Title
Preliminary report on use of CO2 laser treatment of traumatic pulpal exposure in dogs: a clinical study

Authors
Wilder-Smith, Petra BB
Peavy, George M
Nielsen, David
et al.

Publication Date
1997-05-22

DOI
10.1117/12.275046

Preliminary report on use of CO_2 laser treatment of traumatic pulpal exposure in dogs: a clinical study.

Petra Wilder-Smith, George M. Peavy, David Nielsen, Anna-Marie Arrastia-Jitosho and Michael Berns. Beckman Laser Institute and Medical Center, University of California, Irvine, CA 92612.

ABSTRACT

The objective of this study was to evaluate CO_2 laser surgical treatment of pulpal exposures in canine patients. 17 permanent teeth with exposures of $\leq$48h were randomly allocated to receive either (a) localized laser pulp surgery to remove all compromised soft tissues or (b) localized pulp surgery using a large round sterile bur under sterile saline irrigation. Single laser pulses were used at 0.01s pulse duration, 1.0s pulse interval, a spot size of 0.004cm^2 and an energy density of 276J/cm^2. Exposures were dressed with CaOH and Glass ionomer. Clinical and radiographic evaluations were performed by one blinded clinician 4, 12, 24 and 52 weeks after treatment using standard scales of 0-(-1).15/17 laser-treated teeth assessed over $\geq$1 year post-treatment remained clinically and radiographically healthy.

Keywords: Pulpotomy, CO2 laser, pulp surgery, dogs, root canal treatment

1. INTRODUCTION

When dental decay or traumatic damage in teeth is advanced to the dental pulp, effective treatment after removal of the decayed enamel and dentine must fulfill the following requirements: removal of infected pulpal tissue with minimal damage to underlying healthy pulp tissue; hemostasis; elimination of bacterial contamination in the affected area; stimulation of reparative dentine formation over the pulp wound. At the moment, treatment options are limited. Options include:
(1) formocresol pulpotomy involving amputation of the infected pulp portion, then mummification of the remaining pulp with formocresol. This is a prolonged, painful procedure, and problems with hemostasis, high systemic levels of formaldehyde after treatment, unpredictable and ineonsistent reparative dentine formation are common.
(2) Devitalization and endodontic treatment. Disadvantages of this procedure include discomfort and prolonged treatment duration of endodontic therapy, increased danger of tooth fracture, poor aesthetics, financial cost.
(3) Where the pulpal exposure is pinpoint, direct or indirect pulp capping may be performed. However, a small percentage of cases is deemed suitable for this type of conservative approach and frequent problems obtaining hemostasis often seriously jeopardize the outcome of this treatment option.

Thus, both in primary and in permanent teeth, there exists a real need for viable alternatives to conventional techniques.

Pulpotomy is defined as the surgical removal of part of the coronal pulp in an attempt to maintain the health of the remaining pulp [1]. It is widely accepted that crucial requirements for a successful pulpotomy include minimal trauma and hemorrhage control [2,3]. The CO_2 laser became available over 20 years ago and represented an important breakthrough. It emits an infrared beam at a wavelength of 10.6 μm which is readily absorbed by the water in soft tissue [4]. Thus tissue penetration is minimal and laser effects remain superficial and direct to the impact area. The CO_2 laser as a surgical tool has several desirable characteristics compared with other lasers and with conventional surgical techniques. It has the ability to perform precise, bloodless soft tissue surgery with minimal disturbance of the surrounding tissues [4,5,6]. Furthermore, the potential for sterilization has also been demonstrated [6,7]. The CO_2 laser can be used to sever pulpal tissues

SPIE Vol. 2970 • 0277-786X/97/$10.00

while inhibiting hemorrhage. Because the laser beam has no mechanical contact with the tissue, the incision does not inflict trauma on the remaining healthy pulp tissue. In addition, bacterial contamination can be avoided during surgery, a factor believed to cause internal resorption during calcium hydroxide pulpotomy [8]. In this respect, the CO_2 laser has much to offer to improve the success rate of pulpotomies.

The object of this study was to determine the effectivity of CO_2 laser as an alternate mode for the surgical removal of diseased pulp tissues in dog's teeth. Radiographic and clinical evaluation was conducted for up 12 months at this point in time.

