Commentary

Is There Clinical Benefit From Using a Diode or Neodymium:Yttrium-Aluminum-Garnet Laser in the Treatment of Periodontitis?

Charles M. Cobb*

Despite a quarter of a century of laser research, there is a persistent debate regarding the efficacy of dental lasers in the treatment of periodontitis or periodontal maintenance therapy. There are many claims and much hyperbole surrounding the use of lasers, either as a monotherapy or adjunctive to scaling and root planing, to treat periodontitis. There is little evidence that using a diode or neodymium: yttrium-aluminum-garnet laser adds clinical value over and above conventional non-surgical or surgical periodontal treatment. There is a significant need for better designed human clinical trials. Data from such trials should be analyzed according to initial probing depth and characteristics of the treated sites, such as non-molar, molar flat surfaces, and molar furcations, and evaluated for long-term post-treatment results. J Periodontol 2016;87:1117-1131.

KEY WORDS

Lasers; lasers, semiconductor; lasers, solid state; periodontal diseases; periodontitis.

As the title implies, there is a persistent debate regarding the efficacy of dental lasers in the treatment of periodontitis or periodontal maintenance therapy. One would think that after 25 years of laser research the question of utility and effectiveness would have been answered long ago; sadly, such is not the case. Why does this profession find itself in this predicament? Could it be that dentistry refuses to accept the concept of evidence-based decision making? Is it simply a bad case of confirmation bias or possibly cognitive dissonance? Professionals trained in the science of dentistry should know how to read a published clinical trial, recognize the weaknesses, and determine whether the results can be extrapolated to specific patient populations. However, this evidently is not what happens once the peer review environment of dental school is left and private practice is entered. It is estimated that only 7% to 8% of all dental treatment is evidence based and that >60% of dentists turn to friends and colleagues for their evidence.[1] It should be obvious that decisions based on poor-quality data generally result in poor clinical outcomes,[2] and great short-term results do not always equate to good long-term results.

In July 2015, the *Journal of the American Dental Association* (*JADA*) published a systematic review with meta-analysis and evidence-based practice guidelines on the treatment of periodontitis by scaling and root planing (SRP) with and without adjunctive therapies.[3,4] Two of the adjunctive therapies considered in the meta-analysis were the diode and the neodymium:yttrium-aluminum-garnet (Nd:YAG) lasers. The laser-assisted new attachment procedure (LANAP)† protocol, which also uses an Nd:YAG laser, was not part of the systematic review or meta-analysis (a review of the strength of evidence regarding LANAP has been previously published[5]).The meta-analysis reported that, when used adjunctively with SRP, neither the diode nor the Nd:YAG lasers provides additional clinical benefits beyond that achieved by SRP alone.[3]

* Department of Periodontics, University of Missouri–Kansas City, Kansas City, MO.

† Millennium Dental Technologies, Cerritos, CA.

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A letter to the *JADA* editor published in the December 2015 issue illustrates the dissonance regarding lasers and periodontal therapy. In this letter, the author writes of "having trained thousands of dentists and dental hygienists over the past 20 years" and having received "only positive feedback as to the efficacy of laser adjunctive treatment." This should not be mistaken for evidence but simply hearsay testimony. The author continues, "Pocket decontamination with various wavelengths is the second most common procedure in general practice. Every laser manufacturer has had to show clinical efficacy and safety with specific power and pulse recommendations to the US FDA for marketing approval."[6] Does the author mean "approval" or "clearance"?

Given this background, a more analytical consideration of the evidence reveals some interesting results. To this end, an abbreviated summary of part of the evidence base for the two most commonly used lasers in private practice, i.e., the diode and Nd:YAG lasers, is presented.

FOOD AND DRUG ADMINISTRATION (FDA) APPROVAL VERSUS CLEARANCE

As evidenced by the author of the letter referenced above, there is confusion regarding what constitutes an FDA approval versus FDA clearance. Simply put, new technology is approved by the FDA using the premarket approval application process. Using the 510(k) process [Section 510(k) of the Food, Drug, and Cosmetic Act],[7] dental lasers are cleared as substantially equivalent to legally marketed dental lasers having the same laser light technology and same intended uses. This process requires only data showing safety of use; it does not require published clinical trials and/or related studies showing efficacy of treatment. In the commercial marketing of dental lasers, it is often claimed that a laser has received FDA 510(k) "approval." Such a statement is simply not true; the laser has been "cleared" for sale on the open market based on safety and nothing more. Consequently, because of this scenario, the generation of clinical research data regarding lasers in the treatment of periodontitis has trailed the commercial introduction of lasers to the practicing community.

