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Computed Tomographic Evaluation of Tooth Growth in Response to Diode Laser Irradiation in Rabbits

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Abstract:

BACKGROUND: While many dental procedures induce pulpal damage by increase the temperature, this study was established to evaluate the thermally effect of different laser methods on pulp, oral soft and hard tissues.

OBJECTIVES: In this study, laser irradiation applied to measure how increased in power output can influence on dental pulp by using CT images.

METHODS: Ten adult New Zealand white rabbits were divided into 2 groups receiving 3 and 5 watt for 15 second respectively on left side cheek teeth after shortening of third upper and first lower premolars. Right cheek teeth trimmed as well and served as control. CT scans were taken immediately after lasing and repeated every week for one month.

RESULTS: The statistical analysis of dental measurements shows that teeth length of right and left third upper premolar was significantly different during time (P<0.012). While in first lower premolar there was no significant differences between right and left sides (P=0.338). In every week CT, group one showed no differences in right and left side in comparison to group two (P>0.05). Only third upper premolar in fourth week showed a significant difference between two groups (P=0.047).

CONCLUSIONS: laser radiation could influence on tooth growth in both groups. This study revealed that the higher laser power would have been more effective on reduction of growth rate of teeth. In addition, 3D CT scans could be an appropriate tools for dental growth investigation.

Keywords:

CT images, Dental growth, Laser irradiation, Rabbit, Thermal damage

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Introduction

In human dentistry, high temperature made during most different dental procedures can cause unwanted injuries to the vital dental pulp (Kwon et al., 2013, Zach and Cohen, 1996). Thus, to reduce the thermal damages to the pulp or surrounding tissues, it is required to find new ways in each technique.

After invention of laser, many different researches started to find various potentials of each types of laser on dentistry. In this way, side effects like thermal damages on dental pulp reported, as one of the most problematic issues by using laser therapy. An in vitro study on 809-nm GaAlAs laser suggested that time of irradiation as well as the power are the two parameters that can rise the temperature from 0.5 to 32.0 C. (Kreisler et al., 2003).

In another study intra pulpal temperature during pulsed Nd: YAG laser irradiation increased significantly by increasing power, frequency and time (White et al., 1994).

Klunboot et al., (2012) study demonstrated that the higher power densities of the diode laser is correlated with higher temperatures of pulpal tissue.

Miserendino et al., (1994) studied pulsed Nd:YAG laser energy delivered with simultaneous air and water cooling showed no histologic damage from that of normal untreated teeth on rabbit dental pulp. These findings suggests that laser wavelength, power output, time of radiation, pulse or continuous mode of radiation and using water cooling spray are ways to make the least damages on vital pulp.

The diode laser is classified as solid lasers with wavelength ranges from 800-1064 nm. While different wavelength have different absorption tendency, the 980 nm diode has affinity to absorb by pigmented tissue and hemoglobin. Diode beams are poorly absorb by dental hard tissues (enamel, dentin, bones) and can penetrate them to reach target blood elements accumulated on pulp. The advantages of diode laser such as small size and being portable and cost benefit make it one of the most applied laser instruments on human dentistry. (David, Gupta 2015).

Rabbits (Oryctolagus cuniculus) have hypsodont dentition which means long crowned (Hypsodont) continuous growing whole lifetime (Elodont) teeth.

Ever growing feature of rabbit teeth make it suitable as a dental model to evaluate the thermal effect of laser irradiation on vital pulp.

The aim of this study was to evaluate the destructive effect of 2 different power of diode laser irradiation on dental pulp measuring by computed tomographic scans as a useful clinical instrument.

Materials and Methods

Ten adult New Zealand white rabbits (mean body weight 2.5- 3 kg) were housed individually in boxes. All animals fed complete pellet diets and water was accessed ad libitum.

Laser method: Rabbits divided in 2 groups of 5 animals in each. The animals anesthetized with ketamine 10% (alfasan, Holland), (30- 35 mg/kg) intramuscularly in combination with xylazin 2% (alfasan, Holland), (5 mg/kg). At the beginning of the procedure, the first premolar of lower (PM1) and third premolar of upper (PM3) cheek teeth of either side were shortened on occlusal surface using diamond burr. This

shortening used as a land mark for growth and wear on CT images.

In both groups, left lower and upper cheek teeth treated with laser beam and right lower and upper cheek teeth left just trimmed and left without lasing, so served as control.

