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Clinical evaluation of Laser-Assisted New Attachment Procedure® (LANAP®) surgical treatment of chronic periodontitis: a retrospective case series of 1-year results in 22 consecutive patients

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Conflict of Interest
Dr. Yukna has no direct financial interest in, but is a consultant for, Millennium Dental Technologies; a Certified Instructor for the IALD; and has received speaking honoraria and research support from them. He has similar involvement with other laser companies as well.

ABSTRACT

Purpose: Treatment for periodontitis has evolved over the years as new technologies have become available. Currently, lasers seem attractive as a treatment modality, but their effectiveness needs to be verified. The purpose of this project was to evaluate Laser Assisted New Attachment Procedure® (LANAP®) surgery as a single treatment modality.
Methods: As part of a mandatory training program for periodontists and other dentists, 22 consecutive patients diagnosed with moderate to severe periodontitis (probing depth [PD] up to 11 mm) were treated with the LANAP® surgical approach using a 1064-nm Nd:YAG laser as part of a multi-step protocol. Following single-session active therapy, they were entered into a maintenance program. Their clinical status was re-evaluated at 12–18 months following surgery.
Results: All 22 patients completed the 12- to 18-month follow-up. PD, clinical attachment level, and furcation (FURC) showed substantial improvement. Recession was minimal (mean, 0.1 mm), while 93.5% of PD measurements were 3 mm or less at re-evaluation. Furthermore, 40% of grade 2 FURC closed clinically.
Conclusions: Within the limits of this case series, LANAP® was found to be an effective, minimally invasive, laser surgical therapy for moderate to advanced periodontitis.

Keywords: Laser; Periodontitis; Surgery

INTRODUCTION

Periodontitis is a major dental disease, especially in adults. It has been reported that overall about 42% of U.S. adults have periodontitis, with about 34% having moderate to severe cases [1]. Historically, a variety of non-surgical and surgical treatments have been used to reduce probing depth (PD) and inflammation. While non-surgical treatments are modestly effective [2-6], surgical treatment is often recommended as a more effective modality for the problems of increased PD, loss of clinical attachment level (CAL), and bone loss; in recent years, studies have focused on the regeneration of lost or damaged supporting tissues [7,8]. Since most

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patients would like to keep their teeth, the main goal of all dental therapies is the retention of natural teeth in health, comfort, function, and esthetics. Clinical parameters such as PD, CAL, non-bleeding percentage (nBOP), and the modified gingival index (mGI), are surrogate markers for periodontal status, but provide practical clinical information. Generally, the treatment goals are to have no or minimal gingival inflammation or bleeding, shallow (3 mm or less) PDs, and minimal gingival recession (REC).

Lasers have been used as a single treatment, before or after scaling and root planing, and combined with surgical treatment. While non-surgical laser treatments have demonstrated variable results [9], a definitive laser surgical approach [8,10], Laser-Assisted New Attachment Procedure® (LANAP®), has shown promise in published case reports as a single treatment, laser based, surgical approach to improving periodontal parameters [11-16].

Information regarding the results of different treatment modalities is continually needed in periodontics. This is particularly true of newer treatment approaches and techniques, such as LANAP®, which uses a particular laser wavelength (Nd:YAG, 1,064 nm). LANAP® can only be legally performed after required training, including hands-on work with actual patients, is completed. Details about the protocol can be found in articles by Aoki et al. [10] and Jha et al. [17]. Human histologic evidence supports the concept of periodontal regeneration/new attachment with this procedure [18,19]. The LANAP® protocol includes active, definitive full-mouth surgical treatment as the initial therapy, and regular follow-up periodontal maintenance and occlusal adjustments, including a biteguard. This protocol saves patient treatment time, generally reduces patient costs, and potentially has equal or better results than the typical 2 step approach (initial therapy followed by surgical therapy) in achieving the treatment goals stated above. The typical treatment and follow-up scheme for LANAP® patients is shown in **Table 1**.

The purpose of this retrospective case series is to report clinical results following LANAP® treatment. The radiographic results will be reported separately.

MATERIALS AND METHODS

The current evaluation documents the clinical periodontal changes following LANAP® in 22 consecutively treated patients after 12–18 months of follow-up. This retrospective study was accorded exempt status after review by the Western Institutional Review Board due to its retrospective nature, so there was no need for separate informed consent (WIRB #281385). The physical and digital records of the patients who met the predetermined eligibility criteria were de-identified using a computer-generated numbering scheme.

