Evaluating Nd:YAG Laser Effectiveness in Treating Gingival Hyperplasia Following Orthodontic Treatment

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Abstract— **Objective: Nd:YAG laser has been extensively utilized in oral and periodontal surgery. This interference on tissues is evident in a number of operations: frenectomy, lesions excision, gingivectomy and gingival augmentation, coagulation of the graft-donor area, and crown lengthening. Laser has the ability to mitigate post-treatment complications, such as bleeding; it also reduces the possible complications during the removal of enlarged gingiva, especially with the presence of gingivitis. These aforementioned considerations induced us to study gingivectomy performed by Nd:YAG laser in gingival overgrowth cases following orthodontic treatment.**

Materials and methods:This study included 10 patients. Indices of bleeding on probing (BoP), gingival overgrowth (GO) and gingival inflammation (GI) had been measured prior to removing gingival structures. Gingivectomy was then performed for each jaw in two ways: Nd:YAG laser was used on one side, and the traditional surgical method on the other. Thus, the study included 40 samples, and then the same indices were studied 6 months after treatments.

Results:After 6 months, post-treatment indices yielded the following values. Regarding the BoP index, the mean value for all the cases in the laser group reached 16.33; it was less and better than that of the traditional surgery group, which increased to 24.68. Mann-Whitney test achieved a degree of -2.583, and the p-value registered 0.010. As for the GO and GI indices, no statistically significant differences in the mean values were depicted between the two research groups.

Conclusion: Nd:YAG laser has shown good effectiveness in the management of post- orthodontic gingival hyperplasia and is superior to traditional surgical treatment by improving some clinical indices such as bleeding on probing. However, no improvement was found in the laser group over the traditional one regarding the other two indices, namely GO and GI.

Index Terms— **gingivectomy, Nd:YAG laser, bleeding on probing index, gingival overgrowth index, gingival inflammation index.**

This investigation aimed at evaluating the effectiveness of Nd:YAG laser when treating gingival hyperplasia, which results from orthodontic treatment. Precisely, our study focused on the recession of all inflammatory aspects throughout studying three indices: bleeding on probing (BoP), gingival overgrowth (GO), and gingival inflammation (GI).

I. INTRODUCTION

Histologically, the general health of periodontal tissues is considered a prime factor contributing to the success of orthodontic treatments. Likewise, periodontal complications are of the common side effects that have been found to be connected to orthodontic treatment. Chief amongst those complications that accompany medical interference are gingivitis, periodontitis, gingival recession and gingival hyperplasia. Throughout dental medicine, Nd:YAG laser has been abundantly used in oral and periodontal surgery in a multitude of operations; these include frenectomy, lesions excision, investigative and excisional biopsies, gingivectomy and gingival augmentation, surgical incisions preceding ostectomy, coagulation of the graft-donor area, and crown lengthening. Laser has the ability to mitigate post-treatment complications, such as bleeding; it furthermore reduces the possible complications of removing gingival enlargement, especially with the presence of gingivitis [1].

Gingival-orthodontic effect

The most important common relationship among the different dental specialties is the periodontal-orthodontic relationship, termed in this investigation as the gingival-orthodontic effect. This relationship is mutual, as the success of orthodontic treatment on the short or long term is affected by the patient's periodontal condition, during all stages of orthodontic treatment. Many pathological gingival conditions may improve through the orthodontic movement. Conversely, the orthodontic movement is a risk factor for periodontal defect. This is in the event of an increase in the presence of infectious periodontal germs. Neglecting this dependent gingival-orthodontic effect leads to the renowned orthodontic failure at the level of periodontium [2].

Periodontal benefits of orthodontic treatment:

The orthodontic treatment ha many Periodontal benefits like improving plaque control (overlapped teeth, unhealthy contact points), solving some occlusal problems (restoring the anterior guide, returning the tooth to the correct occlusal position), correction of dental changes resulting from periodontal diseases(tooth tilt, elongation), improving the condition of the periodontium , reducing the pocket depth and reducing bone destruction in some movements(after tilting movement like an example.

