Histologic Effects of a Contact Diode Laser on Intraoral Soft Tissue

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- CONTENTS -

Ⅰ. INTRODUCTION

In recent years, much attention has been directed toward the use of lasers in dentistry. The main focus of clinical laser use at present involves soft tissue applications such as gingivectomies and gingivoplasties, biopsies and removal of fibromas and leukopakias, debridement of diseased epithelial lining, incising and draining of abcesses, soft tissue crown lengthening, tissue retraction for impressions, hemostatic assistance, reduction of drug-induced gingival hypertrophy and removal of granulation tissue. Such procedures typically involve various forms of soft tissue excisions, incisions and coagulation techniques.

Investigators have reported findings related to the safe use of lasers with a variety of emission wavelengths applied to oral tisses *in vivo*, particylarly on pulp, enamel and bone.[1-5]

Others have studied the safety and effectiveness on oral soft tissues *in vivo* of pulsed Nd:YAG lasers up to 30 Hz.[6-9]

Fiberoptic-delivered Nd:YAG lasers with high repetition rates have been developed to increase efficiency of oral soft tissue laser applications. Such an instrument, pulsed to 100 Hz, has shown no detrimental effect on dental pulp when applied to enamel.[10]

The present study evaluated the safety and effectiveness of a Diode laser as compared to conventional fiber delivered Nd:YAG pulsed laser system with a high repetition rate on oral soft tissue. Incisions were made in fresh bovine tongue and histological sections were examined microscopically. Width and depth of tissue removed as well as lateral and deep thermal coagulation at various laser settings were measured. Temperature rise of underlying tissue was also measured during laser incisions. This data was used to compare laser parameters to standard laser soft tissue procedures using an *in vitro,* model previously employed to evauate earlier laser systems.

Ⅱ. MATERIALS AND METHODS

A free-runnimg pulsed Nd:YAG dental laser with a 1064 nm wavelenth and pulse duration of 100 μsec was used as the standard laser device (Incisive PulseMeter™ Nd:YAG Dental Laser System, American Dental Technologies, Troy, Michigan). A contact delivered Diode laser with continuous wave or interrupted pulse modes was compared to the standard Nd:YAG laser. This Diode laser has emission wavelength of 815 nm, power of 0-10 W and fiber optic contact delivery (400 μm diameter). Two aspects of safety and effectiveness were evaluated: temperature and histology. To determine temperature rise in the underlying tissue, type-T thermocouples were placed 5.0 mm ($\pm$0.5 mm) below fresh bovine tongue. To ensure that the thermocouples were accurately measuring heat rather than laser energy, they were optically isolated with a thermal-conducting paste. Temperatures in the underlying tissue were measured during laser excision with the fiber in contact with the tissue. Laser operating parameters were from 0 to 10 W at 50 and 100 Hz or continuous wave. The laser was used with 10 $\pm$ 10 gm of pressure and cutting rate of 2.5 mm/sec. The operator moved the fiber-optic over the tissue above where the thermocouples were located at the calibrated state and pressure. The maximum temperature rise was recorded three times per laser exposure.

Tissue specimens were bioprepared, fixed in formalin, sectioned and stained with hematoxylin and eosin to detemine histologic cutting and coagulation effects. The sections were taken from the middle of the cutting zone to ensure that the area represented the most characteristic zone of each paticular incision. A measuring microscope at 10x magnification was used to document five representative sections for each laser parameter. Measurements were made of the width and depth of excision as well as lateral and deep coagulation. Linear regression was utilized to evaluate temperature rise, width and depth of tissue removed and lateral and deep coagulation. For comparison, Nd:YAG laser at 50 Hz was compared to Diode laser at 50 Hz and Nd:YAG laser at 100 Hz was comapred to Diode laser at continuous wave.

Ⅲ. RESULTS

The temperature rise in tongue has in previous studies been shown to be more consistent and higher than that measured in bone. The data indicated that as power increased, subsurface temperature increased in tongue (Figure 1). Temperature rise was greatest with the Nd:YAG laser at 100 Hz. At laser patameters below 6 W, at usual clinically relevant operating parameters, temperture rise was minimal.

Figures 2 through 7 show photomicrographs of the Nd:YAG laser and Diode laser excisions after histologic processing of tongue. The width and depth of cut and the lateral and deep coagulation are clearly visible in the photomicrographs.