2. MATERIALS AND METHODS

2.1. Animal Inclusion Criteria

Animal selection will be based on the following criteria: Either male or female normal cephalic dogs, weighing between 25-75 lbs. were chosen. The dogs were "conditioned" i.e. dewormed, and had received all necessary immunizations including those against rabies, distemper, and infectious canine hepatitis. The dogs were in overall good health. An in-house blood and chemistry panel was performed within seven days. The medical and physical examination results of the dogs were unremarkable. Urinalysis was done when liver or kidney tests results were elevated and when clinical signs and symptoms indicated the need. Stool examinations were required if the patient presented with gastro-intestinal problems. Medically compromised patients such as those with concurrent heart, liver, renal disease or malignant neoplasia were excluded from this study. Special attention was given to behavioral patterns of dogs including chewing habits, as well as dietary habits.

2.2. Tooth Selection

The criteria for tooth selection were based on clinical and radiographic examinations.
The clinical criteria were as follows: The tooth to be treated should have experienced a recent pulpal exposure. The pulp should not have been exposed to the oral fluids for longer than 48 hours. Any pulp exposure size was acceptable as long as the tooth involved was restorable and said exposure was supra or equi-gingival. The exposure size was assigned to one of the following sub-groups: <1mm diameter; 1 to <3 mm diameter; 3 to <5 mm diameter; ≥5mm diameter. If the pulpal exposure was a result of trauma, any causative horizontal or vertical fractures had to be above the gingiva. A tooth with any fracture line involving the root portion of the tooth was excluded from the study. Excessive hemorrhage from a pulp exposure indicating long standing inflammation was cause for exclusion from the study. The general oral condition of the patient had to be healthy. Causes for exclusion included: severe gingivitis; periapical infections, including draining fistulas, periapical redness and swelling ; periodontal diseases, with pockets measuring over 6mm, and with tooth mobility exceeding 2mm; very deep and very large carious lesions; crowned restorations.
The radiographic criteria for tooth selection were as follows: The tooth to be treated should present normal radiographic features. The lamina dura should be intact and continuous. The periapical tissue and surrounding bone should also be normal. Pulp stones obliterating the pulp chamber should not be present in the radiographs. The radiographic pulp size should be at least a third of the mesio-distal, bucco-lingual, and cervico-occlusal height of the tooth. Radiographic indications of chronic pulpitis/pulpal inflammation including the presence of periapical bone deposition, hypercementosis, or incipient chronic apical periodontitis on any teeth were cause for exclusion from the study.

At the time of this presentation, 17 teeth had been treated and followed up over a period of 1 year or more.

2.3. Laser Treatment

Laser parameters were selected according to the following criteria:
(1) from preliminary studies which identified parameter configurations with minimal thermal impact in adjacent pulpal tissues [9].
(2) according to the constraints of the device available to us.
Pulpal exposures were treated using a CO_2 laser at the following parameters
spot size: $0.004cm^2$
pulse interval: 1.0s
pulse duration: 0.01s
power: 4W
irradiation duration: usually 3 bursts of 0.5s each

2.4. Surgical Procedure

After obtaining a complete and comprehensive medical and dental history of the patients, the patient was pre-anesthetized using an oral administration of Propotol (2-4 mg/lb.) with maintenance on isothurane and oxygen. Cardiac and respiratory functions were likewise constantly maintained. After the onset of sedation, straight on and angulated periapical radiographic exposures were taken of the tooth to be treated. Conventional straight-line access to the pulp, using burs #2, 701, 703, 253 was prepared using a high speed dental handpiece. All carious dentine was removed with a #2,3 spoon excavator. Sterile saline solution was used to debride the access cavity and bleeding controlled when appropriate with sterilized cotton pledgets. The exposure site was then irradiated, dressed with calcium hydroxide paste and restored with Glass Ionomer Cement . Post-operative radiographs were taken, and the patient's recovery closely monitored.

2.5. Treatment Evaluation

Clinical evaluations including visual and tactile tests to diagnose the presence or absence of periapical pathologies, including abscess formation, pus drainage, or a fistulous tract, were performed by one blinded, standardized operator 4, 12, 24, and 52 weeks post treatment. Clinical response was scored as follows:

-1	Periapical palpation suggests development of a pathosis. A pathology is clinically present when there is abscess formation, pus drainage, or a fistulous tract.
0	Unchanged from the baseline. Suggests a stable condition.