Possible damages of orthodontic treatment:

Gingival damage (inflammation, hyperplasia, recession), Root resorption, Alveolar bone resorption and pocket formation .Orthodontic forces can affect the alveolar bone by accelerating its resorption and worsening its condition[3].

With adequate oral hygiene, there is a diminished chance of

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developing gingival hyperplasia. Nonetheless, with fixed orthodontic appliances and poor oral hygiene, gingival overgrowth can develop. This enlargement may range between being moderate and severe, and in some cases, gingival overgrowth can also be reversible after removing the orthodontic device.

Studies showed that the Nd:YAG laser and the Er:YAG laser can be beneficially used in periodontology for gingivectomy. And demonstrated that subgingival laser treatment can result in significant reduction of the initial levels of periodontal pathogens. Nd:YAG laser gingivectomy results in similar improvement of deep periodontal pocket as conventional flap surgery, with the advantages such as minimal bleeding and post-operative pain, no swelling, and neither sutures nor post-surgical dressing are needed. Both non-surgical and surgical laser treatments are often performed without local anaesthesia, making full-mouth treatment in one session possible. Treatments are well accepted by the patients and require about 50% less time than the conventional therapies. Laser-de-epithelialization for periodontal regeneration has been experimentally attempted, but more controlled studies are needed to establish its usefulness in the clinic. Laser treatment of peri-implantitis is not recommended[4].

II. LITERATURE REVIEW

A. Nd:YAG laser

The Neodymium: yttrium aluminum garnet laser is one of the most commonly used lasers in the field of dental medicine. It appeared for the first time in 1964 when used by Geusic; besides, it came about to be the first laser used for dental purposes in 1989 by Terry Myers. This laser was recognized by the Food and Drug Administration (FDA) in 1990 [5]. This laser is a solid-state one, whose wavelength is 1064 nm. Its active substance is neodymium-doped yttrium aluminum garnet (Y3Al5O12). It is an invisible laser, so Helium- Neon laser accompanies it as a directing laser to indicate the location of the laser beam on the target area [6]. The emission pattern of this laser is versatile, free-running pulse mode. It contacts the target tissue using a flexible optical fibers ranging in their core diameter from 200 to 600 μm [5]. The Nd:YAG laser has a large penetration depth of 2-5 mm into the target tissue, which makes it the most penetrating among surgical lasers used in dentistry. This means that the adjacent structures under the target tissue are exposed to the energy of the laser beam. A fact as such increases the possibility of defect to these structures, whether they are dental, beginning with dental sensitivity and ending with pulp necrosis, or bony structures. Damages like these manifests themselves to be of the major disadvantages of this laser [7].

III. MATERIALS AND METHODS

A. Study Design

This research followed the split-mouth Randomized controlled Trial. Gingivectomy was performed using the traditional surgical method in one hemiarch and the other half using the Nd:YAG laser based in the Laser Research Unit in the Faculty of Dental Medicine, Damascus University. The three indices were studied for each patient in the first session and after 6 months of treatment.

B. Inclusion Criteria

Each patient of our sample must:

1. have gingival hyperplasia of moderate to severe degree, following orthodontic treatment.
2. not be taking any type of medication and not suffering from any systemic disease.
3. have at least six teeth, which suffer from gingival hyperplasia.
4. not be allergic to photodynamic therapy.

C. Exclusion Criteria

We excluded from this study patients who:

1. are pregnant women.
2. have bad fillings or prostheses, in the gingivectomy area.

D. Sample Size

The sample size for the present study was determined using G*Power 3.1.9.2 software, with a significance level set at 0.05, confidence level at 0.95, and a size effect of 0.95, based on a previous similar study conducted by Petersen B, 1993.

E. Ethics

The Scientific Research Committee of the Faculty of Dentistry of Damascus University obtained the necessary regulatory approvals to conduct the research, and the study was registered with number 718 on 01/03/2017, written informed consent after receiving a comprehensive explanation of the study objectives, procedures, and considerations regarding patient privacy.

