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CLINICAL AND RADIOGRAPHIC EVALUATION OF HEALING EFFECT OF LOW LEVEL LASER THERAPY ON CHRONIC APICAL LESIONS

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ABSTRACT

Objective: This study evaluated clinically and radiographically, the healing in chronic apical lesions using low level laser therapy (LLLT).

Methods: Twenty female patients between the ages of 20 and 30 years with chronic apical lesions in anterior maxillary teeth diagnosed on the basis of their clinical signs and symptoms and radiographic findings were included in the study. The patients were randomly divided into two main groups according to treatment plan: group I; received conventional endodontic treatment only, group II; received conventional endodontic treatment and then LLLT was used. The low level laser was applied for 120 seconds in the session for three sessions in week for four weeks and the selected parameters were (200 mw, 810 nm, CW). The healing was evaluated clinically, radiographically. Clinically to record pain, swelling, or any other adverse event that occur after treatment for one week. Radiographically to evaluate bone density and area of periapical lesions using cone beam computed tomography (CBCT) and image fusion. Images were obtained immediate after obturation and after the three follow up periods (1, 3 and 12 month) .

Results: clinical signs and symptoms decreased in the lased group faster than conventional group. Pain reduction in the laser group was more effective than the conventional group without significant difference. Bone density analysis showed that Laser had significantly higher bone density after 1 ,3 and 12 month evaluation periods compared to control group ($P<0.05$). Comparing the area values of control and laser groups, a significant difference was found throughout the three evaluation periods compared to the area immediate after obturation.

Conclusions: Based on the results of this study; LLLT favored the healing process of apical lesions especially when combined with nonsurgical endodontic treatment. Image fusion and CBCT can provide an accurate and reproducible method for assessment the healing of periapical lesions.

KEY WORDS: Low-level laser therapy; Bone healing, chronic apical lesions, cone beam computed tomography (CBCT)

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INTRODUCTION

Periapical lesions of endodontic origin represent an inflammatory response to bacterial infection of the root canal. The bacterial infection generally result in total pulp necrosis accompanied by the development of an immune response in the periapical lesions that cause periapical bone destruction [1] .Bone resorption and loss of skeletal mass is the only function of osteoclasts [2].Periapical radiolucency is the most pronounced clinical hallmark of these lesions. Most, but not all, periapical lesions will heal in response to properly performed endodontic treatment [3].

The occurrence of chronic apical disease can remain unnoticed for prolonged periods of time or a patient in pain may seek dental care. Clinically, the existence of apical pathosis may be detected by sensitivity to biting or percussion, but asymptomatic apical periodontitis frequently does not elicit such a response [4].

The scientifically documented procedure for the best results in canal disinfection of teeth with apical periodontitis is based on complete debridement and irrigation of the root canal during the first appointment [5], followed by the application of calcium hydroxide [Ca (OH)2] dressing[6] .Obturation of the root canal is then performed at the second or later appointment [7].

It has been shown that treatment with Ca (OH)2 as an intracanal dressing in the presence of periapical lesions can create environment more conductive to healing and start bone repair [8]. Ca (OH)2 is an effective intracanal antibacterial agent because of its high PH 12.5 with bactericidal and bacteriostatic effect [5-8] .

Conventional intraoral periapical radiography remains the standard for radiological diagnosis of existence, persistence or healing of apical periodontitis [9]. Digital radiography has become widespread since the 1980s; it reduced patient dose and eliminated development time [10]. Cone beam computed tomography (CBCT) has been introduced in the 1990s and has found a variety of indications in endodontics [11]. It has also been suggested to be superior in detecting periapical bone loss in situations where no pathosis was detected in periapical radiographs [12] CBCT can be used for more precise radiographic evaluation of periapical lesion areas measured in different follow-up periods, owing to the method's ability to detect extremely small bone changes [13-16] .

Low level laser therapy (LLLT) is the application of light usually a low power laser in the range of 1 mw to 500 mw [17] using wavelengths usually in the red and near-infrared spectrum (600-1000 nm), because other wavelengths are absorbed by melanin pigments in skin, hemoglobin in blood or water in tissues and do not reach the mitochondria of target tissues [18]. LLLT uses photonic energy to provide biological therapeutic advantages and is considered a noninvasive and painless process [19]. The biostimulatory and inhibitory effects of lasers are based on Arndt-Schultz Law, which indicates that weak stimuli will increase physiological processes and strong stimuli will inhibit physiological activity [20].