Measurements in tongue were used because in many cases the gingiva and oral mucosa are compeletly excised making measurements in these tissues impossible. The width of tissue removed for both the Nd:YAG laser and Diode laser were equivalent and related to fiber diameter (Figure 8). Within the range of laser parameters studies, all parameters cut bovine tongue. The Diode laser was superior for depth of tissue removed for all powers (Figure 9). Lateral coagulation was minimal for both devices and the Nd:YAG laser and Diode laser produced the same lateral coagulation (Figure 10). In the range of clinically relevant parameters (below 6 W) the Nd:YAG laser at 100 Hz had the greatest deep coagulation (Figure 11). The Diode laser at 50 Hz had increasing coagulation whereas all other laser parameters had the same coagulation.

Ⅳ. DISCUSSION

The temperature results of this study confirmed similar findings that had beem reported in earlier studies[11-12]. This suggests that proper use of the laser even at high settings will cause no detrimental effects or thermal necrosis to the underlying tissues, when the laser is used for cutting and the fiber is kept moving across the tissue being excised. This experimental model for temperature measurement has been shown to be more sensitive when measuring thermal penetration in tongue than bone.[13] This may be due to the more homogenous water content in soft tissues than in the mixture of mineral and water associated with bone. Higher temperature rise is associated with high average power, so it is advisable that the practitioner use the lowest average power which achieves the treatment objectives of cutting and coagulation. It is also important to keep the fiber constantly moving.

There are limitations associated with the cutting efficiency model used in this study. As can be noted in the data, there were a number of measurements that seem to be inconsistent with the overall trend. In a controlled laboratory model, one would expect consistent results: as power and/or frequency is increased, the depth of ablation would also increase. In this model, the laser incisions are done manually to simulate the clinical setting. Consequently, inconsistencies such as changes in rate or amount of pressure used while lasing affect the histologic measuremenets. Overall these represent the range of clinical usage for the device and there were no data where adverse effects would be expected due to temperature or coagulation for either device below 10 W.

Clinical experience has shown that as frequency and/or power increases, depth and width of tissue removed increase accordingly. This study's findings support these clinical observations regarding the correlation between increased power and excision. In this controlled *in vitro* study, the average power was the primary determinant of cutting efficiency. Differences in the results of this study and clinial impressions exist. Clinial impressions regarding repetition rate are *not* supported by this study: increased repetition rate appears not to increase the amount of tissue removal. Research using earlier laser models with lower repetition rates established clinical benchmarks using the lower settings. However, newer laser devices are capable of both low power and high repetition rates, as well as high power and low repetition rates. It is our belief that these more recent laser designs are maximized for cutting and the coagulation of intraoral soft tissue. Additionally, increased repetition rate may give the practitioner added tactile sensation and a perceived increase in speed.

A range of useful laser parameters was determined in the course of this study. It is clear that the minimum possible power should be used to perform a procedure effectively. This minimizes the temperature rise and deep coagulation occurring with use of the laser.

Ⅴ. CONCLUSION

This study revealed that the Diode laser was the same as the standard Nd:YAG laser for temperature rise to underlying tissue which was minimal. The Diode laser was superior in depth of tissue removed and the same for lateral and deep coagulation.

ACKNOWLEDGEMENTS

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국문초록

접촉식 다이오드레이저조사가 구강연조직에 미치는 조직학적 영향

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본 연구는 두가지 관점, 즉 다이오드레이저를 구강연조직에 접촉식으로 조사하여 조직을 절제할 경우 첫째 심부조직에서의 온도 상승 정도에 대한 분석 평가, 둘째 절제에 따른 조직의 열적 응고에 대한 조직학적 분석 평가를 위해 시도되었다.