A continuous 980 nm wavelength diode laser (Doctor Smile, Italy) with microfiber diameter of 400 µ were used. Irradiation was performed by direct contact of fiber with tooth surface. Group 1 received radiation of 3 watt for 15 second on left upper and lower cheek teeth. Group 2 received radiation of 5 watt for 15 second on left upper and lower cheek teeth as well.

Computed Tomography: CT scans were obtained using SOMATOM spirit Dual CT scanner (Siemens, Germany). Images were acquired at 130 KV, 90 mA, slice thickness of 1 mm. CT of the head was carried out immediately after laser irradiation and then repeated in one week intervals during a month. For this procedure rabbits were taken under general anesthesia.

CT images of the skull were investigated by Syngo MMWP Software (Siemens AG, Germany). The length of shortened teeth were measured in sagittal plane from apex to the occlusal surface for upper premolars and occlusal surface to gingival margin for lower premolars. Also three-dimensional images were taken for investigation of how shortened landmark teeth change during time after irradiation.

Statistics: All analyses performed in SPSS 16.0 with the significant set to 0.05. Tooth length measurements of right and left sides in each upper and lower jaw in different time points compared using Repeated measures ANOVA. Independent samples t-test used to compare differences between 2 groups.

Results

Three-dimensional imaging findings: Trimming about 2-3 mm of third upper premolar (PM3) and first lower premolar (PM11) of right and left side of the jaw performed as a land mark for three-dimensional CT images (Figure 1, 3, 5). This defect expected to remain by passing time in lased teeth of left side and wear off in control side (right side). Height differences between trimmed PM3 and PM1 with adjacent teeth was clearly visible in images immediately taken after trimming. Land mark in right side of both groups and left side of group one worn off during 4 weeks of study so that the occlusal surface of upper teeth reached to opposed jaw (Figure 2,4). While left land marks in group 2 was still remained at the end of 4 weeks and it was detectable on 3D images (Figure 6).

In group 2, coronal elongation of first upper premolar is detectable since third week post trimming.

Tooth length: In right side dental length increased during 4 weeks ($P<0.001$ for PM3; $P<0.017$ for PM1). The changes in teeth length of right and left PM3 was significantly different during time ($P<0.012$). While in PM1 there was no significant differences between right and left sides ($P=0.338$).

In any time point (each week) group one comparing group two showed no differences neither in right nor left side of upper and lower jaw ($P>0.05$). Only PM3 in fourth week showed a significant difference between 2 groups ($P=0.047$) (Figure 7,8).

Discussion

As described before, examination of dental growth by means of CT scan is a sensitive

Figure 1. 3D image of right side immediately after trimming of PMs (Control). The defect in PM1 and PM 3 is clearly detectable.

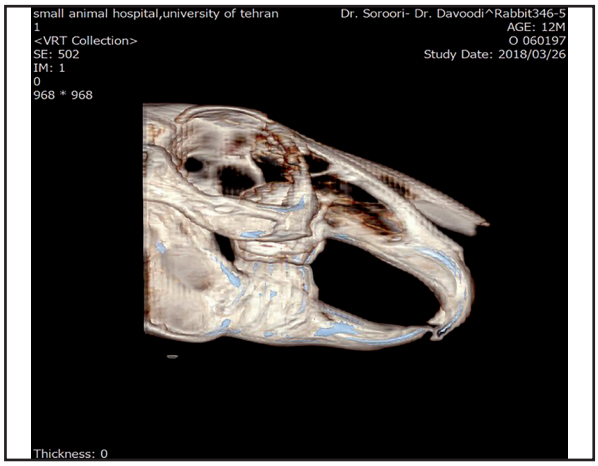

Figure 2. 3D image of right side after 4 weeks. The defect is not detectable any more.

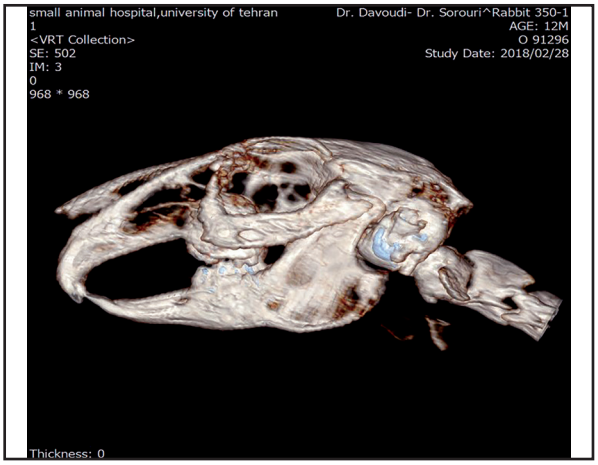

Figure 3. 3D image of left side teeth in group 1 immediately after trimming and lasing of PMs.