Some studies indicate that LLLT stimulates cell proliferation [18], osteoblast activity, vascularization, and collagen deposition [19]. During the initial stages of bone repair, LLLT increases the expression of osteogenic genes and stimulate new bone formation [20].

Several studies have demonstrated that the nonsurgical near-infrared laser is more suitable for bone repair, due to deeper penetration in bone tissue when compared to visible laser [21]. Although the use of LLLT on bone healing biomodulation has been growing steadily and several studies have demonstrated positive results on the healing of bone tissue [18-21]. Few studies had attempted quantitative assessment of the effects of LLLT on periapical healing by CBCT. In this way, considering the above mentioned differences in the healing process of periapical lesions, along with the biomodulation activity of LLLT, the aim of the present study was to evaluate the effect of LLLT both clinically and radiographically on healing of periapical lesions.

MATERIALS AND METHODS

Selection of the cases

The clinical design and protocol of this study were approved by the research ethics committees of Oral and Dental Medicine, Cairo University (9/6/2014). All patients underwent endodontic treatment in the Endodontic Department, Faculty of Oral and Dental Medicine, Cairo University.

Twenty female patients with chronic apical periodontitis of maxillary anterior teeth were selected and their mean age was 25± 2.99 years (range 20 -30 years). These patients were seen over one year period, from August 2014 to August 2015. The patients were treated after they had been informed of the benefits of the planned procedures. All provided written informed consent to participate in this study.

All Selected patients were systemically healthy and not receiving any medication at the time of study. The inclusion criteria were as follows; accepted oral hygiene, no evidence of gingival inflammation, no evidence of acute oral infection.

Endodontic procedure (treatment)

Teeth were subjected to a common two- visit root canal treatment. In the first visit, access cavities, cleaning and shaping of root canals was done by a step back technique using hand files with intermittent irrigation with 2.5% NaOCl (Clorox, Nobelwax Factories for chemicals, Egypt). $Ca(OH)_2$ (Sigma chemicals, sigma-Aldrich cheme Gmbh, Germany) mixed with saline was placed as intra canal medicament. Access cavities restored with Glass ionomer (Medifil; Promedica; Neumuenster/ Germany) until the next visit. On the second visit, the tooth was checked for any symptoms such as pain, swelling, sensitivity to percussion, or which took place 7 days after the first visit, Patient recalled after a week for review. During the recall visit, after removing the Glass ionomer coronal filling, the root canals were irrigated by using 1 mL 15 % EDTA (Endo-Solution, Cerkamed, Stalowa Wola, Polska). to remove the smear layer, and the root canals were filled with gutta-percha (Meta Biomed, Cheongju, Korea) and zinc oxide eugenol sealar (Dentsply DeTrey, Konstanz, Germany) by using a lateral compaction technique.

Study design (Grouping of the cases)

The selected twenty cases were randomly divided in two equal groups. The control group cases received conventional endodontic treatment only without low level laser irradiation. Laser group cases received low level laser irradiation after conventional endodontic treatment.

Laser irradiation

Irradiation schedule with a total of 12 sessions postobturation; started with immediate postobturation session, and then the following irradiation sessions were delivered to the patients as three session per week on a "day on day off" basis within four week. Infrared low power diode laser device locally manufactured (photon Scientific, Industrial area – Qaliub, *Egypt)* was used in this study for irradiating the laser group. The laser device is 810 nm with output power of 200 mW (at the end of the intraoral tip), the total exposure time was 120 seconds. per tooth periapical lesion from labial side. The laser beam was a continuous wave (C W), and the laser delivery tip was used in contact mode.

Evaluation of treatment

Patients were clinically and radiographically **we**re evaluated immediately after obturation. Clinical evaluation was done daily for one week and radiographic evaluation was done one, three and twelve month after obturation.

a) Clinical evaluation of the treatment

The investigated teeth and surrounding tissues were clinically examined for any signs of inflammation, namely pain, swelling, tenderness to percussion or any other adverse event that occur after obturation for one week .