Patients presenting to the University of Colorado School of Dental Medicine Graduate Periodontics Clinic diagnosed by an experienced clinician with generalized moderate to severe chronic periodontitis (i.e., meeting the case definition of generalized moderate to severe chronic periodontitis used at that time (American Dental Association [ADA]case type 4) (Armitage [20]), were treated with LANAP® if they met the following inclusion criteria: generalized moderate to severe chronic periodontitis, no definitive periodontal treatment nor antibiotic use in the last 12 months, no systemic diseases that would influence the results of periodontal therapy, and no pregnancy or breastfeeding. Smokers were included. The study period was from November 2006 to November 2010.

Table 1. LANAP® treatment protocol

LANAP® treatment protocol		
Patient name:		Date:
Time interval date:	Time needed	Procedure
1st appt.	1 hour	Periodontal charting (DDS) X-rays (DA)
10–14 days	30 minutes	Treatment plan consultation (DDS) Prescriptions Preoperative and postoperative Information
ASAP	2 1/2 hours	LANAP® surgery, half mouth
7–12 days	2 1/2 hours	Postoperative (DDS) Occlusal adjustment first side LANAP® surgery, other half mouth
10–14 days	30 minutes	Postoperative - (DDS) Occlusal adjustment - (DDS)
14–28 days	30 minutes	RDH polish Possible occlusal adjustment - (DDS)
1 month	30 minutes	RDH polish Possible occlusal adjustment - (DDS) Impressions for biteguard - (DA)
1 month	30 minutes 30 minutes	RDH polish Possible occlusal adjustment - (DDS) Biteguard delivery - (DDS)
1 month	1 hour	Periodontal maintenance (RDH) Possible occlusal adjustment - (DDS)
3 months	1 hour	Periodontal maintenance (RDH) Possible occlusal adjustment - (DDS)
3 months	1 hour	Periodontal maintenance (RDH) Possible occlusal adjustment - (DDS)
3 months	1 hour	Periodontal maintenance (RDH) Possible occlusal adjustment - (DDS)
2–3 weeks	1 hour	Periodontal charting - (DDS) X-rays - (DA)
Q3 months	1 hour	Periodontal maintenance (RDH) Possible occlusal adjustment - (DDS)
Annually	1 hour	Periodontal charting - (DDS) X-rays (DA)

LANAP®: Laser-Assisted New Attachment Procedure®, DDS: doctor of dental surgery; DA: dental assistant, RDH: registered dental hygienist.

Patients had complete periodontal charting and 7 vertical bitewing and panoramic radiographs completed at baseline and at 12–18 months after active treatment. Clinical and radiographic findings, the diagnosis, etiologies, prognosis and all primary treatment options were discussed with the patients at a separate treatment planning appointment. These included no treatment, scaling and root planing, flap surgery (either subtractive or additive), laser surgery, and/or extraction and replacement. All patients expressed a desire to keep their teeth if possible, and opted and consented orally and in writing for laser surgery. They were advised that their treatment would be performed by "trainees" using the laser under supervision.

No initial periodontal treatment was provided. Patients who consented to LANAP® went directly to laser surgery. LANAP® was performed in 1 half mouth at a time using local anesthesia. The patients were treated with LANAP® during a 3-day training program developed by the Institute for Advanced Laser Dentistry (IALD). Patient treatment was supervised one-on-one by various certified and calibrated instructors of the IALD, with overall on-site supervision by the author.

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Clinical periodontal measurements were performed by the author, an American Board of Periodontology–certified periodontist, at baseline and at 12–18 months after completion of the second half mouth of full-mouth LANAP®. Standard parameters were evaluated including PD; the free gingival margin (FGM) level from the cemento-enamel junction; CAL, was calculated from the prior 2 measurements; bleeding on probing, reported as the nBOP (bleeding on probing was deemed positive if bleeding occurred within 30 seconds after probing, and the score was converted to a non-bleeding value); furcation (FURC) involvement [21]; tooth mobility (MOB) [22]; the modified plaque index (mPI) [23]; and the mGI [24]. The investigator was calibrated with measurements in 3 patients who were diagnosed as having chronic periodontitis and were not included in this study. FGM position, PD, nBOP, and FURC were repeated after a 2-day interval. The intra-examiner kappa scores were 0.94 for PD, nBOP, and FURC, and 0.88 for FGM and mPI. FGM, PD, nBOP, and mPI were recorded at 6 sites of all teeth present except third molars using a manual periodontal probe (UNC15, Hu-Friedy, Inc., Chicago, IL, USA). FURC measurements were made with a calibrated Nabers probe (Hu-Friedy, Inc.).

