The Effect of an Er,Cr:YSGG Laser in the Management of Intrabony Defects Associated with Chronic Periodontitis Using Minimally Invasive Closed Flap Surgery. A Case Series

Rana Al-Falaki [1], Francis Hughes [2], Reena Wadia [2], Christie Eastman [3], Elias Kontogiorgos [4], Samuel Low [3]

1: Private Practice, London, UK.
2: Dept of Periodontology, Kings College London Dental Institute, University of London
3: Department of Periodontology, University of Florida, College of Dentistry
4: Department of Restorative Sciences, Baylor College of Dentistry, Texas A&M University

Aims: This is an extended case series of patients treated with an Erbium, Chromium: Yttrium Scandium Gallium Garnet (Er,Cr:YSGG) laser as an adjunct to scaling for the management of intrabony defects.
Materials & methods: 46 patients with 79 angular intrabony defects associated with pocket depths of >5mm, and a mean age of 53 ± 9 years presenting with chronic periodontitis were included in the analysis. All patients underwent a localized minimally invasive closed flap surgery utilizing Er,Cr:YSGG laser therapy. Final radiographs and pocket depths were compared to pre-treatment measurements with a time period of 8 ± 3 months.
Results: Treatment resulted in significant overall pocket depth reduction. The mean pre-op probing depth was 8.1 ± 1.9mm, reducing to 2.4 ± 0.9mm post-treatment. Bony infill of the defects was visible radiographically and there was an increase in overall radiographic coronal osseous height compared to a pre-treatment baseline. Radiographs of 15 of the defects were available for further measurements after >12 months, and showed in these sites there was a significant reduction in intrabony defect depth, but no change in suprabony bone height. 9 of the 15 sites showed 50% or more, bony infill of the intrabony defect.
Conclusions: The results demonstrate that the utilization of an Er,Cr:YSGG laser in a closed flap approach with chronic periodontitis may be of significant clinical benefit. Further studies using this laser surgical protocol are required to test these observations in well-designed randomized controlled trials.

Key words: Er,Cr:YSGG laser · root surface debridement · intrabony defects · bone growth · pocket reduction

Introduction

Surgical treatment for the management of periodontal pockets associated with intrabony defects can be challenging. Due to access, these defects often require surgical intervention, employing regenerative surgical techniques including barrier membranes, osseous graft material or application of a biologically active material. The alternative therapy is root surface debridement, which may have an unpredictable outcome with the exception of narrow three wall bony defects.

There has been increasing interest in the use of lasers for managing periodontitis including non-surgical root surface debridement and a range of surgical therapies, with minimal clinical trials to demonstrate

Addressee for Correspondence:
Dr Rana Al-Falaki BDS, MFDS RCSI, MClinDent, MRD RCS (Eng)
Specialist In Periodontics
Al-Fa Perio Clinic, 48A Queens Road, Buckhurst Hill, Essex IG9 5BY
Tel: +44 208 506 0701 e-mail: info@al-faperio.co.uk

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efficacy. The Nd:YAG has shown improvement in periodontal clinical trials with clinical parameters including a histologic assessment. [1, 2, 3)]. The Er:YAG laser has been proposed as an alternative or adjunct to conventional mechanical periodontal therapy. Randomized clinical trials of these wavelengths for managing periodontitis have shown mixed advantages over conventional flap treatment. [4, 5, 6, 7)] There are few studies that have evaluated the use of the Er,Cr:YSGG water-cooled laser [8, 9)].

The objective of this case series was to report on, and develop a retrospective analysis of the effectiveness of utilizing an Er,Cr:YSGG laser as a minimally invasive surgery procedure to manage periodontitis associated with intrabony defects.

Materials and methods

Forty six patients (31 females and 15 males) with an age range of 35 to 76 and a mean age of 53 years, with a clinical diagnosis of localized or generalized moderate to advanced chronic periodontitis were eligible for inclusion in this analysis. Full mouth periodontal probing along with peri-apical radiographs utilizing a paralleling technique was completed at a baseline appointment. No exclusions were made based on nicotine use, or medical history. None of these patients had been treated with adjunctive antibiotics. 7 patients were smokers, and 39 non-smokers. Informed consent for the use of an erbium laser in this procedure was obtained.