Pain evaluation

A visual analogue pain scale was given to each patient to record pain preoperatively. The patient's mark on the horizontal scale represented the intensity of pain experienced at the selected time according to the following criteria; (1) No pain: the treated tooth felt normal,(2) Slight pain: the tooth involved was slightly painful for a time, regardless of the duration, but there was no need to take analgesics, (3) Moderate pain: the tooth involved caused discomfort and/or pain, which was either tolerable or was rendered tolerable by analgesics,(4) Severe pain: the pain caused ,by the treated tooth disturbed normal activity or sleep and analgesics had little or no change in pain score after treatment(22). Pain evaluation was done through studying the change in pain score after treatment and pain absence during follow up.

b) Radiographic Evaluation

Digital Radiographic Evaluation

Digital intraoral radiographs were taken with standardized paralleling technique by the XCP alignment system (Trophy Radiology, 94300 Vin Cennes, Type 6510, France) to obtain pre and postoperative radiographs for comparison for all patients.

Cone beam

CBCT images for the maxillary anterior region were obtained immediately after obturation, one, three and twelve month after endodontic treatment for five cases in each group. CBCT machine (Soredex, Helsinki, Finland) used in this study was characterized by the following: The detector of this machine is composed of CMOS flat panel with isotropic voxel size 133 Um. The X-ray tube used to scan the samples posses a current intensity 16 mA, Kilovoltage 85 Kvp and a focal spot size 0.5 mm. The scanning time was 10 seconds (according to the FOV used) of pulsed exposure resulting in an effective exposure time 3 seconds to scan FOV of 6cm Height x 6 cm Width x 6 cm Depth, FOV adjustment was guided by three laser light beams to centralize the area of interest within the scanning field. Image assessment was performed by a calibrated endodontist and a maxillofacial radiologist using the CBCT software tools Ondemand 3D (Cybermed Inc. Seoul, Korea). Assessment included evaluation of the extent or area of the lesion and bone density. All scan parameters were identical.

Statistical analysis

The collected radiographic data (bone density and area of periapical lesions) were presented as mean and standard deviation values to test the significance of difference during the three follow up periods (1, 3 and 12 month). Newman-Keuls Multiple Comparison Test was used to test the significance of difference during the three follow up periods between the two groups at the different follow up periods (one, three and twelve month). Results were considered statistically significant at $P < 0.05$. Pain data were analyzed by chi-square test.

RESULT

Clinical assessment

Results of clinical evaluation showed that the condition of 14 teeth was asymptomatic (70%) and discovered during radiographic investigation in the other department while in the remaining 6 teeth (30%) were painful. Three patients with painful teeth were included in control group and the other three patients were included in laser group.

For all patients, obturation was done in the second visit after one week from the first visit when the teeth were not painful and canals were dry. Clinical assessment was done daily for one week after treatment and laser application. All the cases became asymptomatic after one week in control and laser groups.

Follow up of pain

Overall comparisons of the two groups

In control group , the change in recorded pain scores during one week after treatment showed that, score 1 was recorded in 70% of the cases immediate after obturation, while it increased to 80% in the second day after obturation and 90% in the fourth day of obturation and 100% in the six day of obturation . Score 2 was recorded in 10% of the cases which disappear in forth day. Score 3 was recorded in 20% of the cases which changed to 10% in the fourth day after obturation and then disappear in the sixth day.

In laser group, the score 1 was recorded in 70% of the cases after the first laser session which changed to 100% after the third laser session. score 2 was recorded in 10% of the cases which disappear after the second laser session (second day). Score 3 was recorded in 20% of the cases which disappear after the third laser session (fourth day) .There was no significant difference between the two groups.

Radiographic assessment

A) Bone density:

Overall comparisons of two groups:

Table 2. *Figure 1*, 2, 3

Regarding the bone density in control group; the bone density at 1, 3 and 12 month was significantly higher than the bone density immediate after obturation ($P<0.001$). The twelve month bone density was significantly the best in control group ($P<0.001$).