F. Procedure

Initially, all cases were diagnosed clinically; both medical and medicinal histories of each patient were recorded. Then, the three clinical indices were measured. Following this step, scaling and root planning were performed for all patients, ensuring raising their awareness of the correct way of brushing and the proper oral hygiene. After a month, the clinical indices were recorded again. Later, the remaining patients, who met our inclusion criteria, were included in the research sample.

G. Surgical Gingivectomy

Deep anesthesia was administered in the mucogingival side. Then the pockets were identified above each surface by periodontal depth marker, by inserting the tip of the straight end into the depth of the pocket so that it is parallel to the long axis of the tooth. The marker's sharp angled end was then pressed to obtain a bleeding point on the outer surface of the gingiva. Each pocket is marked with several bleeding points in different areas to mark its track on each surface. A Kirkland scalpel was used to make incisions on the vestibular, lingual and lateral surfaces

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of the last tooth. The Orban scalpel was also used to section the gingiva in the interproximal spaces. As for the scissors and blades, they were used as auxiliary tools. After that, the incision was done apically for the pockets-marking points (bleeding points). It was directed toward the crown to the point between the pocket base and bone edge. The cut had to be very close to the bone without exposing it. The incision was made at an angle of 45 degrees against the tooth surface, somewhat in line with the natural borders of the gingiva.

Then the gingival margins were beveled to make them thin, and the walls of the pockets were removed, and the area was cleaned (granular tissues and incised remnants). Later, scaling and debridement of the exposed root surfaces was carried out using scaling and curettage tools. This is to obtain smooth and clean surfaces. Finally, a periodontal dressing was applied [2].

Figure 1: Scaling, root planning, and pre-treatment preparation

H. Laser Gingivectomy

The gingival sites were cut using an Nd:YAG laser on the right region of all arches. This was done with the laser based in the Laser Research Unit in the Faculty of Dental Medicine. It is a pulse laser with a wavelength of 1064 nm and an energy of 200 mJ, whose pulse duration is 100 milliseconds. In addition, a diode laser with red light at a wavelength between 630-680 nm with a power of 5 mW was added to this laser. The diode laser light had the function of an indicator to the location of the Nd:YAG laser beam on the target tissue; a power of 3 watts was used.

Figure 2: Pre-laser-cut gingiva Figure 3: Post-laser-cut gingiva Indices

All of the three indices – BoP, GO, and GI – were recorded post-treatment in 6 months for the two research groups, Surgery and Laser.

Figure 4: A case prior to treatment

Figure 5: A case following treatment in 6 months.

IV. RESULTS

The research sample consisted of ten patients, males and females, between the ages of 16 and 23 years, with an average age of 19.30 (± 2.214). Each patient was considered as two participants in the study, where each person's arch is considered a participant in the research sample. In terms of the method of work and the type of treatment used, each participant was divided into two hemiarches (cases). The laser was applied on one side (case) and traditional surgery on the other side (the other case). There was an interval of one week between surgery and laser for each patient. Thus, the number of cases included in the research became 40 cases. In total, traditional surgery was applied to 20 cases and laser was applied to 20 cases.

A. Bleeding on Probing Index

In order to study the differences in the BoP index in the pre-treatment and post-treatment phases between the surgery group and the laser group, a study was conducted employing Mann-Whitney test. Results are shown in Table 1.

It is evident from the results on Table 1 that there is no statistically significant difference concerning the BoP index in the pre-treatment phase between the surgical group and the laser group. The value of Mann-Whitney test registered 0.000; its p-value was 1.000, which is greater than the confidence interval of 0.05, so the difference is not statistically significant.

On the other hand, it is clear from the results in the same table that there is a statistically significant difference in the post-treatment BoP index between the two study groups, where the value of the Mann-Whitney test was -2.583 and its p-value was 0.010, which is smaller than the level of significance, 0.05. Henceforth, the difference is statistically significant and in favor of the post-treatment laser group. The participants' BoP mean in this group is 16.33, which is lower and better than that of the surgery group, 24.68.