Patients with at least one angular intrabony defect, related to a probing depth of at least 5mm, received a combination of conventional root surface instrumentation, followed by an Er,Cr:YSGG laser application for a total of 79 defects. For the surgical procedure, 2% lidocaine hydrochloride solution with 1:80,000 adrenaline local anaesthetic was administered to achieve both tooth and soft tissue anaesthesia. Supra- and subgingival debridement was carried out using ultrasonic power driven instrumentation. The respective periodontal sites were treated with the Er.Cr:YSGG laser using a 14mm, 500 micron radial firing periodontal tip (RFPT5, Biolase, Irvine, CA, USA). The settings used were the following: power 1.5W, frequency 30Hz, 20% water, 11% air, H (short pulse – 60us) mode. The tip was inserted into the base of the pocket maintaining an angle parallel to the long axis of the root in sweeping motions both in a vertical and horizontal dimension until no granulation tissue was noted exiting the pocket, as shown in **Figure 1**.

Intrabony defects were managed by utilizing the radial firing periodontal laser tip as described above and inserted into the pocket until it touched osseous structure and was then withdrawn slightly. It was moved in a similar fashion with the same settings, until no further granulation tissue was noted as being flushed out of the pocket. A curette was used to degranulate along the bony walls of the defect. The laser tip was then re-inserted in the pocket, using the same setting except an altered frequency of 50Hz. Again, the tip was moved slowly, and angled parallel to the root surface, and then towards all the osseous levels surrounding the root. The tip was placed outside of the periodontal pocket parallel to the tissue to remove the epithelium surrounding the tooth by a distance of at least 5 millimeters from the gingival margin. This was seen visibly as white mottled tissue.

Patients were advised to commence normal brushing the following day post-operatively and to use the appropriate sized interdental brushes with no post-operative rinse or medicament. No occlusal adjustment was carried out and no adjunctive antibiotics were utilized.

Periodontal probing reassessment was performed at 5 to 8 months. Peri-apical radiographs (paralleling technique) were repeated on those sites with intrabony defects at the same visit.

Operator, examiners, and exclusions

The same periodontist (RAF) performed the initial charting and reassessment of periodontal pockets to the nearest millimeter (mm) using a 15mm UNC probe. The radiographs taken before and after treatment were done using standardized film holders and radiographic units. The same respective operator performed all of the laser surgical procedures in private practice.

A second blinded examiner (RW) performed the radiographic assessment. Pre- and post-operative radiographs for each intrabony site were placed side by side on a black viewing background. Due to the non-standardization of radiographs taken, gain in bone height was measured as a ratio of root length. This analysis of relative bone height within the defect was carried out by measuring root length from CEJ (or reproducible tooth coronal landmark as a restorative margin) to the most identified coronal extent of bone height on the root surface (shown in **figure 2**). Analysis of each pair was performed and recorded for statistical analysis.

A further 15 radiographs were available for analysis after more than 12 months, and the same measurements were repeated to measure both increase in linear bone height and percentage bone fill (FJH).

Results

Patient demographics consisted of 46 patients and 79 total defects to undergo analysis. In all cases, healing was uneventful, with no post-operative infections, administration of antibiotics, or other adverse events. Some patients reported temperature sensitivity, mild soreness or discomfort on brushing, or use of analgesics for the first few days.

Pocket depth reductions of the intrabony defects are shown in **Table 1**. The mean probing depth before treatment was 8.1 ± 1.9 mm (range 5 to 14 mm) and following surgical laser therapy 2.4 ± 0.9mm (range 1 to 6mm) demonstrating significant reduction ($p < 0.001$). **Figure 3** shows the mean probing depth for each patient before and after treatment.

Radiographic analysis of baseline and final images also demonstrated an improvement of osseous apposition from 1.1 ± 0.4 to 0.9 ± 0.4 units respectively as measured from the CEJ to the coronal aspect of the osseous levels. ($p < 0.001$).

An additional analysis was performed of the radiographic findings to demonstrate a gain in bone height. The difference between baseline and post surgery (5-8 months later) provided the descriptive stats and 1 sample t-test to explore if this difference was different from zero. These measurements are a ratio, and do not have a value (e.g. millimeters). Therefore, one can multiply by 100 and demonstrate a gain in bone height by 19% ± 28% ($p<0.001$). More interestingly, despite the small increase in bone height, the bony infill of the defects visible radiographically is marked in all cases. **(Figure 4)**.