During the laser application. laser safety rules were followed, including wavelength-specific eyewear protection for all individuals in the operatory, close monitoring of laser settings, and careful observation of the tissue response to the laser energy.

Using a 1064-nm PerioLase MPV-7™ laser, Millennium Dental Technologies, Cerritos, CA, USA **Figure 1**, the settings were as follows: 3.6 W average power, 20 Hz pulse repetition rate, pulse duration of 100 μs for first laser application and 550 μs for the second laser application delivered through a 360-micron quartz fiber in a special handpiece. This yielded an energy delivery of 180 mJ per pulse, an energy density of 177 J/cm^2, and a power density of 3,537 W/cm^2. The peak power was 1800 W during the first pass and 327 W during the second laser pass. The goal was to deliver 10–12 J/ per millimeter of PD, based on a recommended maximum of 12–16 J per millimeter of PD, which was almost always achieved (data on file) [25].

Between the 2 laser applications, the roots were thoroughly debrided with a piezoelectric ultrasonic scaler and tips (Piezon 400, Electro Medical Systems, Nyon, CHE); and

Figure 1. PerioLase MVP-7 Nd:YAG laser, Millennium Dental Technologies, Inc.

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decortication/intra-marrow penetration was performed at the base and along the walls of the bony defects [26]. In all cases, in accordance with LANAP®, mobility and other manifestations of occlusal pathology were assessed. The occlusion was carefully addressed and managed. No additive materials (such as bone replacement grafts, membranes, or biologics), sutures, or periodontal dressings were used.

Post-surgically, patients were prescribed ibuprofen (800 mg) for possible pain, doxycycline (100 mg, twice daily for 7 days) for residual bacteria, and a 0.12% chlorhexidine rinse to control new bacterial accumulation, since mechanical plaque removal was to be avoided on each treated side for the first 2–3 weeks.

Following surgical treatment of the second side, patients were seen frequently for general evaluations, oral hygiene instructions, supra-gingival polishing/de-plaquing to minimize inflammation, and occlusal adjustment to minimize unfavorable forces. After 4–6 weeks, a maxillary flat plane biteguard was delivered. Periodontal maintenance every 3 months followed. Occlusal evaluation and adjustment were planned for each visit (**Table 1**). As per protocol, neither probing nor sub-gingival instrumentation was performed unless a clinical need such as evident calculus or inflammation arose (none did) until the 12- to 18-month re-evaluation.

RESULTS

All 22 patients completed active treatment and the 12- to 18-month follow-up sessions, except for isolated instances (no more than 2) of missed appointments for any given patient.

Table 2 presents the age, sex, ethnicity, tooth status and smoking habit of the patients. The initial sextant diagnosis was generalized moderate to severe chronic periodontitis in 18 cases, and severe with some moderate chronic periodontitis in the other 4 cases. All were ADA case type 4 [20]. Patients had a mean of 26.7 teeth at the start. Eight teeth in 4 patients were considered hopeless due to extreme bone loss and grade 3 mobility and were extracted during the LANAP® treatment, resulting in a mean of 26.3 teeth per patient present after 12–18 months. No teeth were lost during those 12–18 months.

Clinical changes were favorable following LANAP® for the common periodontal parameters of nBOP, PD reduction, CAL gain, REC, MOB, and FURC severity.

Table 2. Demographic information of 22 patients treated with LANAP®

Values	Values
Mean age	45.6 years (range: 33–68 years)
Sex	
Males	10
Females	12
Ethnicity	
Caucasian	11
African-American	7
Hispanic	4
Mean number of teeth	
Start	26.7
Re-evaluation	26.3
Smoking	
Yes	6
No	16

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Table 3. Clinical parameters of 22 patients treated with LANAP® at 12–18 months post-treatment

	Pretreatment	Post-treatment
(nBOP%[a])	61.9 (30–83)	90.5 (80–96)
PD[b]		
Total sites	3,540	3,492
PD ≤3 mm	52.0%	93.5%
PD 4–6 mm	38.4%	6.6%
PD 7–9 mm	8.9%	0%
PD ≥10 mm	0.7%	0%
CAL changes[b]		
Total sites	1,650	
Gain ≥2 mm	54.0%	
Loss (1 mm)	4.0%	

LANAP®: Laser-Assisted New Attachment Procedure®, PD: probing depth, CAL: clinical attachment level.
[a]nBOP: non-bleeding (healthy) percent score on a patient-level basis; [b]PD and CAL on a site-level basis.