Figure 4. 3D image of left side teeth in group 1 after 4 weeks.

Figure 5. 3D image of left side teeth in group 2 immediately after trimming and lasing of PMs.

Figure 6. 3D image of left side teeth in group 2 after 4 weeks. The defect is still remained.

method and obtains accurate information (Riggs et al., 2017). In 3dimensional computed tomography of sagittal and oblique view, clinical crown and shortened marker teeth (PM3 and PM1) was obviously detectable immediately after trimming and lasing.

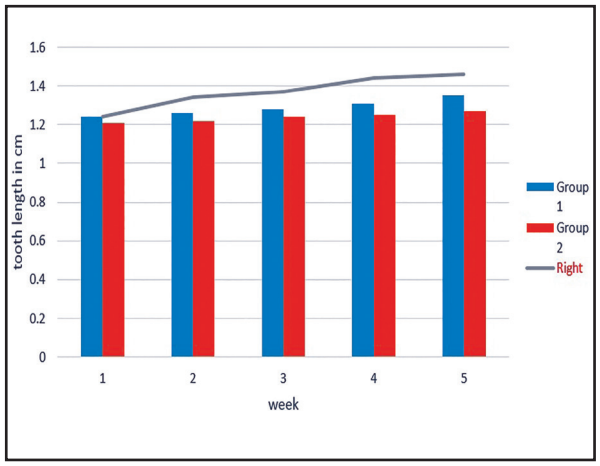

Figure 7. Tooth length. Mean total length of PM3 of group 1 and 2 in left side in 5 time point; time 0: immediately after trimming, 1 to 4: with 1 week intervals; measurements on Centimeters.

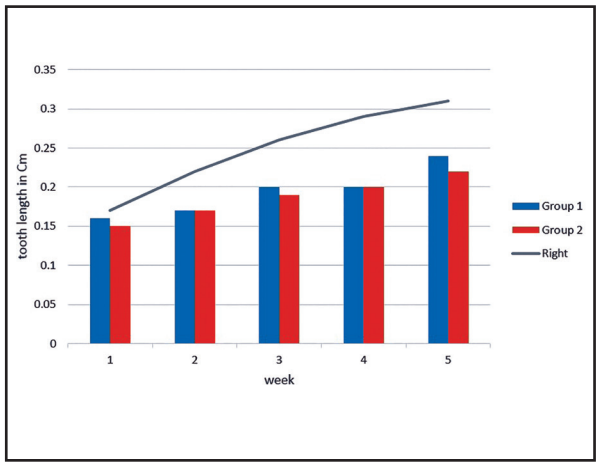

Figure 8. Tooth length. Mean total length of PM1 of group 1 and 2 in left side in 5 time point; time 0: immediately after trimming, 1 to 4: with 1 week intervals; measurements on Centimeters.

Since the pulpal temperature changes are often measured in vitro, for evaluation of potential thermal damages of laser beam on vital dental pulp in vivo situation, rabbits with ever growing teeth seem a proper animal model.

By passing time, non-lased right trimmed PM1 and PM3 grew and reached to occlusal surface of opposed teeth. In fourth week scans the induced defect worn off completely in right side of both groups. By considering the growth rate of about 1 mm/week which is suggested in most previous studies (Bohmer, 2015) and no irradiation on right teeth, gradual growing of trimmed teeth was expected.

In contrast, the defect of left trimmed teeth which received laser beam were still remained and were detectable in every week scans. Additionally, Left side teeth showed less changes in length which can be explained by effect of laser irradiation on dental pulp to cease growing. This effect is more obvious in group 2 of 5 watt radiation power, rather than 3 watt in group 1. The measurements of tooth length were in consistent with 3D images investigation.