THE DATA

For a more detailed analysis of the data reported in human clinical studies that use lasers to treat periodontitis, the reader is referred to a recently completed narrative review due to be published in late 2016.[8] The review found a total of 21 human clinical studies devoted to diode[9-28] and 18 devoted to Nd:YAG[29-46] lasers. These clinical studies covered the two decades between 1996 and 2015. The totals include both adjunctive use of the lasers with SRP and lasers applied as a monotherapy. In the case of the diode laser, only two of the 21 studies were published before 2004. For the Nd:YAG laser, three of the 18 studies were published before 2005. If one includes the photodynamic therapy (PDT) literature, zero of 41 human clinical studies were published before 2001. Consequently, anyone teaching the use of lasers for the past 20 years, i.e., from 1995 to 2015, was doing so during the first 5 of those 20 years with minimal to no research evidence in support of their message.

The soon to be published narrative review[8] considered all human clinical studies regardless of the level of bias detected in the study design. Tables 1 and 2 list only those studies in which the clinicians/examiners were both masked and calibrated, criteria that eliminate a significant portion of the original 21 diode and 18 Nd:YAG studies. Lack of calibration and masking of clinicians/examiners is a major reason for biased data and should be a red flag when evaluating reported results in a clinical trial.[47]

Table 1 shows only seven[16-19,23,24,28] of the 21 human clinical studies involving a diode laser that may be considered to be without bias. The summary of these seven studies shows that 236 patients participated in the studies (an average of 33.7 patients per study). When the study by Angelov et al.[16] was excluded (because it was concluded at 15 days and measured only bleeding on probing [BOP]), the average difference in initial probing depth (PD) between control and test sites was 0.13 mm. After treatment (SRP versus SRP + laser), the average difference in PD reduction was 0.13 mm at 3 months and 0.15 mm at 6 months, post-treatment average gain in clinical attachment level (CAL) was 0.13 mm at 3 months and 0.02 mm at 6 months, and the average difference in reduction in BOP was 6% at 3 months and 1% at 6 months. None of these average differences, regardless of clinical parameter, can be considered as clinically significant.[48,49]

Reductions in subgingival bacterial loads were insignificant because four[16,18,23,28] of the seven diode studies did not measure this effect. Of the remaining three studies, only one favored treatment by SRP + adjunctive laser, and two studies detected no significant differences between the test groups.

In a similar analysis, Table 2 lists a total of eight human clinical studies[35,37-39,42-44,46] that used Nd:YAG laser. Only those considered without study design bias are listed. A total of 239 patients were enrolled and completed these studies, yielding an average of ≈30 patients per study. The average difference in initial PD between control and test sites was 0.11 mm. The average difference in PD reduction between treatment groups (SRP versus SRP + laser)

Table 1.

Summary of Clinical Studies Using the Diode Laser (808 to 980 nm wavelength) in the Treatment of Periodontitis (clinician/examiner masked and calibrated)

Study	Length of Study	Examiner Masked/ Calibrated	C Versus T Treatment	No. of Patients	Mean Initial PD (mm)	Mean Reduction in PD (mm)	Mean Gain in CAL (mm)	Mean Reduction in BOP (%)	Reduction in Bacteria
Angelov, et al., 2009[16]	5 to 15 days	Yes/yes	C, SRP only	60	NA	NA	NA	70	NA
			T-1, SRP + 630 to 670 nm diode (1/day for 5 days)					90	
			T-2, SRP + 630 to 670 nm diode (1/day for 10 days)					94	
Kamma et al., 2009[17]*	6 months	Yes/yes	C, no treatment	30	6.20	3 months: 0.13 6 months: 0.13	3 months: 0.27 6 months: 0.27	6 months: NA	Significant reductions after SRP + laser for *Porphyromonas gingivalis*, *Tannerella forsythia*, *Treponema denticola*, and total bacteria at 6 months after treatment. Reported no difference in levels of *Aggregatibacter actinomycetemcomitans*.
			T-1, SRP only		6.47	3 months: 2.34 6 months: 2.34	3 months: 1.80 6 months: 1.87	6 months: 56	
			T-2, diode laser only		5.93	3 months: 2.00 6 months: 2.00	3 months: 1.94 6 months: 1.94	6 months: 61	
			T-3, SRP + 980 nm diode		6.67	3 months: 2.87 6 months: 2.80	3 months: 1.94 6 months: 2.14	6 months: 58	
Aykol et al., 2011[18]	6 months	Yes/yes	C, SRP only	36	4.04	3 months: 1.07 6 months: 1.22	3 months: 0.90 6 months: 1.10	NA	NA
			T, SRP + 808 nm diode		3.89	3 months: 1.38 6 months: 1.41	3 months: 1.10 6 months: 1.17		
De Micheli et al., 2011[19]	1.5 months	Yes/yes	C, SRP only	27	5.80	2.40	1.90	NA	No significant difference between C and T.
			T, SRP + 808 nm diode		6.20	2.10	1.20		
Zingale et al., 2012[23]	6 months	Yes/yes	C, no treatment	25	5.28	3 months: 0.89 6 months: 0.89	NA	3 months: 53 6 months: 62	NA
			T-1, SRP only		5.72	3 months: 1.59 6 months: 1.57		3 months: 71 6 months: 68	