B. Gingival Overgrowth Index

In order to study the differences in the magnitude of this index in the pre-treatment and post- treatment phases between the surgery group and the laser group, another axis was highlighted. Mann-Whitney test outcome is displayed and the results are shown in Table 2. It can be noticed from that there is no statistically significant difference in the pre-treatment GO index between the surgery group and the laser one. The value of Mann-Whitney test was 0.000, and its p-value 1.000. This is indicative of a greater level than the level of significance, 0.050, leading to insignificant difference. The results of table 2 also trace no statistically significant difference in the GO index after treatment between the two research groups. The value of the Mann-Whitney test was -0.411, and its p-value was 0.681, way greater than the confidence interval of 0.050. Therefore, the difference is not statistically significant, i.e. there are no statistically significant differences in the GO index across the groups in both the pre-treatment and post-treatment phases.

C. Gingival Inflammation Index

In order to study the differences in the GI index in the two phases before and after treatment between the surgery group and the laser group, the application of the Mann-Whitney test helped us formulate rational decision. The results are underpinned in Table 3. It is noted through the results that there is no statistically significant difference in the pre-treatment GI index between the surgery and laser groups. The Mann-Whitney test value was -0.313, and its p-value registered 0.755. Such probability level is greater than the predefined level of significance 0.050, so the difference is not statistically significant. It is also apparent that there is no statistically significant difference in the GI index of between the surgery group and the laser group after administering the treatment. The value of the Mann-Whitney test reached -0.411 with a p-value of 0.681, greater than the confidence interval 0.050. Henceforward, the difference is not statistically significant. There are simply no statistically significant differences in the GI index between the surgery group and laser one in the pre-treatment and post-treatment stages.

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V. DISCUSSION

Since the state of gingival hyperplasia following orthodontic treatment is one of the widespread hindrances affecting the success of treatments, the importance of this research lies in evaluating the effectiveness of the Nd:YAG laser in the treatment of gingival hyperplasia following orthodontic treatment. Plainly, our investigation scrutinizes the effectiveness of laser in relieving pain, during treatment and in the three days following treatment. It also evaluates the recession of inflammatory manifestations through studying each of the three indices: BoP, GO and GI. It studies the effectiveness of each index at the level of clinical recovery. This comes in light of the fact that laser has become extensively used in various fields of life, and the Nd:YAG laser has been chosen to study its effectiveness as it has proven less harmful to the oral tissues. The sample consists of 10 male and female patients; furthermore, the study follows the split mouth design, as the mouth of each patient was divided into four sections. In the upper right quadrant, a traditional surgical gingivectomy was performed, and in the upper left quadrant, an Nd:YAG laser gingivectomy was performed. Likewise, the lower right quadrant admitted a traditional surgical gingivectomy, and the lower left quadrant admitted an Nd:YAG laser. The Nd:YAG laser was compared with the traditional surgical method using the surgical scalpel, as it is an easy-to-use tool that does not cause any additional harm, desirable if used near the osseo-structures [8]. The surgical scalpel is quick and does not require preparation that may not be available in the clinic [9]. This traditional surgical method has generally proven inexpensive [8] and fast [10] . In a nutshell, It is the approved standard method [11]. The severity of gingival overgrowth was chosen as grade 2 and 3. This is because grade 1 gingival overgrowth regresses after scaling and oral care. Regarding hygiene, the patients' oral health level was raised prior to surgical interference, by performing scaling and roots planning. The patients were given oral health instructions regarding systematic and correct tooth brushing, and use of oral rinses chlorhexidine 0.12%. However, three periodontal indices were studied: bleeding on probing (BoP), gingival overgrowth (GO) and gingival inflammation (GI); their values were recorded for two times. The first time was at the onset of medical interference, the pre-treatment phase. The second time was 6 months after the medical interference, the post-treatment phase.

