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Performing Apicotomy with ER: YAG Laser - Determining the Optimum Pulse Of Work (In-Vitro Study).

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ABSTRACT

Laser (an acronym that means light amplification by stimulated emission of radiation) is a device that produces light beam that is monochromatic, coherent and focused, and which consists of a pure color that is usually invisible but converted into thermal energy can provide different therapeutic effect. The speed and efficiency of laser procedures are defined by the laser parameters, the surface area of the target and the speed with which the operator moves the hand of the camera, and therefore the laser beam (laser to conduct blow) on the surface of the target tissue. To achieve optimal effect, depending on the desired intervention is necessary to set appropriate terms of energy / power and frequency to obtain ideal results.

Keywords: laser, apicotomy, cracks, damage of the resected root surface.

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INTRODUCTION

Natural light is composed of different electromagnetic waves traveling in the direction disoriented and is known as incoherent light. The laser light emits a specific wavelength of the electromagnetic spectrum and travels in a predictable direction. The laser produces calibrated (waves are parallel with each other), coherent (all waves are in the same phase) and monochromatic beams of light (waves of the same wavelength). The effect of laser emission on biological structures depends on the wavelength of the radiation emission emitted from the laser, the power density of the beam and the temperature characteristic of beam energy. To achieve optimal effect, depending on the desired procedure, it is necessary to set the appropriate terms of energy/power and frequency to obtain ideal results. As a general rule should be followed when working with the laser: the greater the energy that is absorbed per unit area, the greater the effect.

The laser beam can be continuous or pulsed. Continuous laser allows formation of laser beam with the exact output power, while the pulse laser, form very short beam pulses, several nanoseconds and with high rate of recurrence. Pulsed Er:YAG laser (2940nm wavelength which is also the goal of our study) has a thermal mechanical effect on hard dental tissues and bone. Wavelength of Er:YAG laser agree with the basic absorbing maximum of the water and is highly absorbed by hydroxyapatite. This is the secret of a very efficient thermal and non-invasive ablative effect on human dental hard tissue. Efficient ablation is achieved by rapid and selective evaporation of water linked to dentin and enamel. [1] Expansion of water generates high pressures, causing removal of hard dental tissue through so-called micro-explosions. Hydroxyapatite melts during ablation because almost all of the laser energy is used for water evaporation. The energy of very short laser pulse of Er:YAG, completely transform with ablative effect and minimal thermal effect on surrounding tissues. Owing to the various tissues that contain water, removal of dentine caries is more pronounced than the removal of healthy dentin and also stronger in the dentin than in enamel, leading to non-invasively selectively scrape.

Aim

Advances in modern dental industry and technology day by day results in more sophisticated devices and technologies that offer new opportunities for improving the permanent treatment methods With the invention of the laser and its applied usage in oral surgery, there was a need to determine the optimal parameters to achieve the best results. The objectives of this paper are: 1. determination of optimal VSP pulse in terms of determining the ideal relationship between pulse energy /pulse frequency for apical resection of tooth, 2. comparation between the ideal VSP pulse that creates the Er:YAG laser with his contact extension R14, with the work of mechanical hand piece efficiency in performing apical resection of tooth and 3. analysis of resected root surface and determining the correlation between the energy of the laser beam and the occurrence of damage of dentin(occurrence of cracks and crater formation).

MATERIAL AND METHODS

The study was performed in the University Dental Clinical Center "St. Pantelejmon" in Skopje. For realization of the set goals, we included a total of 75 extracted single root permanent teeth, with circular apical part. The teeth did not show damage to their root surface, it was recorded based on visual examination (magnifying glass).Once the teeth were extracted they were stored in 5 % formalin solution in a maximum time of 1 week. Cleaning the teeth in order to remove all soft and hard tissue debris and blood was done with a brush after they were washed with water and gently dried leaving them on the room temperature. Root canals were processed and were filled with gutepercha and iodophorm cement. We analyzed resected root area in each of groups to determine which group has the most damage to the dentin (necrosis and carbonification, the occurrence of cracks on the treated root surface and appearance of crater formations). Each tooth sample was measured and outlined the circular line to mark the localization of the tooth where the diameter is 3mm. This was done in order to cut the same amount of dentin on all samples.