Table 1. (continued)

Summary of Clinical Studies Using the Diode Laser (808 to 980 nm wavelength) in the Treatment of Periodontitis (clinician/examiner masked and calibrated)

Study	Length of Study	Examiner Masked/ Calibrated	C Versus T Treatment	No. of Patients	Mean Initial PD (mm)	Mean Reduction in PD (mm)	Mean Gain in CAL (mm)	Mean Reduction in BOP (%)	Reduction in Bacteria
			T-2, flap + SRP		5.80	3 months: 1.79		3 months: 62	
						6 months: 1.57		6 months: 71	
			T-3, SRP + 810 nm diode		5.82	3 months: 1.68		3 months: 80	
						6 months: 1.72		6 months: 65	
			T-4, SRP + laser + laser sealing		6.00	3 months: 1.91		3 months: 65	
						6 months: 1.62		6 months: 71	
Alves et al., 2013[24]	6 months	Yes/yes	C, SRP only	36	5.69	2.76	2.10	63	No significant difference between C and T.
			T, SRP + 808 nm diode (×2)		6.13	2.56	1.70	60	
Nguyen et al., 2015[28†]	3 months	Yes/yes	C, SRP only	22	5.86	0.91	0.68	25	NA
			T, SRP + 940 nm diode		5.68	0.93	0.53	28	
Summary and comparison of SRP only (C) versus SRP + laser (T)				236; $\overline{X}$ = 33.7	C, $\overline{X}$ = 5.60	3 months: $\overline{X}$ = 1.66	3 months: $\overline{X}$ = 1.32	3 months: $\overline{X}$ = 48	One study favored SRP + laser.
						6 months: $\overline{X}$ = 1.97	6 months: $\overline{X}$ = 1.69	6 months: $\overline{X}$ = 62	Two studies reported no significant differences.
					T, $\overline{X}$ = 5.73	3 months: $\overline{X}$ = 1.79	3 months: $\overline{X}$ = 1.19	3 months: $\overline{X}$ = 54	Four studies did not measure effect on bacteria.
						6 months: $\overline{X}$ = 2.12	6 months: $\overline{X}$ = 1.67	6 months: $\overline{X}$ = 61	
					Δ = 0.13	3 months: Δ = 0.13	3 months: Δ = 0.13	3 months: Δ = 6	
						6 months: Δ = 0.15	6 months: Δ = 0.02	6 months: Δ = 1	

C = control group; T = test group; PD = probing depth; CAL = clinical attachment level; BOP = bleeding on probing; NA = not applicable (the study did not measure this parameter); Δ = difference between groups.
* Aggressive periodontitis.
† Periodontal maintenance patients only.

Table 2.

Summary of Clinical Studies Using Nd:YAG Laser in the Treatment of Periodontitis (clinician/examiner masked and calibrated)