Radiographic evaluations were conducted by the same clinician to determine changes in integrity of the lamina dura as well as the development of areas of rarefaction.
The radiographic evaluation was scored separately:

-1	Break in the continuity of the lamina dura; development of a periapical pathosis indicated by an area of rarefaction on the radiograph.
0	Unchanged from the baseline. Suggests a stable condition.

2.6. Statistical Evaluation

This paper presents preliminary results of an ongoing study. A formal statistical analysis of these preliminary findings is not appropriate at this stage.

3. RESULTS

3.1. Clinical Impressions

During laser treatment, hemostasis was not always immediate, and in most cases some use of pressure applied using cotton wool pledgets was required to achieve full cessation of bleeding. Otherwise, the laser procedure was very rapid, and added only a few seconds to total treatment duration.

3.2. Clinical Results

1 year after treatment, 15/17 treated teeth appeared clinically healthy according to the criteria listed above. The 2 teeth which developed periapical swellings had both experienced loss of their restoration within a few months of treatment.

3.3. Radiographic Results

1 year after treatment, 15/17 treated teeth appeared radiographically healthy according to the criteria listed above. The 2 teeth which developed periapical radiolucencies had both experienced loss of their restoration within a few months of treatment. These were the same 2 teeth in which treatment also failed as judged by clinical criteria.

4. DISCUSSION

In dogs, treatment of exposed pulps remains problematic: the outcome of pulpotomy procedures is variable, at best, and root canal treatments are expensive, demanding and also less than predictable in their outcome. Tooth extraction is undesirable for a wide range of reasons. Similar arguments apply to current pulpal treatment modalities in humans.

The laser parameters used in this study were dictated by 2 factors: laser capability and thermal considerations. From the experience gained in this investigation, it has become apparent that careful modification of the laser parameters used is necessary to improve hemostatic effect whilst minimizing thermal implications in collateral tissues.

The prerequisites for successful pulpotomy are well met - theoretically - by the surgical properties of CO_2 lasers. The preliminary results presented in this paper do indeed demonstrate a great potential for localized pulp surgery using this device. Interestingly, the 2 teeth in which treatment failed both lost their restorations early, so that at this time it remains unclear whether this failure was due to the laser pulp treatment, or pulpal re-infection.

In conclusion, these preliminary results demonstrate the feasibility of using the CO_2 laser for localized laser pulp surgery in dogs. Further studies are required to optimize the laser configuration and to identify the range of clinical pathologies which can be treated using this modality.

ACKNOWLEDGMENTS

This study was supported by: DOE Grant DE903-91ER 61227, ONR N00014-90-0-0029, NIH RRO1192, seed grant funding from Loma Linda University, the Edna P. Jacobsen Charitable Trust for Animals, Inc.

REFERENCES

1. Cvek M. A clinical report on partial pulpotomy and capping with CAOH in permanent incisors with complicated crown fracture. J Endodon 1978;4,232-237.
2. Shaw D.W., Sheller, B., Barnes, B.D., et al. Electrosurgical pulpotomy: a 6 month study in primates . J Endodon 1987; 10, 500-505.

3. Shalman, E.R., Mc Iver, F.T., Burkes, E.J. Comparison of electrosurgery and formocresol as pulpotomy techniques in monkey primary teeth. Pediatr Dent 1987; 9, 189-94.
4. Fisher, S.E., Frame, J.W. The effects of the carbon dioxide surgical laser on oral tissues. Br J Oral Maxillofac Surg1984;24,414-425.
5. Jeffrey, I. W. M., Lawrensen, B., Longbottom, C. et al. CO_2 laser application to the mineralized dental tissues-the possibility of iatrogenic sequelae. J Dent Res 1990;18, 24-30.
6. Shoji, S. Nakamura, M., Horuichi, H. Histopathological changes in dental pulps irradiated by CO_2 laser beam. J Endodon 1985;11,379-384.
7. Melcer, J. , Chaumette, M. T., Melcer, F. Dental pulp exposed to the CO_2 laser beam. Lasers Surg Med 1987;7, 347-352.
8. Miserendino L.J, Neiburgerr, E. J., Walia, H., et al. Thermal effects on continuous wave CO_2 laser exposure on human teeth: an in vitro study. J Endodon 1989; 15, 302-305.
9. Arrastia, A., Wilder-Smith, P., Berns, M.W. Thermal Effects of CO2 Laser on the Pulpal Chamber and Enamel of Human Primary Teeth: an in vitro Investigation. Lasers in Surgery and Medicine 16:343-350, 1995.