The difference of total tooth length between 2 groups was significant in fourth week after lasing, which support that by passing time teeth of group 1 had higher growth rate than group 2. These effects can be supported by previous studies which demonstrate increase in laser power is one of the most important factors which induce thermal damage on vital pulp (Kivanc et al., 2012, Soleiman et al., 2006).

Although the total length of right Pm1 was slightly higher than left PM!, we did not find any significant difference between them. Maximum control of laser-tissue interaction can be achieved if the incident laser beam is perpendicular to the tissue surface. Reducing the incident angle towards the refractive angle of the tissue surface will increase the potential for true light reflection with an associated reduction in tissue change (Gaspar, 1991). As the first premolar of mandible is anatomically curve, it might hypothesized that laser beam may be more scattered or reflected rather than be absorbed by target organs on pulp (Hemoglobin).

Always there is a correlation between growth and wear of cheek teeth in normal

situation (Muller et al., 2014, Wyss et al., 2016). The fact that the trimmed left lower PM1 was being occupied by left upper PM1 can be explained by the difference between growth rate and wear rate. While the growth stops over 4-week period, the wear continues.

Zach and Cohen (1965) study in a monkey model, suggest that a 5.5°C temperature rise was likely to cause irreversible pulpal damage. This threshold has been used in many studies to evaluate how different methods affect pulpal damage.

By considering this threshold as pulpal damage, the laser power of higher than 3 watt might be harmful to the pulp (Sulieman et al., 2006, Klunboot et al., 2012). In contrast, an in vitro study on human intra-pulpal temperature rise between 8.9°C and 14.7°C did not produce pulpal injury (Baldisara et al., 1997).

As a future direction and to confirm the results of this study, it is recommended to evaluate the histopathologic effects of laser irradiation on the dental pulp. In conclusion, a high power of the laser above safety guideline may stopped growing of ever-growing teeth of rabbits as a land mark for pulpal injury. This effect is related to high power output, continuous time of radiation, using no cooling methods.

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Conflicts of interest

The author declared no conflict of interest.

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مجله طب دامی ایران، ۱۳۹۷، دوره ۱۲، شماره ۴، ۳۱۲-۳۰۵

بررسی چگونگی تغییرات رشد دندانی خرگوش پس از تابش لیزر دایود با استفاده از تصاویر سی تی اسکن

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چکیده

زمینه مطالعه: از آنجایی که بسیاری از اقدامات دندان پزشکی با تولید حرارت سبب آسیب به بافت زنده پالپ می شوند، مطالعات متعددی جهت بررسی اثرات تخریبی حرارت تولیدی ناشی از تابش لیزر بر روی پالپ دندانی شده است.

هدف: در این مطالعه، تابش انرژی های متفاوت لیزر بر رشد دندانی با استفاده از سی تی اسکن مورد ارزیابی قرار گرفت.

روش کار: ده سر خرگوش نیوزلندی سفید به دو گروه تقسیم شدند. دندان گونه ای سوم فک بالا و اول پایین هر دو سمت راست و چپ برای اندازه گیری میزان رشد کوتاه شدند. بر این اساس در هر گروه دندان های گونه ای سمت چپ هر کدام مورد تابش لیزر با انرژی تابشی به ترتیب ۳ و ۵ وات و هر کدام به مدت ۱۵ ثانیه قرار گرفتند.

نتایج: بررسی آماری اندازه طول دندان ها نشان داد که بین طول سومین دندان راست و چپ فک بالا در طول زمان اختلاف آماری معنی داری وجود داشت ($P<۰/۰۱۲$). در حالیکه تفاوت آماری معنی داری بین طول اولین دندان گونه ای سمت راست و چپ فک پایین در طول زمان وجود نداشت($P=۰/۳۳۸$). در تصاویر هر هفته، گروه ۳ وات بین سمت راست و چپ تفاوتی در رشد دندانی در مقایسه با گروه ۵ وات نداشت ($P>۰/۰۵$). تنها در هفته چهارم این تفاوت بین دو گروه معنی دار بود ($P=۰/۰۴۷$).

نتیجه گیری نهایی: این مطالعه نشان داد که انرژی تابشی بالای لیزر می تواند بر روی رشد دندانی تاثیر بگذارد و با بالا رفتن انرژی تابشی اثرات کاهشی در رشد دندانی بیشتر خواهد شد.

واژه‌های کلیدی:
سی تی اسکن، رشد دندانی، تابش لیزر، خرگوش، آسیب دمایی

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