From the measurements of the small sample of patients that had more than one year follow-up radiographs, in these sites there was a significant gain in linear bone height within intrabony defects (18±11% of root length) but no change in suprabony bone height. 9 of the 15 sites showed 50% or more bony infill of the intrabony defect (as shown in **figure 6**), with the serial radiographs showing continued bone fill over time (as shown in **fig 7**). One patient (number 7) showed an initial increase in bone fill within the defect in the first 5-8 months, followed by subsequent deterioration and loss of bone, which could not be explained clinically given that the pocket remained healed.

Discussion

Most previous studies reported on the use of lasers in periodontal therapy have mainly investigated diode, Erbium: Yttrium Aluminium Garnet (Er:YAG) and Nd:YAG lasers [5, 6, 10, 11, 12, 13]. However, the Er,Cr:YSGG laser has had few studies in the field of periodontology, and on occasion has been grouped together with the Er:YAG laser due to having similar wavelengths and both having hard and soft tissue targets.

In previous clinical studies with Erbium lasers, the findings have varied both in efficacy and superiority over conventional scaling as a treatment modality. Several studies seem to imply the use of adjunctive laser treatment leads to a prolonged stability, with less bleeding on probing, higher CAL gain, and less recession one and two years post-operatively [8, 14]. Conversely, no significant advantage was reported in other studies [4, 10]. The use of Er,Cr:YSGG has also been compared to conventional surgery (open flap

Table 1: Probing Depth and Radiographic Bone Height for Pre- and Post-operative (5-8 months later) assessment

	Pre-operative Probing Depth (mm)	Post-operative Probing Depth (mm)	Pre-operative Bone Height	Post-operative Bone Height
Mean ± SD	8.1 ± 1.9	2.4 ± 0.9	1.1 ± 0.4	0.9 ± 0.4
Median	8.0	2.0	1.0	0.9
Interquartile Range	2.0	1.0	0.6	0.6
Minimum	5.0	1.0	0.3	0.2
Maximum	14.0	6.0	2.7	2.3
Wilcoxon Signed Ranks Test (α =0.05)	P≤.001		P≤.001	

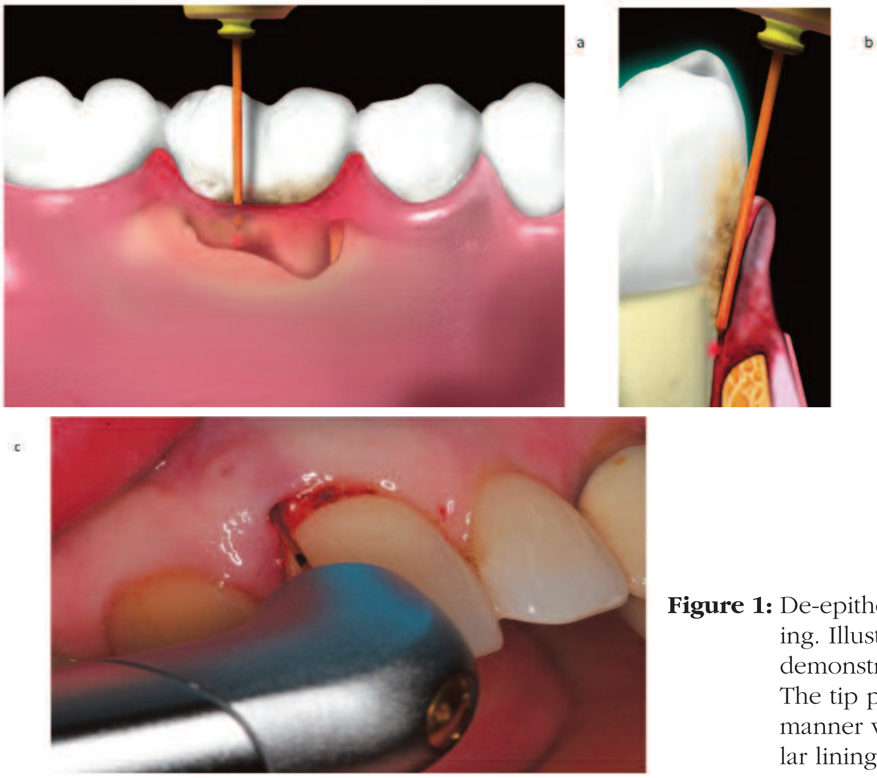

Figure 1: De-epithelialization of diseased sulcular lining. Illustrations (a,b) and clinical photo (c) demonstrating radial firing tip placement. The tip provides energy moving in a lateral manner with the target being both the sulcular lining and the root surface.

