Effect of Electrosurgery and Laser Gingivoplasty on the Temperature of Pulp, Bone, and Gingivae In Vitro

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\textbf{Purpose:} Lasers are increasingly being used for gingival dental surgery and to replace the use of electrosurgery. The aim of this study was to evaluate and compare the temperature rise in hard and soft tissues when using lasers and electrosurgery units and for soft-tissue dental surgery.

\textbf{Materials and Methods:} Gingivoplasty was carried out by one operator on fresh pigs’ jaws using two electrosurgery machines and three dental lasers (a CO\textsubscript{2} laser and two diode lasers). The temperature in adjacent dental tissues was recorded using thermocouples located in bone, pulp, and gingivae. A total of 12 readings were recorded for each electrosurgery and laser unit at each location.

\textbf{Results:} The temperature rise in the bone was 0.6 ± 0.9°C for the CO\textsubscript{2} laser, 1.8 ± 1.7°C and 1.6 ± 1.4°C for the two diode lasers, and 3.6 ± 1.7°C and 2.3 ± 1.5°C with the two electrosurgery units. In the pulpal recordings, the temperature rise of 0.5 ± 0.3°C for the CO\textsubscript{2} laser was significantly less (p < 0.001) than that recorded with the other two lasers, 1.7 ± 0.7°C and 1.2 ± 0.6°C. With electrosurgery, the temperature rise in the pulp was 1.6 ± 0.8°C and 2.1 ± 1.1°C. For the gingival recordings, the CO\textsubscript{2} laser generated the highest temperature rise at 13.6 ± 8.1°C, which was significantly higher (p < 0.001) than that with the diode lasers, 6.9 ± 3.4°C and 2.9 ± 2.0°C. The electrosurgery units generated a temperature rise in the gingivae of 1.7 ± 1.2°C and 1.8 ± 2.0°C. All three lasers generated higher temperatures in the gingiva than did the two electrosurgery units (p < 0.05). There was no significant difference in the temperature rise in any tissue between the high frequency (27 MHz) and low frequency (3 MHz) electrosurgery units.

\textbf{Conclusion:} Heat generated during gingivoplasty is unlikely to be of concern when the equipment is used correctly, but caution is required with all electrosurgical and laser techniques, particularly the CO\textsubscript{2} laser. Following the manufacturer’s guidelines and proper training are recommended.

\textbf{Keywords:} electrosurgery, carbon dioxide lasers, diode lasers, temperature rise.

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Electrosurgery and lasers are currently available options for the manipulation of dental soft tissues as part of routine restorative procedures.\textsuperscript{1-3} Both techniques make use of electromagnetic radiation within the infrared part of the electromagnetic spectrum and involve the generation of heat in the target tissues.

Electrosurgery devices produce a high frequency radiowave at a metal cutting tip. The frequency output of an electrosurgery unit varies according to the manufacturer of the unit and is typically in the range of 3 to 27 MHz. The radiowaves generate local heat within the tissues at the cellular level which vapourises the cell con-
tents and thereby brings about cutting and coagulation.

Lasers have been used for many clinical applications in dentistry and are increasing in use.4 Lasers operate with wavelengths of 10,600 nm for CO2 lasers and 830 nm or 980 nm for diode lasers, producing local heat in the tissues and resulting in tissue vaporisation or ablation. Carbon dioxide lasers have been used for soft-tissue applications in both dentistry and surgery for many years, and more recently diode lasers have been introduced for the manipulation of gingival tissues.3

As electrosurgery units and lasers generate heat in the surrounding dental tissues, the temperature rises may be of concern. It has been shown5 that bone is highly temperature sensitive and damage can occur at approx 47°C, but no studies have investigated the effect of electrosurgery techniques on bone temperature.

Studies have investigated the effect of laser surgery on the temperature of dental tissues with varying results.6-9 The dental pulp is even more temperature sensitive, and a rise of 5.5°C can cause damage.10 Badissara et al11 showed dentine injury was a potential cause of pulpal damage, while Glockner et al12 showed that the rate of rise of pulp temperature is low.