RESULTS

Time of resection

The 75 samples of teeth were divided by random selection into five groups. The first four groups were treated with Er:YAG laser and the R 14 contact hand piece (extension) , and they were treated with different radiation energy in order to determine the most optimal pulse terms of energy and frequency for apex resection . Pulse width, i.e. pulse duration was constant and 100 msec (VSP Mode), so that all samples are treated equal. After the results, these four groups were compared with the fifth group who was treated with mechanical hand piece and is used as a control group.

For all five groups of research we analyzed average time of resection (Table 1). In group I, where the teeth were treated with 300mj and 30Hz, average time of resection accounted for 65,4 ± 7,4 sec, with a minimum of 57,1 sec and a maximum value of 81,2 sec. The calculated mean values or median show that in 50% of teeth at the time of resection group was greater than 63,6 sec. In group II where the teeth were treated with 300 mj 20Hz and average time of resection accounted for 77,3 ± 5,9 sec, with a minimum of 68,1 sec and a maximum value of 90,2 sec median indicates that in 50% of teeth in this group the time of resection was greater than 78,1 sec in group III where teeth were treated with 200mj 30Hz and average time of resection amounted to 130,0 ± 7,0 seconds, with a minimum value of 115,2 sec and a maximum value of 141,2 sec. The median indicates that in 50% of teeth in this group the time of resection was greater than 129,1 sec. In the treatment of teeth with 200mj and 20Hz, group IV, the average time of resection amounted 318,8 ± 21,6 sec, with a minimum value of 286,6 sec and a maximum value of 352,2 sec. In median obtained for this group, with 50 % of decay time of resection was greater than 315,2 sec. In the control group treated with mechanical hand piece (Group V) the average time of resection accounted for 39,4 ± 2,8 sec, with a minimum value of 34.5 and a maximum value of 43,5 sec. In median obtained for this group, with 50 % of decay time of resection was greater than 39,7 sec. The results of descriptive analysis indicate that in the groups treated with different pulsed energy shows different effect, i.e. by reducing pulse energy from Group I to Group IV shows declining ablative effect of laser or extended time of resection.

Table 1: Descriptive analysis of the average time of resection

Time of resection (sec)						
Groups	Means	Std.Dev.	Std.Err.	Minimum	Maximum	Median
Group I 300 mj / 30 Hz	65,4407	7,4097	1,91319	57,1200	81,1500	63,6200
Group II 300 mj / 20Hz	77,3413	5,9156	1,52741	68,1200	90,1500	78,0500
Group III 200mj / 30Hz	130,0187	6,9550	1,79577	115,1500	141,2200	129,1100
Group IV 200mj / 20Hz	318,7513	21,5504	5,56430	286,5500	352,1800	315,1900
Group V Mechanical hand piece	39,3527	2,8421	0,73382	34,5200	43,4800	39,6500