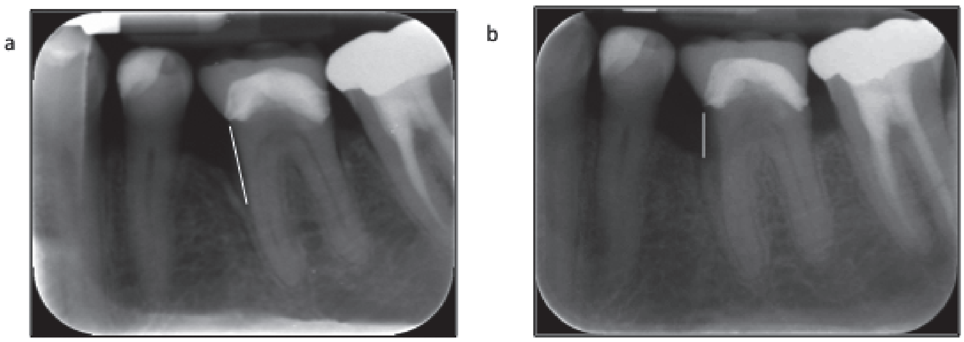

Figure 2: Measuring a fixed point to the most coronal osseous level at baseline (a) and the most coronal osseous level at the post laser surgery evaluation (b).

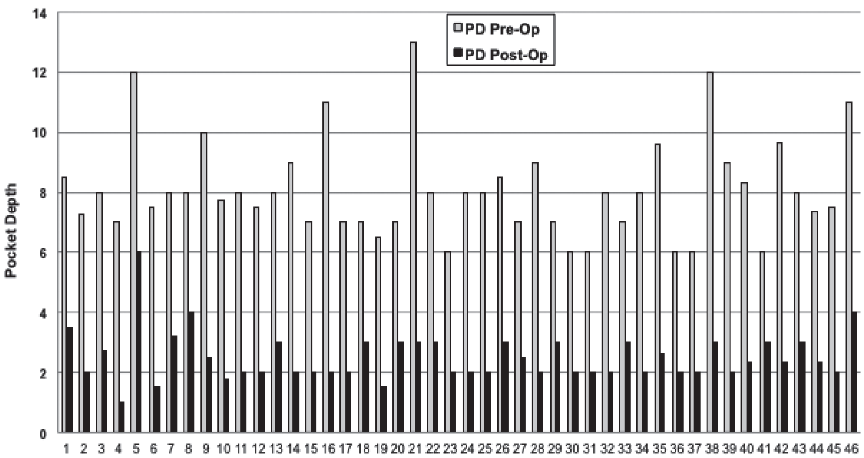

Figure 3: Mean pocket depth measurements (mm) of infrabony pockets for all 46 patients pre- and post-operatively (5-8 months later).

debridement) and found to achieve similar CAL gains, but with less gingival recession. [9]

A systematic review by Karlsson et al., [15] based on studies that looked at the effectiveness of laser therapy as an adjunct to non-surgical periodontal treatment in subjects with chronic periodontitis was only able to use 25 abstracts and 4 randomised controlled clinical trials, all using different laser methods, and therefore making it impossible to conduct a meta-analysis. The conclusions to most studies suggest the need for more