Study	Length of Study (months)	Examiner Masked/ Calibrated	C Versus T Treatment	No. of Patients	Mean Initial PD (mm)	Mean Reduction PD (mm)	Mean Gain in CAL (mm)	Mean Reduction in BOP (%)	Reduction in Bacteria
de Andrade et al., 2008[35]	1.5	Yes/yes	C, SRP only	17	4.80	1.90	0.90	NA	No significant difference between treatment groups in total CFUs or levels of *Pg*, *Pi*, and *Aa*, although both were significantly reduced versus baseline. Bacteria returned to baseline levels at 6 weeks.
			T, SRP + Nd:YAG laser		4.90	1.80	0.60		
Dilsiz et al., 2010[37]	12	Yes/yes	C, Flap surgery + EMD	21	7.30	6 months: 4.20	6 months: 3.20	6 months: 90.5	NA
						12 months: 4.30	12 months: 2.9	12 months: 52.4	
			T, flap surgery + Nd:YAG laser + EMD		7.30	6 months: 2.90	6 months: 1.60	6 months: 90.5	
						12 months: 4.00	12 months: 2.60	12 months: 90.5	
Qadri et al., 2010[38]	3	Yes/yes	C, SRP only	30	4.41	0.84	NA	NA	NA
			T, SRP + Nd:YAG laser		4.59	1.47			
Gómez et al., 2011[39]	2	Yes/yes	C, SRP only	30	4.47	0.89	NA	66	The study found no significant difference between treatment groups in levels of *Pg*, *Pi*, *Pm*, *Fn*, *Cr*, *Ec*, *Tf*, *Capnocytophaga* spp., *En*, and *Aa*.
			T, SRP + Nd:YAG laser		5.07	0.82		52	

Table 2. (continued)

Summary of Clinical Studies Using Nd:YAG Laser in the Treatment of Periodontitis (clinician/examiner masked and calibrated)

Study	Length of Study (months)	Examiner Masked/ Calibrated	C Versus T Treatment	No. of Patients	Mean Initial PD (mm)	Mean Reduction PD (mm)	Mean Gain in CAL (mm)	Mean Reduction in BOP (%)	Reduction in Bacteria
Eltas et al., 2012[42]	6	Yes/yes	C-1, SRP only (smokers)	52	5.40	C-1, 1.20	C-1, 0.10	NA	NA
			C-2, SRP only (non-smokers)		5.30	C-2, 1.70	C-2, 0.30		
			T-1, SRP + Nd:YAG laser (smokers)		5.40	T-1, 1.60	T-1, 0.30		
			T-2, SRP + Nd:YAG laser (non-smokers)		5.30	T-2, 2.20	T-2, 0.50		
Eltas et al., 2012[43]	9	Yes/yes	C, SRP only	20	5.05	3 months: 0.94	3 months: 0.88	NA	NA
						9 months: 1.32	9 months: 1.10		
			T, SRP + Nd:YAG laser		5.11	3 months: 1.92	3 months: 1.82		
						9 months: 2.49	9 months: 2.41		
Slot et al., 2012[44]*	6	Yes/yes	C, SRP only	30	5.46	0.85	NA	16	NA
			T, SRP + Nd:YAG laser		5.39	0.97		4	
Qadri et al., 2015[46]	3	Yes/yes	C, SRP only	39	4.41	0.84	NA	NA	NA
			T-1, Nd:YAG laser only		4.48	0.61			
			T-2, SRP + laser		4.44	1.48			
Summary and comparison of SRP only (C) versus SRP + laser (T)				239: $\overline{X}$ = 29.9	C, 5.15	1.5 to 3 months: $\overline{X}$ = 1.08	1.5 to 3 months: $\overline{X}$ = 0.89	C, $\overline{X}$ = 57.5	No study reported a significant difference between treatment groups.
						6 to 12 months: $\overline{X}$ = 2.02	6 to 12 months: $\overline{X}$ = 1.88		
					T, 5.26	1.5 to 3 months: $\overline{X}$ = 1.50	1.5 to 3 months: $\overline{X}$ = 1.21	T, $\overline{X}$ = 48.8	Two studies reported no significant differences.

Table 2. (continued)

Summary of Clinical Studies Using Nd:YAG Laser in the Treatment of Periodontitis (clinician/examiner masked and calibrated)

Study	Length of Study (months)	Examiner Masked/ Calibrated	C Versus T Treatment	No. of Patients	Mean Initial PD (mm)	Mean Reduction PD (mm)	Mean Gain in CAL (mm)	Mean Reduction in BOP (%)	Reduction in Bacteria
						6 to 12 months: $\bar{X}$ = 2.14	6 to 12 months: $\bar{X}$ = 1.78		
					Δ = 0.11	1.5 to 3 months: Δ = 0.42	1.5 to 3 months: Δ = 0.32	Δ = 8.7	Six studies did not measure the effect on bacteria.
						6 to 12 months: Δ = 0.12	6 to 12 months: Δ = 0.10		