Damage of the resected root surface

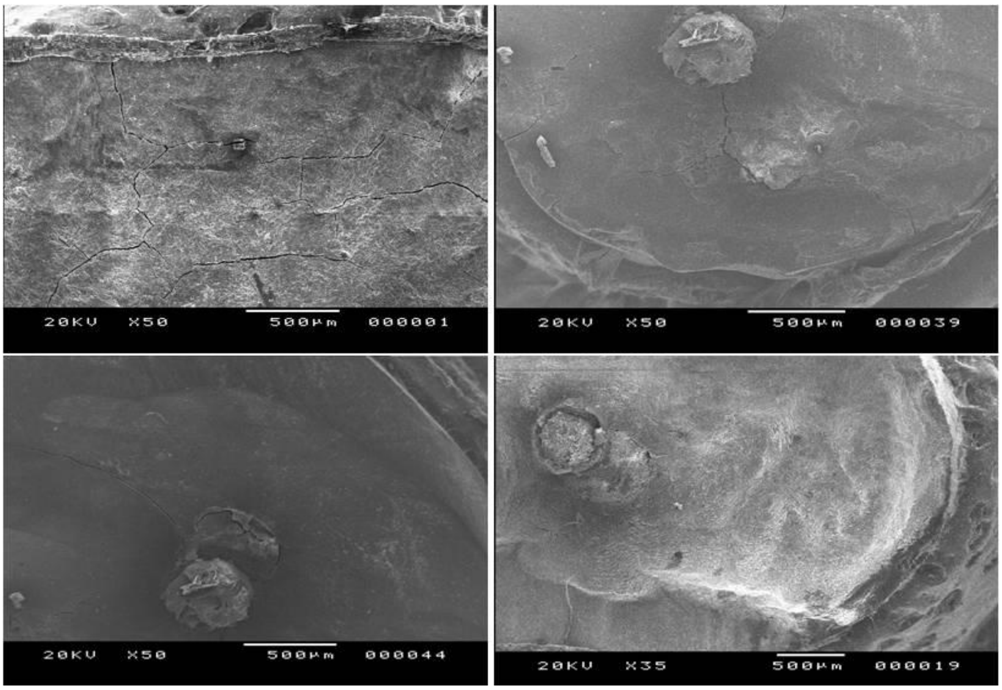
Descriptive analysis of damage of the resected root surface, expressed by the average number of cracks for each of the five studied groups is shown in Table 2. In group I, after treatment with 300 mj / 30 Hz, the average number of cracks equals 5,5 ± 1,8 with a minimum of 2 and maximum 9 cracks . According to the median in 50 % of teeth in this group the number of cracks was sixth In group II, after treatment with 300 mj / 20Hz, the average number of cracks equals 3,5 ± 2,4 with a minimum of 1 and maximum 8 cracks . The median indicates that in 50 % of teeth in this group the number of cracks was third Treatment with 200mj / 30Hz in group III, resulting in an average of 2,7 ± 2,6 cracks . The minimum number of registered cracks in this group is

0 and the maximum is 7. Median third group indicated that 50 % of the teeth in this group the number of cracks is three. The average number of cracks in group IV, treated with 200mj / 20Hz equals 0,6 ± 1,0. The minimum number of registered cracks in this group is 0 and the maximum is 3. In 50 % of the teeth in this group the number of cracks was 0. In group V, with mechanical hand piece, the average number of cracks equals 0,3 ± 0,8. The minimum number of cracks in this group is 0 and the maximum three. It is remarkable that the minimum and maximum number of cracks on the resected surface and median of Group IV and Group V are identical and the smallest compared with other groups , and they are the biggest in group I followed by group II (Table 2) .

Table 2: The average number of cracks in groups

Number of cracks						
Groups	Means	Std.Dev.	Std.Err.	Min.	Max.	Median
Group I 300 mj / 30 Hz	5,533333	1,846490	0,476762	2,000000	9,000000	6,000000
Group II 300 mj / 20Hz	3,533333	2,356349	0,608407	1,000000	8,000000	3,000000
Group III 200mj / 30Hz	2,666667	2,609506	0,673772	0,000000	7,000000	2,000000
Group IV 200mj / 20Hz	0,600000	0,985611	0,254484	0,000000	3,000000	0,000000
Group V Mechanical hand piece	0,333333	0,816497	0,210819	0,000000	3,000000	0,000000

Figure 1: Resected root damage area: a) above 7 cracks using 300mj/30Hz b) 3-5 cracks using 300mj/20Hz c) with one crack and no cracks 200mj/20Hz using mechanical hand piece.



Number of cracks of the resected area were grouped into four groups: 0, 1 to 3, 4 to 6 and ≥ 7.Results of Multiple Response Analysis of the number of cracks in tested groups are presented in Table 3. The analysis suggests an impressive number of teeth,12 (80 %) of group V and 10 (66.67 %) of group IV who do not have cracks on the resected area . In these two groups not a single tooth is registered ≥ 4 cracks, in 100 % of cases on resected area has up to 3 cracks. Most of the cracks has resected area in group I and group II which is subsequently registered 9 (80 %) or 2 (13.33 %) cases with 4-6 cracks and 4 (26.66 %) and 3 (20 %) cases with ≥ 7 cracks . In these two groups there is no tooth where there were no cracks or a " 0" cracks . Interestingly, the perception that the 10 (66.66 %) cases in group III, on resected area have up to 3 cracks or more than 1/ 3 or 5 (43.33) %have ≥ 4 cracks .