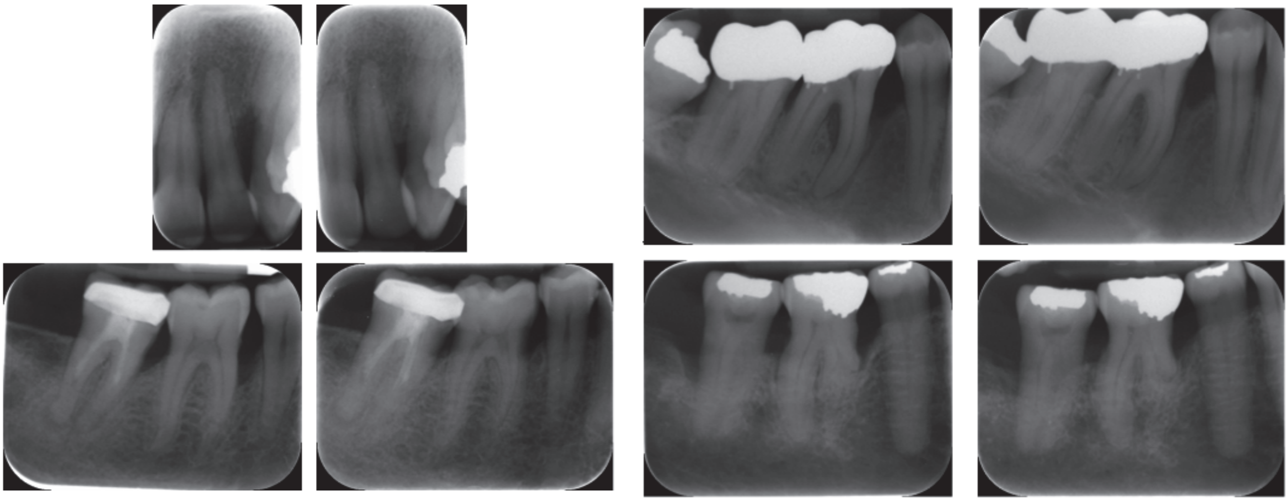

Figure 4: Paired radiographs pre-op (on left) and post-op (on right) showing evidence of radiographic osseous fill of intra-bony defects 8 months following treatment.

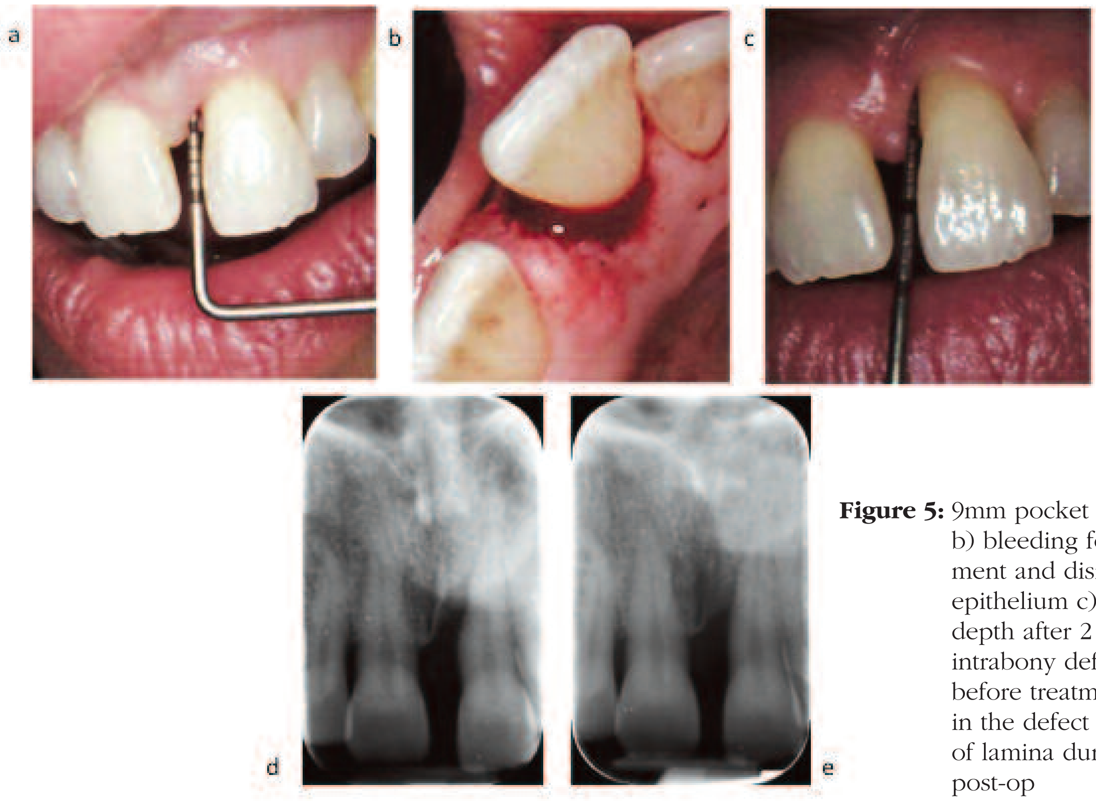

Figure 5: 9mm pocket before treatment b) bleeding following treatment and disrupted outer epithelium c) 2mm probing depth after 2 months d) wide intrabony defect on mesial before treatment e) bone fill in the defect and formation of lamina dura 8 months post-op