연구를 위해 도축된 소의 혀 배면으로부터 5.0±0.5 mm 깊이에 T형 열전대(type T thermocouple)를 설치하고 조사조건에 따른 레이저절제 도중의 온도변화를 측정하고, 또한 해당조사부위의 조직을 대상으로 통법에 의한 H-E염색 후 조직학적 측면에서 열적 응고상을 검색하여 Nd:YAG레이저의 경우에서와 비교하였다. 즉 파장 815 nm의 다이오드레이저를 0-10 W의 출력, 50 Hz와 연속파의 주파수조건에서 접촉식으로 조사하였으며, 또한 파장 1064 nm의 Nd:YAG레이저를 0-10 W의 출력, 50 Hz와 100 Hz의 주파수 조건에서 접촉식으로 조사하였다. 레이저의 접촉조사시 레이저광섬유 첨단부에서 10±10 gm의 일정한 압력과 2.5 mm/sec의 이동속도로 조직을 절제하였다. 레이저가 접촉조사된 조직부위를 통법에 의해 조직학적으로 처리한 후 H-E염색을 시행하였으며, 계측현미경을 이용하여 10배율 아래에서 조직절제의 폭과 깊이, 측방 및 하방 쪽으로 열적 응고의 폭을 계측하였다. 계측치에 대한 통계학적 처리결과 조직절제의 폭과 측방쪽으로의 열적 응고의 폭은 다이오드레이저에서와 Nd:YAG레이저에서 같은 정도를 나타냈다. 조직절제의 깊이는 Nd:YAG레이저에서에 비해 다이오드레이저에서 더 깊었다. 하방쪽으로의 열적응고의 폭은 Nd:YAG레이저를 100 Hz의 조건에서 조사한 경우에서 가장 넓었으며, 다이오드레이저를 50 HZ와 연속파의 조건에서 조사한 경우에서 가장 좁았다. 레이저절제 도중 심부조직에서의 온도변화는 다이오드레이저에서와 Nd:YAG레이저에서 모두 출력이 증가함에 따라 상승되었으며, 다이오드레이저에서 보다 Nd:YAG레이저에서 더 높이 상승되었다.

결론적으로 본 연구에서 시도된 조사조건범위 이내에서는 구강연조직 절제시 다이오드레이저가 펄스형 광섬유전달식 Nd:YAG레이저 보다 심부조직에서의 낮은 온도상승과 하방쪽으로의 좁은 열적 응고의 폭을 보이면서 우수한 조직절제효과를 나타냈다.

주요 단어 : 다이오드레이저, Nd:YAG레이저, T형 열전대, 계측현미경, 열적 응고, 조직절제효과

EXPLANATION OF FIGURES

Figure 1. Temperature rise of underlying tissue during Nd : YAG laser and Diode laser excision of bovine tongue

Figure 2. Photomicrograph of representative histologic section of bovine tongue after Nd : YAG laser exposure at 4 W and 50 Hz (original magnification 10x)

Figure 3. Photomicrograph of representative histologic section of bovine tongue after Nd : YAG laser exposure at 4 W and 50 Hz (original magnification 25x)

Figure 4. Photomicrograph of representative histologic section of bovine tongue after Diode laser exposure at 4 W and 50 Hz (original magnification 10x)

Figure 5. Photomicrograph of representative histologic section of bovine tongue after Diode laser exposure at 4 W and 50 Hz (original magnification 25x)

Figure 6. Photomicrograph of representative histologic section of bovine tongue after Diode laser exposure at 4 W and Continuous Wave (original magnification 10x)

Figure 7. Photomicrograph of representative histologic section of bovine tongue after Diode laser exposure at 4 W and Continuous Wave (original magnification 25x)

Figure 8. Width of tissue removed after laser excision of bovine tongue as a function of device

Figure 9. Depth of tissue removed after laser excision of bovine tongue as a function of device

Figure 10. Lateral coagulation of tissue after laser excision of bovine tongue as a function of device

Figure 11. Deep coagulation of tissue after laser excision of bovine tongue as a function of device

논문사진부도 ①

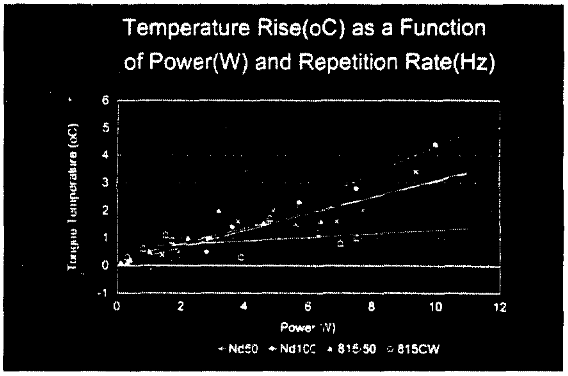


Figure 1.

Figure 2.

Figure 3.