Bleeding On Probing Index

The results showed a decrease in the mean values of BoP, irrespective of the method by which gingivectomy was performed, be it by surgical scalpel or Nd:YAG laser. The mean of BoP for post-treatment in the surgery group was 0.80, which is smaller than that of the same group in the pre-treatment phase that knocked the borders of 1.70. This difference within the same group between the two phases is statistically significant at a p-value < 0.05. The same holds true for the laser group, where the mean of this index after treatment was 0.35, which is smaller than that before treatment within the same group, reaching 1.70 and statistically significant. There are statistically significant differences in the mean values of the BoP index between the two periods concerned, regardless of the study group. Thus, we conclude that the values of the bleeding rate after 6 months from the medical interference were smaller than those before treatment, whether gingivectomy was done by Nd:YAG laser or by traditional surgery across all the research sample. A statistically significant difference is plainly noticeable in the BoP index in the post- treatment phase between the surgery group and the laser one. It sides in favor of the laser group, where the mean value of the BoP index for all the cases of the laser group was 16.33, lower and better than the mean value of the BoP index for all the cases of the surgery group that was 24.68. The value of Mann-Whitney test was -2.583 with a p-value of 0.010. Safely enough, we can conclude that gingivectomy is better performed utilizing Nd:YAG laser than traditional gingivectomy with a surgical scalpel in terms of the BoP index.

Our study agrees with:

- Petersen B, 1993, who studied a method of gingivectomy using a CO2 laser in gingival overgrowth cases induced by using Phenytoin. He found that bleeding improved when gingivectomy was performed by laser [12].
- Lioubavina, 2002, which showed a significant improvement in the reduction of bleeding [4].
- Romanos GE, 1994, which found that the use of Nd:YAG laser in gingivectomy contributed to reducing the BoP index [13].
- Zhang YM, 2002, where the use of Nd:YAG laser in performing gingivectomy resulted in reducing bleeding on probing [14].
- Fornaini C et al., 2007, whose study evaluated the effectiveness of Nd:YAG laser in surgical treatment for soft tissues associated with orthodontic treatments. They concluded that laser treatment revealed remarkable improvement in the BoP index [11].

Gingival Overgrowth Index

The results of this investigation showed the disappearance of the gingival overgrowth after treatment, regardless of the method used to perform gingivectomy, be it with the surgical scalpel or by Nd:YAG laser. The mean of the GO index for the surgery group using the surgical scalpel in the pre-treatment phase was 2.60; this mean plummeted to 0.20, after 6 months from treatment, with a statistically significant difference from what it was before treatment. In addition, the mean of the GO index for the laser group before medical interference with Nd:YAG laser was 2.60; it also decreased after treatment with Nd:YAG laser to 0.15, after 6 months from treatment, with a statistically significant difference from what it was before treatment. We can conclude that the values of the GO index after 6 months were smaller than they were prior to treatment, regardless of the study group across our research sample. However, the differences were not statistically significant in the mean values of the GO index between the surgery group and the Nd:YAG laser group in the post-treatment phase. Such findings reiterate that there is no effect of the treatment method on the values of the GO index.

Our study agrees with:

- Petersen B, 1993, who studied a method of gingivectomy using a CO2 laser in gingival overgrowth cases induced by using Phenytoin [12].

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● Inchingolo F, which made a comparison between traditional surgery and CO2 laser and Nd:YAG laser in the treatment of gingival hyperplasia in patients with Weber- Sturge syndrome [15].

Gingival Inflammation Index

Inflammation in gingival hyperplasia is ascribed to chronic untreated inflammatory changes caused by plaque and localized agents [16]. The results of this study showed a reduction in the mean of GI index after treatment, regardless of the method by which gingivectomy was made, either by the traditional surgery method or with Nd:YAG laser. The mean value of the GI index after traditional surgical treatment, 6 months after treatment was 0.20. It was less than the mean value of the pre-treatment GI index of 0.55. This means that there is a statistically significant difference in this index within the surgery group between the pre-treatment and post-treatment phases. Moreover, the mean value of the GI index 6 months after treatment with Nd:YAG laser decreased to 0.15, less than the value of its counterpart before treatment, which was 0.50. This highlights a statistically significant difference in the GI index within the laser group between the pre-treatment stage and the post-treatment phases. Nonetheless, the differences were not statistically significant in the mean values of the GI index between the surgery group and laser one. This means that there was no effect for the studied group on the values of the GI index. We conclude that there are no differences in the treatment methods, the traditional surgery and the Nd:YAG laser, and their effect on the GI index. Our study agrees with Durham, 2009, who found that there is no difference in the treatment method, Diode laser or traditional surgery, regarding its effect on the GI index [4].