TABLE (1): Comparison between the change in recorded pain scores between the control and lased group during one week follow up

Group	Pain score					
	Score 1		Score 2		Score 3	
	No	%	No	%	No	%
Control						
Immediate after obturation	7	70%	1	10%	2	20%
2 nd day after obturation	8	80%	0	0%	2	20
4 th day after obturation	9	90%			1	10%
6 th day after obturation	10	100%	0	0%	0	0%
Laser						
Immediate (1 st laser session)	7	70%	1	10%	2	20%
2 nd day (2 nd laser session	9	90%	0	0%	1	10%
4th day (rd laser session)	10	100 %	0	0%	0	0%

Score 1=no pain score 2=Mild pain Score 3 =Moderate pain Score 4=Severe pain

Regarding bone density in laser group, there was a significant difference between different times of evaluation (P<0.001). Bone density analysis showed that Laser had significantly higher bone density after one month ,3 and 12 months compared to control group (P<=0.05). There was no significant difference in bone density between three month in control and one month in laser and between twelve month in control and three months in laser group.

B) Area of the lesion

Overall comparisons of the two groups:

Table 3. *Figure 1*, 2, 3

In control and laser groups, there are a significantly decrease in the area of the lesion in square millimeter after one, three and twelve month comparing to area immediate after obturation. (p <0.05). Comparing the area values of control and laser groups, a significant difference was found throughout the three evaluation periods compared to the area immediate after obturation. There was a significant difference in the mean of area values between control and laser groups at one, three and twelve month, but there was no significant between three month in control and one month in laser and between twelve month in control and three months in laser group .

TABLE (2) Means ± SD and statistical analysis of bone density in grey scale in control and laser group after different periods of obturation.

Evaluation Periods	Group	Mean ± SD	P value	Significance
Immediate	Control	327.7±11.8 [a]	>0.5	N Sig
	Laser	363.1± 16.9 [a]		
One month	Control	440±17.2 [b]	<0.001	Sig
	Laser	503.7 ± 5.9 [c]		
Three months	Control	539.5 ±25.7 [c]	<0.001	Sig
	Laser	614.9 ±17.8 [d]		
Twelve month	Control	626.2 ±56 [d]	<0.001	Sig
	Laser	741.2 ±12.45 [e]		

*Different Small letters indicate significant difference (p<0.05) by **comparing bone density after different periods of obturation.***

TABLE (3) Means ± SD and statistical analysis of area of the periapical lesion in mm^2 in control and laser group after different periods of obturation

Evaluation Periods	Group	Mean ± SD	P value	Significance
Immediate	Control	27.7±1.8 [a]	>0.5	N Sig
	Laser	23.3± 1.1 [a]		
One month	Control	21±1 .7 [b]	<0.001	Sig
	Laser	16.33 ± 2.3 [c]		
Three months	Control	15.9±2.7[c]	<0.001	Sig
	Laser	11.03 +1.7 [d]		
Twelve month	Control	8.6 ± 2.4 [e]	<0.001	Sig
	Laser	5.38 ±0.8 [f]		

Different Small letters indicate significant difference (p<0.05) by area of the lesion after different periods of obturation.

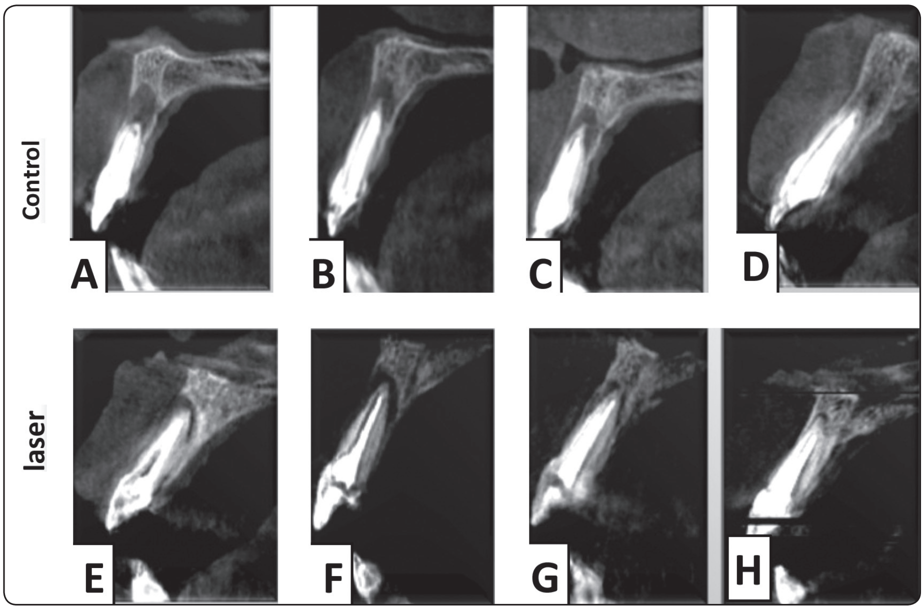

Fig. (1) Cone beam follow up sagittal image for control case and laser case over 12 month period. (A,E) just after obturation, (B,F) one month after obturation (C,G) three month after obturation, (D,H)) twelve month after obturation