Table 3: Number of cracks resected surface groups

Groups	Number of cracks on the resected area				Total
	0	1 - 3	4 - 6	≥ 7	
Group I 300 mj / 30 Hz	0	2	9	4	15
	0,00%	13,33%	60,00%	26,67%	100%
Group II 300 mj / 20Hz	0	10	2	3	15
	0,00%	66,67%	13,33%	20,00%	100%
Group III 200mj / 30Hz	5	5	3	2	15
	33,33%	33,33%	20,00%	13,33%	100%
Group IV 200mj / 20Hz	10	5	0	0	15
	66,67%	33,33%	0,00%	0,00%	100%
Group V Mechanical hand piece	12	3	0	0	15
	80,00%	20,00%	0,00%	0,00%	100%
Total	27	25	14	9	75
	36,00%	33,33%	18,67%	12,00%	100,00%

DISCUSSION

Rapid technological progress in all spheres of human life led to new and modern methods in the treatment of various diseases. One of these new discoveries is LASER who found application in medicine, in all its branches, especially in dentistry. It is predicted that dental laser will be a tool of the 21st century who will replace conventional mechanical hand pieces.

The first parameter that we examined was the time of resection. The results of the descriptive analysis suggest that the groups treated with different pulsed energy shows different ablative effect i.e. by reducing pulse energy is noticeable decline of ablative effect of laser or extended time of resection. Miletic et al. [2] notes that VSP technology of Er-YAG laser that operates at a maximum power level which laser can produce, shows more efficient than mechanical hand piece during the work in hard dental structures.

These our findings correlate with the results of the examination of Grgurevic et al. [3] who observed no significant difference between the groups studied, with the exception of group C (where most energy used) and mechanical hand piece. Time of resection is the lowest i.e. ablative effect is greatest in the first group where pulse energy is greatest, and the time of resection is the longest i.e. ablative effect is lowest in the fourth group where the pulse energy is lowest. Another author who has studied the time of resection is Komori [4] who concluded that although the speed of the cutting during the apicotomy is slightly slower than the classical methods, the clinical application of laser has many advantages such as the absence of discomfort and vibration, less chance for contamination of the operative field and a reduced risk of trauma to the surrounding tissue. This assertion is contrary to the claim of Shimizu et al. [5], which says that the time of apicotomy with Er: YAG laser is shorter compared with the same intervention performed with handpieces. Miletic et al. [2] claims the opposite of our findings by saying that the work with max. parameters (max mode) and 1000mj/20 Hz laser removes 3.3 times bigger amount of enamel than removal with mechanical hand piece for same period, while in dentin is removed from 8 to 18 times bigger amount of volume with the laser than with drill for the same time period. So this author concludes that the work with Er-YAG laser that work in max mode is more efficient and faster than the work with mechanical hand piece.

Another parameter that was analyzed was damage on the resected root surface. Damage that often appear were cracks on the surface. These cracks are important because of the possibility of migration of bacterial strains present in dental trabecular structure and accessory untreated channels, and compromising the derived intervention. Fildishevski [6] indicates that survival of bacteria in three-dimensional tubular network of root canal can be considered the main reason for failure of endodontics treatment. Pathogenic flora commonly is composed from gram-positive and gram-negative bacteria, which directly affect the creation of inflammatory periapical process. Removing of these bacteria and their toxins is an immediate requirement for a successful endodontic treatment.
During conventional root canal treatment with chemo-mechanical methods, infected pulp tissue and dentin layers of the root canal can be removed only to some extent. While the morphology of the root canal limit the scope of mechanical preparations, chemical solutions are effective only on the dentin layers that lie directly to the wall of the channel.

According Kouchi [7] bacteria are able to invade the periluminal dentin to a depth of 1000µm, while penetrating depth of chemical solutions is limited to 130µm.Because of this lack of penetration into depth of bactericidal agents, pathogenic bacteria survive and represent the cause of cases resistant to therapy and performed operational failures after intervention.