C = control group; T = test group; PD = probing depth; CAL = clinical attachment level; BOP = bleeding on probing; NA = not applicable (the study did not measure this parameter); EMD = enamel matrix derivative; Δ = difference between groups; *Aa* = *Aggregatibacter actinomycetemcomitans*; *Cr* = *Campylobacter rectus*; *Ec* = *Eikenella corrodens*; *En* = *Eubacterium nodatum*; *Fn* = *Fusobacterium nucleatum*; *Pm* = *Parvimonas micros*; *Pg* = *Porphyromonas gingivalis*; *Pi* = *Prevotella intermedia*; *Tf* = *Tannerella forsythia*.
* Periodontal maintenance patients.

was 0.42 mm at 3 months and 0.12 mm at 6 months. The average difference in gain in CAL between treatment groups was 0.32 mm at 3 months and 0.10 mm at 6 months. The average difference in BOP after treatment was 8.7%. Here again, none of the average differences, regardless of clinical parameter, can be considered clinically significant. The reductions in subgingival microbial loads are not significant primarily because six[37,38,42-44,46] of the eight studies did not measure this parameter, and the remaining two studies found no significant difference between treatment groups.

When nine reviews devoted to PDT are excluded, there are currently 28[3,50-76] narrative and systematic reviews of the literature that address lasers in the treatment of periodontal diseases. Seven of these reviews also include a meta-analysis. Based on the 28 reviews in Table 3, one might conclude that the aggregate of evidence indicates that lasers have little to no clinical benefit and, because of poor study design, there remains a need for well-designed clinical trials. Two of the 28 reviews might be viewed as offering support for lasers in periodontal therapy,[62,67] five reviews offer equivocating conclusions,[52,57,59,72,76] and the remaining 21 reviews (78%) concluded there is insufficient, inconclusive, or no evidence showing that lasers provide additional benefit when used adjunctive to traditional nonsurgical therapy.

Diode and Nd:YAG lasers are frequently cited as having wavelengths that specifically target subgingival dark pigment-producing microbes, i.e., members of the *Porphyromonas*, *Bacteroides*, and *Prevotella* genera.[77-79] This ignores the fact that the vast majority of the microbes associated with periodontitis are not pigment producers.[80] Furthermore, it disregards that no study has ever demonstrated that the so-called black/brown pigmented bacteria (BPBs) produce dark pigments while inhabiting the periodontal pocket.[68,81] Despite the often stated goal of reducing BPBs during periodontal therapy, it should be noted that two of three red complex bacteria,[82] *Tannerella forsythia* (*Tf*) and *Treponema denticola* (*Td*), do not produce a pigment under any condition, in vitro or in vivo.

In summary, the collective body of evidence supporting the adjunctive use of diode or Nd:YAG lasers with SRP is of poor quality and insufficient to warrant recommendation of using either laser type in the treatment of chronic (CP) or aggressive (AgP) periodontitis or in periodontal maintenance therapy. The bulk of existing published peer-reviewed data indicates there is little added clinical benefit regarding reductions in PD, BOP, and subgingival bacterial loads or gains in CAL (Tables 1 and 3).

Table 3.

Narrative and Systematic Reviews of the Literature Regarding Lasers in the Treatment of Periodontal Diseases

Review	Included Meta-Analysis	Laser Types Evaluated	Conclusion
Rossmann and Cobb, 1995[50]	No	CO_2, Nd:YAG	Lasers need more scientifically based research and not merely anecdotal case reports.
Aoki et al., 2004[51]	No	Diode, CO_2, Nd:YAG, Er:YAG, argon, alexandrite, excimer	Clinical results are still insufficient to support laser usage in treatment of periodontitis. More are necessary to determine effectiveness of lasers versus SRP.
Ishikawa et al., 2004[52]	No	Er:YAG	The Er:YAG laser may be an effective instrument for periodontal therapy.
Cobb, 2006[53]	No	Diode, Nd:YAG, Er:YAG, CO_2	There is insufficient evidence to suggest that lasers are superior to the traditional modalities of therapy.
Parker, 2007[54]	No	Diode, Nd:YAG, Er:YAG, laser ENAP	There is greater need for studies "that reflect objectivity and reduced subjectivity."
Aoki et al., 2008[55]	No	Diode, CO_2, Nd:YAG, Er:YAG, Er,Cr:YSGG	No laser system is capable of replacing conventional instrumentation (SRP) with improved clinical results. More comparative clinical studies are required to determine effectiveness and outcomes of laser periodontal therapy.
Karlsson et al., 2008[56]	No	PDT, Nd:YAP, Nd:YAG, Er,Cr:YSGG	There is no consistent evidence supporting the efficacy of lasers as adjuncts to non-surgical treatment of CP.
Schwarz et al. 2008[57]	No	Diode, CO_2, Nd:YAG, Nd:YAP, Er:YAG	Er:YAG laser has characteristics most suitable for the non-surgical treatment of periodontitis. Nd:YAG, CO_2, and diode lasers have not demonstrated efficacy versus SRP, and when used as adjuncts, they have not shown significant clinical value.
Ishikawa et al., 2009[58]	No	Diode, CO_2, Nd:YAG, Er:YAG, Er,Cr:YSGG	Laser treatments have been shown to be superior to conventional mechanical approaches for tissue ablation and decontamination hemostasis and result in less postoperative pain.