Concern has been raised about the heat generated in the pulp when using a CO2 laser.13-16 Moriyama et al6 showed that the temperature rise in teeth was dependent on the pulse duration, exposure time, and the energy contained in each pulse. A higher temperature in the EDJ region was demonstrated7 and considered to be due to the dynamics of the tooth structure. Powell et al17 suggested the likely temperature rises with laser surgery would be safe.

This study aims to evaluate the temperature changes in alveolar bone, gingiva, and pulp tissues when using electrosurgery and lasers for soft-tissue surgery around teeth. The hypothesis is that there is no difference in the temperature increase in adjacent tissues when using these treatment modalities.

MATERIALS AND METHODS

The procedures were carried out on freshly prepared juvenile pig maxillae obtained from an abattoir. These were physically similar with no visible melanin differences and the jaws were randomly selected for the study groups. Thermocouples were placed in small holes cut into bone 3 mm below the periosteum using a slow-speed handpiece. Another thermocouple was inserted into the pulp chamber through a minimal access cavity cut using a bur in an air rotor handpiece. A straight dental probe was used to make a channel in the gingival tissues for another thermocouple to lie on the periosteum. Radiographs were taken to confirm that the thermocouples were correctly positioned. The resolution of the digital thermocouple was 0.1°C.

Gingivoplasty, by electrosurgery or laser, was carried out by one operator as follows: for each electrosurgery and laser technique, a continuous horizontal incision 1 mm deep into the gingival crevice was cut, extending from the mesial to the distal of each tooth. Both buccal and palatal aspects of the jaw were utilised, creating a series of gingival troughs around the premolar and molar teeth. A new pig maxilla was used for each electrosurgery or laser unit under evaluation.

Two electrosurgery machines were used in this study. The TCS (Coltene/Whaledent; Mahwah, NJ, USA) has an output frequency of 3 MHz and was used on a power setting of 3 to 4 on the arbitrary scale of 0 to 10. This electrosurgery unit has a backplate which was placed under the pig’s jaw. The Odontosurge (XO Care A/S; Horsholm, Denmark) operates at a frequency of 27 MHz and has a pre-set power level and no backplate. Both electrosurgery devices were used according to manufacturer’s instructions with a straight metal wire cutting tip to remove 1 mm of marginal gingiva. Each cut was made in a single sweep taking between 3 to 5 s to traverse a distance of 8 to 10 mm. Immediately after the cutting procedure, there was a delay of 15 s before further cutting was carried out.

Three lasers (one CO2 laser and two diode lasers) were used to carry out the same procedure as with the electrosurgery machines. The CO2 laser (Opus 20, OpusDent; Tel Aviv, Israel) had a maximum output of 10.0 W. For the diode lasers two Velopex units (Medivance Instruments; London, UK) were employed, one with a maximum output of 5.0 W (830 nm wavelength) and another with an output of 10.0 W (980 nm wavelength).

The CO2 laser was used in noncontact mode with the focal area remaining constant due to a fixed distance between handpiece and the tissue. A continuous waveform was used with the laser beam delivered through a hollow tube. The diode laser requires a light contact and has a continuous waveform delivered through a fibre optic delivery system.

The temperature was recorded using the thermocouples located in bone, pulp, and gingiva. Readings were taken before the procedure started and the peak temperature rise was recorded. Each surgical procedure was repeated three times, and so three tempera-
ture rises were measured for each device on each tissue (bone, pulp, or gingiva) while carrying out the gingivoplasty. This was carried out on buccal and palatal aspects of two teeth, yielding a total of 12 readings for each tissue. The means were calculated for each unit and recording location to allow comparisons to be made. Statistical analysis was carried out on the raw data with Sigmastat.

RESULTS

Table 1 shows the mean temperature rise with the electrosurgery units. There does not appear to be a clinically significant temperature rise in pulp, bone, or gingivae with either electrosurgery unit. There was also no statistically significant difference between the temperature rises recorded with the TCS and Odontosurge units for each tissue (p > 0.05).

The results for the three lasers are presented in Table 2. The CO₂ laser gave very little temperature rise in pulp or bone, but the rise in the gingival temperature was 13.5 ± 8.1°C.