Permeability of the dentin exposed after apicotomy is one of the reasons for failure in surgery, because of the micro cracks and bacterial contamination, which comes to inflammation [8]. Pekora et al. [9] reported that the dentin permeability decreases when smear layer is found on the resected apical third of the root canal . On the other hand, removing of smear layer after apicotomy is useful because it enables the deposition of cement on exposed tooth surface and favoring tissue repair. According Pozza et al. [10] the following operational techniques for apicotomy have the smallest micropermeability:1) apicotomy with mechanical hand piece and treatment of apical surface with Nd: Yag laser, 2) apicotomy with drill and treatment with CO_2 laser and 3) apicotomy with Er:
YAG and treatment of the apical surface with Nd: YAG laser.

Gouw-Soares et al. [11] claim that the main failure after apicotomy is because of the penetration from the dentin surface and the cracks in the channel charge, which allows percolacion and migration of microorganisms and their products from the root channel system into the periapical region, which compromise periapical healing. Tests performed with infiltration of methylene blue on dentin surface and analysis with electron microscopy showed that the group treated with laser has significantly less index of infiltration than other treated with mechanical drill. The group treated with the Er: YAG laser showed a clean flat surface, without spoiled layer (smear layer) and steady homogeneous recrystallization of dentin on irradiated area, closing dental tubules. [1]

The average number of cracks in group II was significantly different relative to the groups I, IV and V but does not show significant difference compared to Group III. In group III, the average number of cracks is significantly different compared to the groups I and IV, the difference was not significant compared to group II. The average number of cracks on the resected surface in group IV is significantly different compared to the groups I, II and III, and no significant difference in terms of the group V. From analysis of the average number of cracks on resected surface, there is insignificant difference between groups II and III and between groups IV and V. This suggests that work with mechanical hand piece and work with laser with parameters 200mj/20Hz gives roughly the same damage, i.e. gives at least damage of resected area.

The results of De Moura et al. [12] correlate with our obtained in equivalent conditions of work. Resected area showed a greater number of cracks during the increase of energy. In tests with electron microscopy, results showed the surface with present smear layer during resection with mechanical hand piece, while laser-treated surface was uneven with big number of cracks.

CONCLUSIONS

According to the results of the survey were adopted the following conclusions: rising of pulse energy and pulse frequency leads to increase of ablative effect of the laser, resulting in a shortening of the time of resection. Increasing of pulse energy and pulse frequency, i.e. reducing the time of resection, increases the damage and the number of cracks on resected tooth surface. Ideal pulse parameters amount 200mj / 20Hz followed by 200mj/30Hz having equivalent effect or subsequently three times greater risk of cracking from mechanical hand piece and six times longer during resection of the tooth surface. Resection with mechanical hand piece still represents the gold standard for performing apicotomy in terms of shortest time and slightest damage of resected tooth surface.

REFERENCES

[1] Camaro C, Selma C. Lasers in Dentistry, 1988,196-205
[2] Miletic I,Barbara A et al. Photomed laser Surg. 2009 Dec;27(6):921-7
[3] Grgurevic J. Lasers Surg Med. 2005 Jun;36(5):347-50
[4] Komori T,, Keiko Y. et al. Journal of Endodontics,1997,vol 23.issue 12,p.748-750
[5] Shimitzu, Takashi Koba et al. J.Oral Laser Applications 2008,bvol 4
[6] Fildishevski A. Magisterski trud, Skopje 2007
[7] Kouchi Y,Ninomyia J. J Dent Res 1980;59(12):2038-2046
[8] Lee BS, Lin CP ,Lin FH, Lan WH. Lasers Surg Med. 2002;30(3):246-52.
[9] Pecora JD, Cussioli Al et al. Braz Dent J. 2001;12(1):27-30.
[10] Pozza DH.Fregapani PW et al. J App.Oral sci.2009;17(6):596-9
[11] Gouw-Soares S, Stabholz A, Lage-Marques JL, Zezell DM, Groth EB, Eduardo CP. J Clin. Laser Med Surg, 2004 Apr;22(2):129-39
[12] De Moura AA. et al. Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 2010 Apr;109(4):e77-82.