Table 4. Gingival margin level changes (recession) in 22 patients treated with LANAP® at 12–18 months post-treatment on a site-level basis

Variables	Mean	Range
Initial	0.0 mm	1.1 to −1.0
12–18 months post-treatment	−0.1 mm	0.8 to −1.4
Change	−0.1 mm	0.3 to −0.7

LANAP®: Laser-Assisted New Attachment Procedure®.

Table 3 shows the frequency of various periodontal PDs prior to treatment and at the 12- to 18-month evaluation on a site-level basis. PDs substantially decreased after treatment, with 93.5% becoming 3 mm or less after 12–18 months. Three-millimeter PDs are a general objective of periodontal treatment. The mean PDs are not presented because the author does not routinely record those that are 1, 2, or 3 mm deep.

Table 3 also presents CAL changes on a site-level basis. Not every site (those 3 mm or less) could gain attachment. Of those that could, 54% gained at least 2 mm, a clinically significant amount. It should be noted that 4% of treatment sites lost attachment and 42% remained the same. In addition, nBOP showed an improvement on a patient-level basis.

Table 4 demonstrates the change in FGM position on a site-level basis. The overall mean REC was 0.1 mm, with the worst patient mean being 0.7 mm. In addition to a small mean amount of REC (0.1 mm), 57% of the treated sites exhibited no REC, 22% exhibited 1 mm of REC, while 21% of the sites showed a gain in gingival margin height.

Table 5 demonstrates changes in MOB on a tooth-level basis. Two-thirds of the teeth had a decrease in MOB. This was due to both the decrease in inflammation and the occlusal

Table 5. Tooth mobility changes in 22 patients treated with LANAP® at 12–18 months post-treatment on a tooth-level basis

Variables	Mobility 1	Mobility 2	Mobility 3
Initial	147[a]	35	2
Post-treatment	94	3	0
Decreased	64%	-	-
Increased	6%	-	-

Change from 3 to 1=2 (100%), Change from 2 to 1=21 (60%), Change from 2 to 0=10 (29%), Change from 1 to 0=85 (58%).
LANAP®: Laser-Assisted New Attachment Procedure®.
[a]Number of teeth with that degree of mobility based on Miller [22].

Table 6. Furcation changes of 22 patients treated with LANAP® at 12–18 months post-treatment

	Pretreatment	Re-evaluation	Percent
Grade 3	2[a)]	Grade 2–1	50
Grade 2	70	Grade 1–25	35.7
		Grade 0–28	40.0
Grade 1	151	Grade 0–85	56.3
Overall			
Improved			62.3
Worsened			12.5
Stayed the same			25.2
Closed			51.0

LANAP®: Laser-Assisted New Attachment Procedure®
a)Number of furcations with that clinical grade based on Hamp [21] on a site-level basis.

adjustments done as part of the LANAP® protocol and the follow-up. Splinting was provided for some teeth in 7 of the patients.

Table 6 lists the incidence and changes in FURC involvement severity on a site-level basis.

Of the two initial cases of grade 3 FURC, one became grade 2 and the other remained grade 3. Seventy cases of grade 2 FURC were present initially, and 75% of them were grade 1 or closed (40% closed) after treatment. Over half of the cases of grade 1 FURC closed clinically.

The mGI per sextant was generally 0, with an occasional 1 on a site-level basis at the 12- to 18-month re-evaluation, compared to a majority of 2's and 3's initially. The mean mPI on a patient-level basis was 38% prior to treatment and 86% plaque free at the 12- to 18-month point.

Postoperatively, 9 patients reported slight bleeding overnight and half reported discomfort that warranted ibuprofen during the night. However, only 4 reported needing ibuprofen after that. Seven patients reported transient sensitivity that resolved within 3 weeks after additional occlusal adjustment.