Clinical cases:

Case number 1
Before Treatment

After using Nd:YAG Laser
After traditional surgical method

Aftter 6 months of treatment

Case number 2
Before treatment

After traditional surgical method

After using Nd:YAG Laser

Aftter 6 months of treatment

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CONCLUSION

We conclude when gingivectomy is performed via the Nd:YAG laser method, there is a noticeable improvement in the BoP index; 6 months after medical interference; over performing it via the traditional surgical method. However, no improvement was found in the laser group over the traditional one regarding the other two indices, namely GO and GI; 6 months after medical interference.

Tables and Figures:

TABLE 1: MANN-WHITNEY TEST RESULTS, BOP INDEX DIFFERENCES ACROSS GROUPS

Phase	Group	Cases	Mean	Sum	MW value	p-value	Decision
Pre-treatment	Surgery	20	20.50	410.0	0.000	1.000	Statistically insignificant
	Laser	20	20.50	410.0			
Post-treatment	Surgery	20	20.68	493.5	-2.583	0.000	Statistically significant
	Laser	20	16.33	326.5			

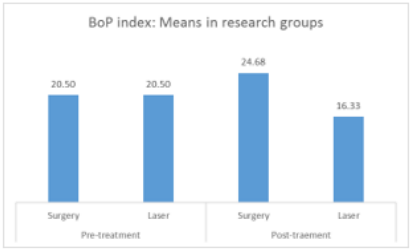

Figure 1: BoP index: Pre-treatment and post-treatment differences across groups

TABLE 2: MANN-WHITNEY TEST RESULTS, GO INDEX DIFFERENCES ACROSS GROUPS

Phase	Group	Cases	Mean	Sum	MW value	p-value	Decision
Pre-treatment	Surgery	20	20.50	410.0	0.000	1.000	Statistically insignificant
	Laser	20	20.50	410.0			
Post-treatment	Surgery	20	21.00	420.0	-0.411	0.681	Statistically insignificant
	Laser	20	20.00	400.0			

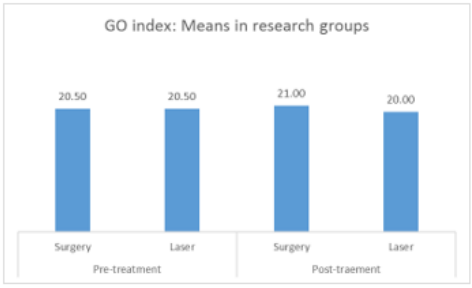

Figure 2: GO index: Pre-treatment and post-treatment differences across groups

TABLE 3: MANN-WHITNEY TEST RESULTS, GI INDEX DIFFERENCES ACROSS GROUPS

Phase	Group	Cases	Mean	Sum	MW value	p-value	Decision
Pre-treatment	Surgery	20	21.00	420.0	-0.313	0.755	Statistically insignificant
	Laser	20	20.00	400.0			
Post-treatment	Surgery	20	21.00	420.0	-0.411	0.681	Statistically insignificant
	Laser	20	20.00	400.0			

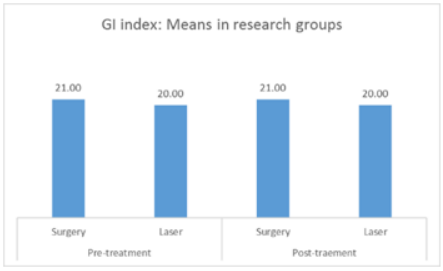

Figure 3: GI index: Pre-treatment and post-treatment differences across groups

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