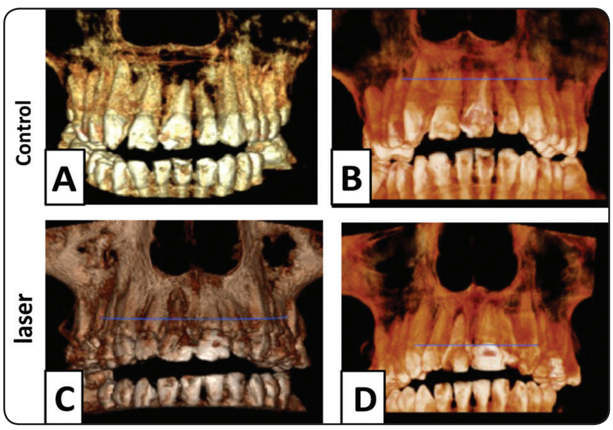

Fig. (2) Cone beam three –dimension image of the periapical lesion area in control and laser group .(A,C) just after obturation, (B,D) twelve month after obturation

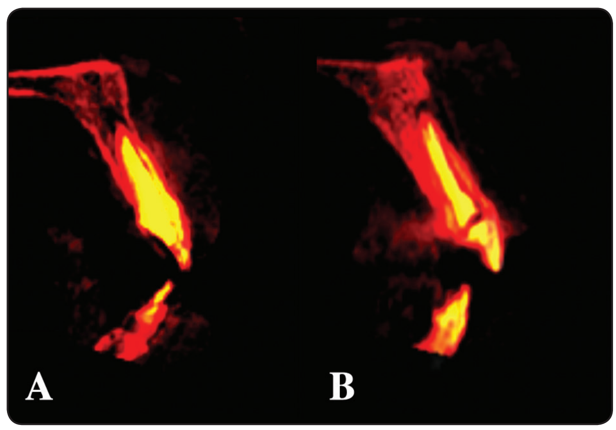

Fig. (3) Fused immediate after obturation and 12 months follows up sagittal image sections in control (A) and laser (B)

DISCUSSION

This study was designed to asses, both clinically and radiographically, the healing effect of low level laser therapy on chronic apical lesions as clinical and radiologic criteria are frequently used to assess the status of endodontic treatment and its correlation with apical periodontitis [23-25].

Periapical lesions of endodontic origin are produced by an inflammatory response at the root apices of teeth with non-vital pulps [26]. The first choice of treatment of periapical lesions should aim to eliminate microbial infection through treatment of the canals, in order to establish an environment favorable to healing [27].

In reference to use the calcium hydroxide as intracanal medicament for one week in all cases of the present study, Ca (OH) 2 has antibacterial effect and can create an environment more conductive to healing and start bone repair [27]. This agrees with the findings of Sjogren et al [8] and other authors who also reported that calcium hydroxide eliminates bacteria from the root canal and stimulate periapical healing through its antinflamatory effect of neutralizing acidic products and stimulation of alkaline phosphatase [28-30] .

Low –level lasers are thought to work by the interaction of light with the cell and tissue. This interaction might be affected by some parameters, such as wavelength, power, energy density, treatment duration, treatment intervention time, method of application, structure, and condition of the tissue [31] .

The 810 nm wavelength of the laser used for bone healing in the present study is within the infrared range and also within the so-called optical window that spans the red and near- infrared wavelengths; this wavelength ensures proper penetration of the laser light into biological tissues .Once light absorption and scattering (which is dependent on the wavelength and its maximal penetration) are obtained in a range between red and near-infrared lights, this interval will provide the ideal penetration into the biological tissue which in accordance with other study [32].