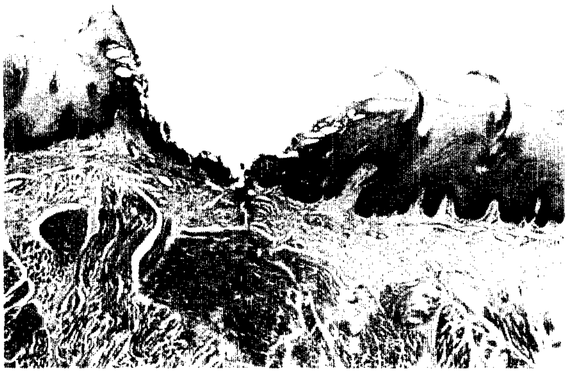


Figure 4.

Figure 5.

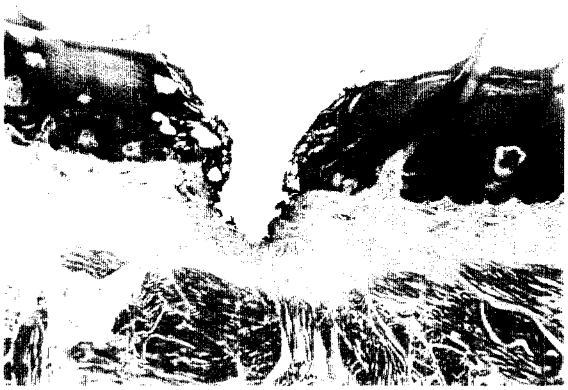
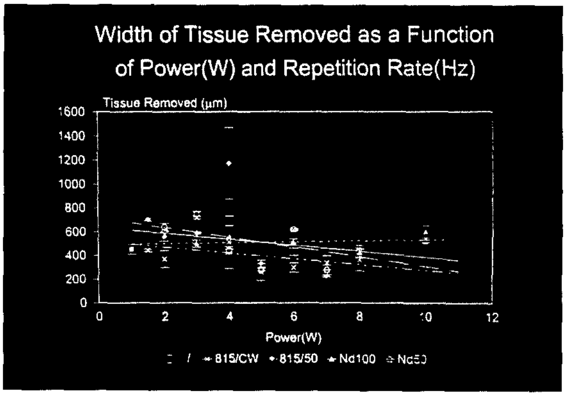


Figure 6.

논문사진부도 ②

Figure 7.



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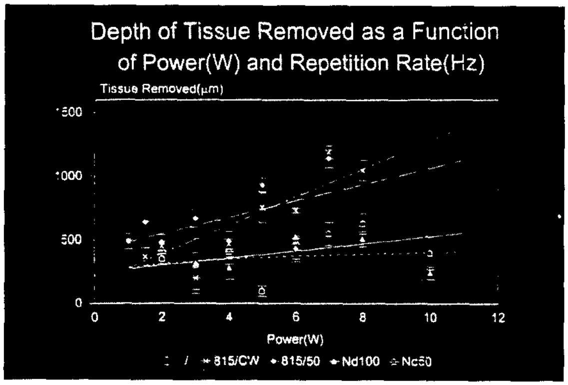

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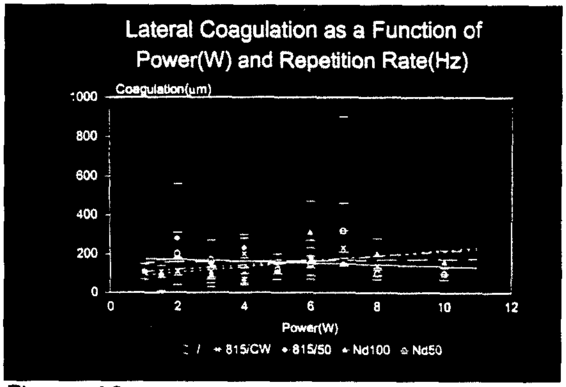

Figure 10.

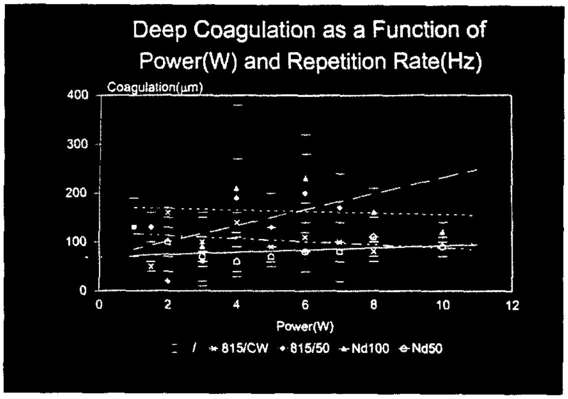

Figure 11.