulness of lasers in dentistry. The next frontier is to integrate laser dentistry as a modular component of undergraduate teaching and the author has developed course structure and clinical case exercises to enable the dental student to receive theoretical and practical education but also to demonstrate competency in a variety of clinical scenario. The only barrier to expansion of undergraduate teaching remains the willingness of the Institutions of Academia to adopt such technology as an integrated element of all forms of clinical armamentaria.

After almost 30 years, laser use in all areas dentistry may be viewed as fully justified and in many instanced, indispensable.

Conflict of interest: None to declare.

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