In the present study LLLT was used with multiple low doses on multiple sessions (12 sessions), this provides a stimulatory effect at low doses and has been found to modulate various biological effects. Better biological effects were obtained by irradiation with multiple doses than single high dose. Application of LLLT has been very well recognized as an adjunctive approach in healing of periapical lesions [33, 34].

The clinical observation in this study showed faster healing of clinical symptoms associated with the periradicular lesions in lased group more than unlased one. These observations came in agreement with Alipanah et al (2011) [35] who observed that LLLT with optimal parameters can accelerate full thickness wound healing. LLLT is successfully applied for tissue healing, mainly due to successful activation of the immune system, anti-oedematous effect and anti-inflammatory effect [36]. Further, a potential biostimulation of underlying and surrounding cells, increased collagen organization and promoting of growth factors and cytokines in response to laser irradiation have been demonstrated [18] .

In the present study, the degree of pain absence was faster in lased group as all patients recorded no pain by the fourth day, while in control group complete absence of pain was recorded by the sixth day. This came in agreement with previous studies that have shown the exposure of the gingiva over periapical area to low –level laser can reduce post –operative pain compared to control groups [37].

To date, there are several suggested mechanisms for pain reduction following LLLT application, such as effect in modulating key factors of inflammation, reduction of the prostaglandin E2 level, inhibition of cyclooxygenase, and/or lymphocyte metabolism that could lead to reducing of edema, and further reduction of inflammatory processes [38, 39]. Also, release of endogenous pain relievers – endorphins and enkephalins, the increase in production of serotonin and suppression of bradikinin activity [37, 40] has been suggested. It has been also shown that laser therapy increases systemic micro-circulation by nitric oxide synthesis, causing the reduction in swelling and pain [37] . Even though, there are several potential mechanisms proposed, the real underlying mechanism following laser therapy for pain reduction is yet to be determined. It is believed that not just one, but two or more coexisting mechanisms or their combination are responsible for the beneficial outcome of LLLT in achieving analgesia.

Liang et al [41] reported that the 3D CBCT has been found to be more sensitive than periapical radiographs in detecting periapical lesion treatment outcomes. Bone density values from CBCT might not correspond to values obtained with periapical radiographs. In the present study, the radiolucent area and bone tissue healing were evaluated by CBCT.

To standardize the study, all of the endodontic treatments and bone density values were performed and measured by the same researcher. A region of 2 mm^2 was measured by using CBCT. The lowest bone density values were recorded in gray scale on scanning the periapical radiolucent area in the buccopalatal direction.

The findings of the present study revealed statistically significant differences between the control group and the laser-treated group at 1, 3 and 12 month regarding bone density. However, no statistically significant differences were observed in the bone density between the control group at one month and the laser group at 3 months, also the control group at 3 month and laser group at 12 month. The findings of this study confirm the efficacy of LLLT in bone formation during healing of apical lesions and this may be due to its capacity in the differentiation of undifferentiated mesenchymal cells, osteoblasts [(42)], osteosynthesis and reduction in osteoclastic activity and anti-inflammatory action [(43)], and due to the increase in vascularization [(44)] or the capacity to increase the growth factors released in the periapical site [(45,46)].

In the present study, as regard area of apical lesions, there was statistically significant differences between the control group and the laser-treated group at 1, 3 and 12 month. To evaluate the healing of periapical lesions, Estrela et al [(15)] successfully used CBCT and periapical index scoring to measure radiolucent areas. In the present study, instead of using an index to score bone density, bone density was quantitatively measured. With successful endodontic treatment, a decrease in the radiolucent area and bone tissue healing were observed. Both of these processes could be evaluated with CBCT.

It should be highlighted that there are no universally accepted parameters for the utilization of LLLT in bone healing in periapical lesion so an adequate clinical protocol might be reached in the future for bone regeneration in dentistry.

CONCLUSIONS

Based on the results of this study, it is possible to conclude that LLLT favored the bone healing process in apical lesions especially when combined with nonsurgical endodontic treatment.

Image fusion and CBCT can prove as an important tool for assessment of healing of periapical lesions after nonsurgical endodontic therapy. It is an effective method for evaluating bone density in endodontic treatment so it is a useful tool for observing the bone accumulation in periapical lesions, but there is a need to reduce the radiation dosage.

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