Table 3. (continued)

Narrative and Systematic Reviews of the Literature Regarding Lasers in the Treatment of Periodontal Diseases

Review	Included Meta-Analysis	Laser Types Evaluated	Conclusion
Schwarz et al., 2009[59]	No	Diode, CO_2, Nd:YAG, Er:YAG, Er:YAP, Er,Cr:YSGG	Over a 6-month or 24-month observation period, the Er:YAG laser might serve as an alternative treatment. However, changes in post-treatment clinical parameters versus those of traditional therapies may not be significant.
Slot et al., 2009[60]	No	Nd:YAG	The majority of studies analyzed showed no beneficial effect of the Nd:YAG laser versus SRP whether used as a monotherapy or adjunctive to SRP.
Cobb et al., 2010[61]	No	Diode, Nd:YAG, Er:YAG, Er,Cr:YSGG, PDT, CO_2	Published clinical trials indicate minimal benefit should be expected with respect to gains in CAL and reductions in PD, BOP, and subgingival microbial loads.
Izumi et al., 2011[62]	No	Diode, Er:YAG, CO_2	Overall, the review was favorable for the potential for laser periodontal therapy.
Sanz et al., 2012[63]	No	Non-surgical therapies, diode, PDT, Nd:YAG, Er:YAG, Er,Cr:YSGG	There is still a need for high-quality clinical research.
Sgolastra et al., 2012[64]	Yes	Er:YAG	No significant differences were found in reductions in PD or BOP and gains in CAL, indicating no evidence of effectiveness.
Sgolastra et al., 2013[65]	Yes	Diode	No significant differences were observed for any investigated outcome of interest, SRP + diode versus SRP alone. Findings suggest that adjunctive use of the diode laser with SRP does not provide an additional clinical benefit.
Sgolastra et al., 2014[66]	Yes	Nd:YAG	The evidence is insufficient to support the effectiveness of adjunctive Nd:YAG with SRP.
Roncati and Gariffo, 2014[67]	Yes	Diode, Nd:YAG	Results indicate that Nd:YAG or diode laser, used as an adjunct to SRP, may provide some additional benefit versus SRP alone.

Table 3. (continued)

Narrative and Systematic Reviews of the Literature Regarding Lasers in the Treatment of Periodontal Diseases

Review	Included Meta-Analysis	Laser Types Evaluated	Conclusion
Slot et al., 2014[68]	Yes	Diode	Adjunctive use of diode laser with SRP provides an effect comparable with that achieved by SRP alone. Review questioned the benefit of the diode laser as an adjunct to SRP in treatment of periodontitis.
Zhao Y et al., 2014[69]	No	Er:YAG	Review indicated that clinical efficacy of Er:YAG laser was similar to SRP at 3 months after treatment. Clinical benefit of adjunctive Er:YAG with SRP is lacking.
Aoki et al., 2015[70]	No	Diode, CO_2, Nd:YAG, Er:YAG, Er,Cr:YSGG, LANAP	The superiority of lasers to conventional treatment has not yet been clearly demonstrated.
Behdin et al., 2015[71]	No	Diode, Nd:YAG, Er:YAG, CO_2 used adjunctively to periodontal surgery	Evidence is insufficient to support effectiveness of lasers as adjuncts to resective or regenerative surgical periodontal therapy.
Passanezi et al., 2015[72]	No	Diode, PDT, Nd:YAG, Er:YAG	The wide variety of protocols makes comparisons among studies difficult. There appears to be support for using lasers in treatment of patients with a compromised immune system or with systemic issues that contraindicate invasive treatments.
Romanos, 2015[73]	No	Diode, Nd:YAG, Er:YAG, CO_2	There is a need for clinical trials and multicenter studies to determine the effects of laser treatment on periodontal and peri-implant diseases.
Slot and Van der Weijden, 2015[74]	No	Diode, PDT, Nd:YAG, water-cooled Nd:YAG	Results support a firm statement to refute the use of lasers as adjuncts to non-surgical periodontal treatment based on the lack of additional clinical efficacy.
Smiley et al., 2015[3]	Yes	Diode, PDT, Nd:YAG, Er:YAG	Results indicate that adjunctive PDT has a moderate level of benefit. There is no evidence of added benefit from adjunctive use of the diode or Nd:YAG lasers when considering gains in CAL.