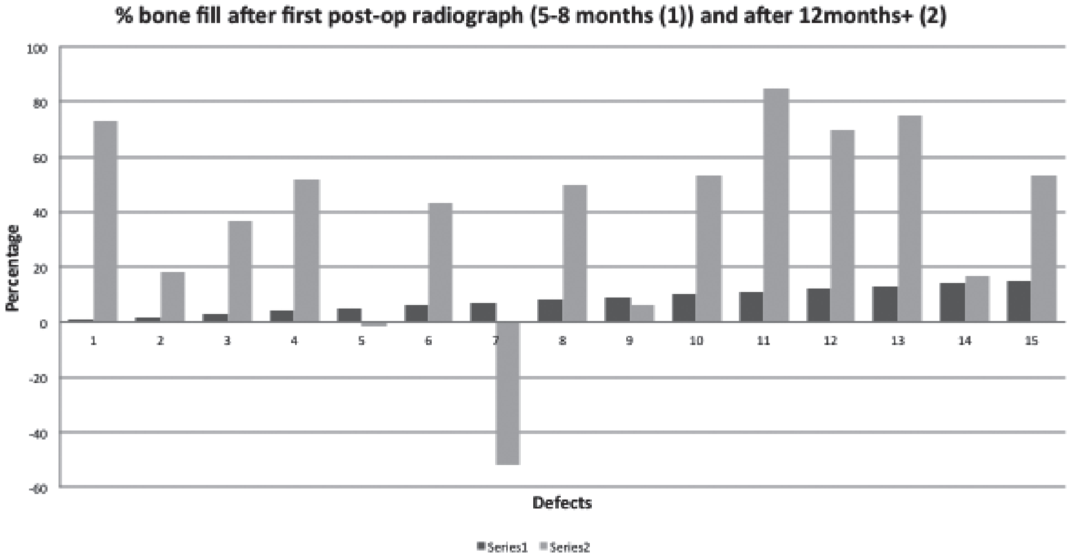

Figure 6: Percentage bone fill in each defect at first post-op of 5-8 months (1) and subsequent post-op > 12 months later (2)

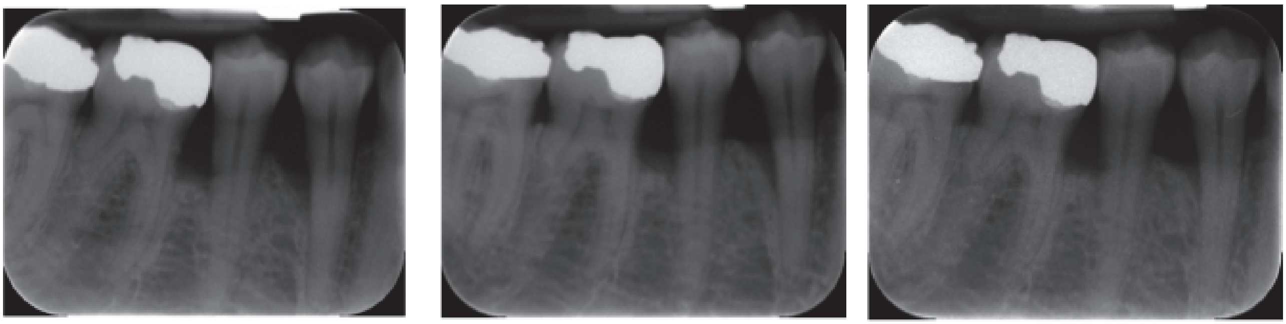

Figure 7: Serial radiographs of one case taken at baseline, 8 months later and 18 months later, showing continued bone fill in the defects over time.

clinical trials. Individual reports are of similar results to traditional methods, but until there is a larger science base, this can only be termed anecdotal.