When the small subset of smokers was compared to the non-smokers, the response to LANAP® treatment was slightly, but not statistically significantly, lower for each of the clinical parameters in smokers (P=0.48).

DISCUSSION

The development of less invasive yet effective procedures has always been a desire for patients and a goal for clinicians. Many times, traditional surgical procedures are not readily accepted by patients due to concerns about pain, swelling, recession, and so forth.

The past several decades have seen a shift from resective (subtractive) to regenerative (additive) procedures, particularly in cases of moderate to severe periodontitis. Regeneration requires that etiologic factors are controlled and/or eliminated prior to or during surgery, and typically that a variety of additive materials be used to stimulate that type of healing. That approach increases costs for practitioners and patients.

Laser-based treatments have been proposed as an additional or alternative treatment for periodontitis, but laser use in periodontics remains controversial. CO_2, diodes, erbiums

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(Er:YAG, Er,Cr:YSGG), and Nd:YAG are the most commonly used dental lasers. Clinicians must realize that all lasers are not the same, and various lasers have different levels of tissue penetration and are primarily absorbed in different tissues/substances. Therefore, each laser must be separately investigated for each periodontal application. Lasers with different wavelengths and other parameters cannot be expected to produce the same results as other lasers. Care must be taken when using lasers because of varying power levels, wavelengths, and delivery modes. Incorrect wavelengths and/or power levels can result in damage during periodontal treatment, causing more harm than good.

The specific steps in the LANAP® protocol employ the principles of regeneration elucidated over the last 60 years. These include removing the pocket epithelium [27,28], eliminating bacteria and their products from the root and soft tissue [29,30], accessing progenitor cells by means of intra-marrow penetration [26], establishing a stable fibrin clot to seal the periodontium from external influences [31,32], and reducing occlusal trauma and tooth mobility using a combination of procedures [33-35].

While **Tables 3**, **5**, and **6** show generally favorable clinical results, there were some instances when a loss of clinical attachment, an increase in mobility, or a worsening/deepening of FURC involvement occurred. A loss of clinical attachment has commonly been found with all periodontal pocket therapies when shallow sites adjacent to deeper sites are treated [36]. FURC may have initially had the entrance blocked by calculus, which was not present at the re-evaluation.

The FURC results were particularly favorable, with 40% of cases of grade 2 FURC becoming clinically closed at re-evaluation. This result compares favorably with a study by Bowers et al. [37] and a review by Evans et al. [38].

Furthermore, 6.3% of sites had residual PD of 4-6 mm (but none deeper than that) at re-evaluation (**Table 3**), generally 1–5 sites per patient. When additional treatment was discussed with those patients, all the same treatment options were discussed as initially, and all the patients requested additional laser treatment, suggesting patient satisfaction with the laser therapy.

These results supported the idea that Nd:YAG radiation provides additional benefits in the periodontal treatment of smokers, and the finding of similar effectiveness in smokers to non-smokers parallels another study [39].

Not having patients undergo scaling and root planing prior to surgery is not common. However, the Nd:YAG wavelength is attracted to inflammation and works better when more inflammation is present [40].

Traditional flap surgery, with or without osseous resection, typically results in reduced PD due to apical positioning of the FGM, creating possible further CAL loss and REC. In comparison, LANAP® appears to reduce PD with minimal recession (**Table 4**), a result seen in another Nd:YAG report [18].

Therapeutic techniques that manage both the etiologies and the clinical changes seen in periodontal disease may result in better outcomes. LANAP® has human histologic validation (new attachment or regeneration in 75% of the teeth treated) [18,19] and evidence of initial and long-term success [16].

LANAP® is a precise treatment protocol combining laser surgery with the well-established principles of traditional periodontal therapy, all based on biologic and clinical principles. While the treatment objectives are similar, LANAP® appears to have several benefits compared to conventional periodontal surgery, including being less invasive and less traumatic; resulting in less swelling; having minimal postoperative discomfort, REC, and thermal sensitivity; leading to more rapid healing; and having equal or better overall results.

Radiographic results will be presented in a separate paper.

CONCLUSIONS

LANAP® appears to present a valid minimally invasive laser surgical option for the effective treatment of chronic periodontitis. It is not known how generalizable these results are, but patients of various ages and ethnic groups participated in this study. Longer-term follow-up data and prospective controlled clinical trials comparing full-mouth LANAP® to other surgical therapies are needed to reinforce these initial findings.

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