Table 3. (continued)

Narrative and Systematic Reviews of the Literature Regarding Lasers in the Treatment of Periodontal Diseases

Review	Included Meta-Analysis	Laser Types Evaluated	Conclusion
Mizutani et al., 2016[75]	No	Diode, PDT, Nd:YAG, CO_2, Er:YAG, Er,Cr:YSGG, LANAP	At present, more evidence-based studies need to be performed to support the integration of various laser therapies into the treatment of periodontal diseases.
Cheng et al., 2016[76]	Yes	Meta-analysis of 12 studies that included diode, Er:YAG, and Er,Cr:YSGG lasers	There was a significant PD reduction of 0.26 mm at 3 months but not at 6 months. There was no significant effect on CAL at 3 or 6 months. Inconsistent results were obtained regarding reductions in BOP. More randomized clinical trials of better design are required to derive reliable conclusions.

CO_2 = carbon dioxide; Er:YAG = erbium:yttrium-aluminum-garnet; ENAP = excisional new attachment procedure; Er,Cr:YSGG = erbium,chromium:yttrium-scandium-gallium-garnet; Nd:YAP = neodymium:yttrium-aluminum-perovskite.

DISCUSSION

Both cognitive dissonance and confirmation bias are concepts that initially appeared in the psychology literature.[83] Simply stated, cognitive dissonance refers to an individual holding conflicting beliefs, whereas confirmation bias is the interpretation of information to confirm one's beliefs and ignore information that may contradict such beliefs. The biologic sciences have adopted the concepts and now apply them to research evidence that seems in conflict with "everyday practice." At a very basic level, both concepts refer to a tendency to interpret information in a way that confirms one's preconceptions while ignoring contradictions presented by the peer-reviewed evidence.

As applied to the issue of lasers and periodontal therapy, cognitive dissonance defines the confusion and conflicting philosophies expressed by "thought leaders" in clinical dentistry when confronted by new information that conflicts with their existing beliefs. Many of the "experts" on laser periodontal therapy appear to have allowed their subjective selves to become dominant and thereby shape controversy into fact. This does not mean that expert opinions are never reliable. However, it does mean that clinicians should not depend solely on secondary sources for information on which they base treatment decisions. The clinician should also evaluate and make knowledgeable judgments of peer-reviewed research articles. Treatment decisions must be based on good evidence that can withstand hard and incisive questioning. Such evidence is not often obtained from the company sales representative or a clinician consultant representing the laser company.

Regarding the concept of confirmation bias, consider that clinicians have a tendency to overestimate the benefits of treatment. No ethical clinician performs a procedure with failure as the goal. Few clinicians like admitting a mistake in judgment. The expense of investment biases opinions toward success. There are no placebo or positive control groups in a clinical practice. Clinicians are not masked to treatment. Clinicians are seldom calibrated for clinical measurements, and clinicians do not randomize patients when planning treatment. Consequently, when the same clinician is responsible for both the treatment and post-therapy evaluation (as in private practice), the benefits derived from a specific therapy are easily overestimated.

The adjunctive use of diode and Nd:YAG lasers as currently taught by various experts is based on several assumptions: 1) subgingival curettage has clinical benefit over that achieved by SRP alone; 2) the laser facilitates a significant decrease and suppression of subgingival bacterial loads and specific types of bacteria; and 3) the laser significantly decreases

inflammatory mediators of inflammation. Interestingly, none of the proposed benefits from adjunctive use of the laser with SRP address the issue of bone loss, specifically the treatment of intrabony defects and furcation involvement. Thus, in some ways, the concept of using lasers as an adjunct to SRP is simply a recycling of "soft tissue management" but with different instrumentation.