The possible reasons why adjunctive flapless laser therapy might result in improved outcomes similar to conventional therapy might include improved root surface debridement and removal of pocket granulation tissue. Studies *in vitro* have reported that the Er,Cr:YSGG laser is effective in the removal of biofilm, smear layer, root surface endotoxins, infected cementum and calculus [16, 17, 18]. Some studies have found this laser to be as effective as manual and power scalers, without causing damage to the root surface, both in terms of morphological changes such as cracks and thermal damage as melting or carbonisation. It has been postulated that the removal of the epithelial lining, as advocated in the manufacturer's protocol may also have a role to play in the effectiveness seen by delaying epithelial down-growth during pocket healing [9]. Of course, without histological evidence, one cannot confirm if all the epithelium is removed, and hence described as a disruption in the epithelium in this study. Animal studies have also suggested that the Er,Cr:YSGG laser energy may also have a direct stimulatory effect on bone healing through gene regulation and cytokine production [19]. All of these actions could perhaps be plausible mechanisms for the changes seen in this extended case series. Aoki [20] describes a minimally invasive surgical technique called laser-assisted comprehensive periodontal pocket therapy (LCPT), using an Er:YAG laser. This protocol has similar steps to the ones used here, including use of the laser to remove outer epithelium, pocket epithelial lining and diseased connective tissue, down to bone, with the use of a curette on bone to aid this latter stage; laser-modification of the root surface, along with detoxification, removal of smear layer and calculus; stabilisation of a blood clot, and some low level laser effects resulting in biostimulation [21, 22, 23)]. Likewise, similar steps, incorporating laser-tissue interaction on the soft tissue are relayed in the laser assisted new attachment protocol (LANAP), using an Nd:YAG laser. This procedure also involves a first laser pass to remove inflamed pocket epithelium, while the calculus removal and bone decortication is carried out with other instruments. A second laser pass is then carried out which helps to stabilise the blood clot, and due to the more deeply penetrating effects of the Nd:YAG, the biostimulatory effect is one of the plausible mechanisms for the regeneration seen using this protocol [1, 2, 3)].

In recent periodontal regeneration studies there has been great emphasis on the importance of wound stability and indeed the use of minimally–invasive surgical techniques using mini-flaps has been shown to result in equivalent regenerative outcomes even without the application of grafts and other regenerative materials [24, 25, 26)]. In the use of the laser described here, debridement and granulation tissue removal is carried out using a minimally invasive surgical technique, without raising a flap, assuming adequate wound debridement [14)].

The issues that seem to arise are that lasers have different wavelengths, might work through different mechanisms, use different tips for different procedures at different angles, and have countless different settings applicable, so it becomes very difficult to accumulate a good evidence base on best practice. One of the key requirements for future studies of laser applications is to identify the optimal parameters, which can profoundly influence therapeutic outcomes [27)]. One of these parameters that should be included is patient-related outcomes [28)]. The hypothesis that can be considered is that both traditional flap procedures and laser closed flap procedures may provide equivalent clinical results but closed flap procedures provide more patient acceptable outcomes as level of discomfort and reliance on analgesics.

As a retrospective analysis of an extended case series these results should be considered a low level of evidence for efficacy of adjunctive surgical laser treatment, but the outcomes are sufficient to warrant the need for proper randomised controlled studies of the Er,Cr:YSGG laser in the surgical and non-surgical management of periodontitis. An additional shortcoming of the retrospective study is not measuring clinical attachment levels thus some of the resulting improvement in pocket depth could also be from the respective recession, but unfortunately this data was not available for the whole group of patients. A radiographic stent could have been utilized to accurately measure change instead of paired non-standardized films. However, the films were analysed by a blinded examiner. These studies of measuring visible osseous levels can not take into consideration a level of increased radiopacity as can occur with subtraction radiography thus undermining a notation of true osseous fill and maturation. Moreover, the analysis may have demonstrated more osseous fill if the study had been carried out longer than the 5 to 8 month time frame, which was the case with a small sample of the patients.

This retrospective case series suggests that the use of the Er,Cr:YSGG laser for surgical treatment of periodontal pockets may be an effective adjunctive management for infrabony defects associated with chronic periodontitis. In future studies, there is a need to identify optimal protocols and parameters for use of Er,Cr:YSGG lasers in specific applications as these may profoundly influence therapeutic responses [27)]. In particular, further well-designed RCTs are required to investigate these findings under more rigorous test conditions.

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