The 5-W diode laser gave a 1.7 ± 0.7°C rise in pulp, a 1.8 ± 1.7°C rise in bone, and 6.9 ± 3.4°C in gingivae. The 10-W diode laser gave little temperature rise in all three tissues (less than 3.0 ± 1.9°C).

For the pulp recordings, the 6-W CO₂ generated significantly lower temperature rises than the other two lasers (p < 0.001). The temperature rises in the bone were not significantly different between the three lasers. In the gingival tissues, the 6-W CO₂ created the higher temperature rise, significantly greater than the temperature generated by the 10-W diode.

Comparing electrosurgery and lasers, the laser induced a statistically significantly higher temperature rise in the gingiva. Both CO₂ and 5-W diode lasers created higher temperature rises than both electrosurgery units (p < 0.001). The 10-W diode also induced higher temperature rises than both electrosurgery units (p < 0.05).

DISCUSSION

The temperature rises reported in this study are within published thresholds based on other dental procedures.
and much less than the recorded bone damage threshold of 47°C by Eriksson and Albrektsson. The risk of bone damage has been considered in detail during implant placement and abutment preparation and includes the use of lasers. Perry et al. used Nd:YAG laser at different power settings on oral soft tissue and found underlying bone temperature increases of 1°C at 3 W to 1.4°C at 5 W. In the present study, the greatest temperature rise in the bone was 3.6°C recorded with the Odontosurge electrosurgery unit.

Baldissara et al. described thermal damage to dentine and pulp and showed the effect of temperature rises ranging from 8.9°C to 14.7°C. The greatest temperature rise in the pulp was recorded as 2.1°C with the Odontosurge unit. While recording in the gingivae, the greatest temperature rise was 13.5°C with the CO2 laser.

The dental pulp is subjected to the risk of thermal trauma from a variety of dental procedures including: the use of ultrasonics, the thermal removal of orthodontic brackets, the curing of resins with LED and quartz curing lights, during the polymerisation of resin-based provisional crowns, and during laser tooth whitening. Nammour et al. demonstrated that when using lasers for root planning, a temperature rise of over 7°C could be produced in the pulp. The use of electrosurgery and laser is not likely to be more detrimental than other known thermal risks to teeth.

Our results show little concern for damaging temperature increases when using electrosurgery or lasers correctly. Temperature rises would be expected to be less in vital tissue due to the presence of a blood supply. The effect of the blood supply may in turn be dependent on the effect of vasoconstrictors in local anaesthetics.

The CO2 laser caused more heat in the gingivae than did the diode laser and electrosurgery. The mechanism of action may be that the CO2 laser causes a more intense beam of energy and is absorbed mainly by water in the tissues, whereas the diode laser beam is absorbed mainly by melanin and haemoglobin. As there is less of these substances in gingival tissue, less laser energy is absorbed, resulting in less heat production. The diode laser is used via a 200- to 400-μm optic fibre, producing a much narrower beam than the CO2 laser, so there is less area of interaction and again less heat generation. The beam width of the CO2 laser depends on the diameter of the tip.

Bornstein et al. used the CO2 laser for excisional biopsy and showed this to be acceptable due to minimal collateral heat damage. Malmstrom et al. also showed high temperature rises of up to 19°C with a CO2 laser used for soft tissue surgery. In order to overcome the effect of heat production, tissue precooling has been suggested and the use of an air and water jet has been shown to be effective. In view of this, it is suggested that an adequate water jet for cooling could be used with the CO2 laser.

The results of the study do not support the hypothesis that electrosurgery and laser devices bring about similar temperature increases, although differences are relatively small. However, both treatment modalities are considered safe to local tissues in terms of temperature rise, provided guidelines are observed, particularly when using a laser.

It is recommended that local and national rules for the use of lasers in general practice are adhered to in order to ensure safe practice. Although the results of this paper suggest that electrosurgery and lasers are safe when used correctly, as laser training is not part of undergraduate studies, additional training is considered essential.

CONCLUSION

1. The temperature rises reported in this study are within published thresholds based on other dental procedures.
2. Our results show there is little reason to be concerned about damaging temperature rises when using electrosurgery or lasers correctly.
3. The CO2 laser caused more heat in the gingivae than did the diode laser and electrosurgery.

REFERENCES


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