Given the current lack of convincing evidence supporting the adjunctive use of the diode and/or Nd:YAG lasers with SRP, how does one justify the increased cost to the patient? Ethical practice would require an increased benefit to the patient proportionate to the increased cost. This "elephant in the room" issue raises the question of introducing a cost–benefit analysis by a health economist in future clinical studies that include adjunctive instrumentation and increased cost to the patient. As yet, no such cost–benefit analysis has been applied to a clinical study that used a laser adjunctive to SRP. Currently, the justification of achieving clinical significance sufficient to warrant an increased cost to the patient is left to the clinician, a decision seldom in favor of the patient.

The issue of statistical versus clinical significance is often an uncomfortable argument for private practice clinicians. As noted by Chambrone and Armitage,[84] statistical significance when comparing two treatment modalities does not imply clinical significance. An indirect example of this paradox is detected in the letter to the editor referenced above in which the use of gain in CAL instead of PD as an outcome measure for the *JADA* systematic review and meta-analysis is questioned.[3,6] Given that few in private practice measure CAL but most consider PD, this is a legitimate question. There are two issues for which PD as a single measurement does not account: 1) gingival recession (REC) and 2) continuity of design of clinical research to facilitate accurate comparisons of studies testing the same or similar instruments and treatment protocols. It is well known that patients can have nearly simultaneous progressive bone loss and REC that results in no increase in PD.[85] Measurement of CAL accounts for this clinical phenomenon. Furthermore, because of the possibility of concomitant bone loss and REC, CAL is the most accurate clinical parameter for determining stability of the periodontium over time in the same patient.[86] Second, CAL measurement has long been the gold standard for periodontal clinical trials.[87] Thus, for accurate comparison of separate clinical trials involving periodontal therapies, it seems reasonable to keep CAL as the one continuous measureable clinical parameter.

So, where does this leave clinicians? Can one justify continued use of the diode and/or Nd:YAG lasers as adjuncts to SRP in the treatment of periodontitis? Probably not, at least based on current evidence. Dentistry has known for years that curettage has no additional clinical benefit over SRP alone and, thus, has no justifiable application during active therapy for CP. The instrument chosen to remove diseased epithelium, i.e., curettage, makes no difference in the clinical outcome. Indeed, the need for removal of pocket wall epithelium during non-surgical treatment of periodontitis was discredited almost 25 years ago.[88-90] The treatment code for curettage was deleted from the American Dental Association Code on Dental Procedures and Nomenclature Revision 4 listing because of a lack of validating evidence in support of the procedure.[88] In both the 1989 World Workshop in Clinical Periodontics and the 1993 First European Workshop on Periodontology, the concept of gingival curettage was deemed to be a procedure that was unjustified.[91,92]

If the majority of studies report little clinical benefit from using lasers in the treatment of periodontitis, what is the rationale for executing yet more studies? To improve reporting of clinical trials, the Template for Intervention Description and Replication checklist should become the standard.[93,94] This 12-item checklist is an extension of the CONSORT (Consolidated Standards of Reporting Trials) 2010 statement.[95] At the very least, analysis of data from such trials should consider initial PD, reductions in PD, BOP and subgingival bacteria, gains in CAL, and characteristics of the treated sites (e.g., non-molar, molar flat surfaces, and molar furcations) and, when possible, include a cost–benefit analysis of treatment.[56]

Duplication of research by other clinicians, extension of existing research, comparison of studies, and determination of evidenced-based patient treatment requires completeness of reporting of clinical trial designs, measured clinical outcomes, and appropriate analysis that considers statistical and clinical significance and patient-centered outcomes.

CONCLUSIONS

There are many claims and much hyperbole surrounding the use of lasers, either as a monotherapy or adjunctive to SRP, to treat periodontitis. There is little evidence showing that use of a diode or Nd:YAG laser, either as a monotherapy or as an adjunct, adds clinical value over and above SRP and/or conventional surgical treatment. However, such therapy does add to patient cost.[96] Last, if the laser is used inappropriately, there is always the possibility of an adverse outcome involving tissue damage.[89]

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Correspondence: Dr. Charles M. Cobb, Department of Periodontics, University of Missouri–Kansas City, 650 E. 25th St., Kansas City, MO 64108. E-mail: cobbc@umkc.edu.

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