Electrotome and Er:YAG laser

A comparison of the temperature changes in subperiostal bone and the risk for bone damage during frenectomies

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_Abstract

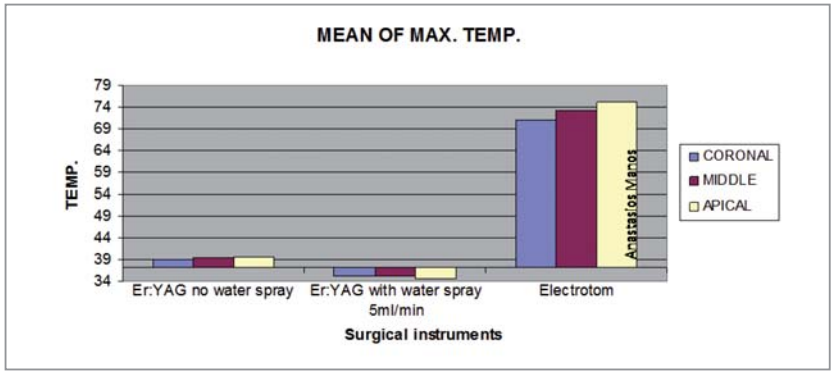
The aim of this study is to investigate the temperature changes in subperiostal bone and the risk for bone damage during frenectomies with electrotome and Er:YAG laser.

Thirty parts of sheep lower jaws with the frenulum preserved were used in the study. Electrodes from thermocouples were inserted in the subperiostal bone tissue in three places, coronal, middle, apical. A water bath with 37 °C was used to stabilize the start temperature in 36.8–37.2 °C. The sheep jaw were stabilized in gypsum inside the water bath with the frenulum part be extended out of the water. The sheep jaws were divided in three groups with 10 parts in every group. In these jaw parts frenectomies were performed using electrotome and Er:YAG laser with water spray and without water spray. The results of temperature changes, the maximum temperature, the irradiation time, the cooling time and the time of the temperature staying above the 47 °C were registered and statistically analyzed.

The results of the temperature changes have shown that the electrotome is creating a much higher temperature elevation in subperiostal tissues (up to 80.3 °C) than the Er:YAG laser without the water spray (up to 40.3 °C) while the use of the water spray in Er:YAG laser creates a maximum temperature drop down to 34.1 °C.

As conclusion we can say that in frenectomies with Er:YAG laser, there are much less thermal changes to the subperiostal bone tissues than with electrotome and therefore the risk of thermal damage with Er:YAG in subperiostal bone tissue compare to the electrotome is minimal.

Fig. 1 & Tab. 1_The mean of the maximum temperature.



	Coronal	Middle	Apical
Er:YAG No Water	38.93	39.24	39.61
Er:YAG No Water	35.25	35.01	34.57
Electrotom	71.01	73.06	75.02
95% Confidence Interval			

_Introduction

The temperature rising and its side effects is always a problem in the surgical procedures when an electronic surgical instrument (e.g., electrotome, laser) it is used instead of the scalpel. Electric or electromagnetic energy can spread in deeper tissues and create side effects which could influence the healing process of the tissues or the prognosis of our therapy. Since 1930's electrotome is used in different surgical procedures and since 25 years ago the laser started to be used in similar surgical procedures. Although different investigators have looked on the temperature rising in the surface of the treated tissues little has been done in investigating the temperature fluctuations in the deeper

parts of the tissues. This research project is trying to investigate the temperature changes in the subperiostal bone tissue during frenectomies in sheep jaws with an Er:YAG laser and an electrotome.

_Materials and methods

An electrotome and an Er:YAG laser was used as surgical instruments in this study. These two electronic surgical instruments were used as a scalpel for performing frenectomies in sheep jaws. These frenectomies were performed in order to investigate the temperature fluctuations in the subperiostal bone under the frenulum.

30 parts of lower sheep jaw with preserved frenulum were used in the study. Electrodes from thermocouples were inserted in the subperiostal bone tissue in three different places 5 mm away from each other in the vertical dimension (coronal—middle—apical) in order to register the temperature changes in the subperiostal bone during the frenectomy procedures. The sheep jaws were stabilized in a gypsum base in a water bath. The water bath was used in order to simulate the physiological temperature of the living tissues of 37 °C. The preserved frenulum, with the electrodes of the thermocouples was kept out of the water in order to avoid any interference during the frenectomy procedure from water in the water bath.

The thirty lower sheep jaw parts were divided in three groups of ten. In the first group the electrotome was used to perform the frenectomies in the central frenulum, in the second group the Er:YAG laser was used without water spray and in the third group the Er:YAG laser with water spray (5 ml/min).

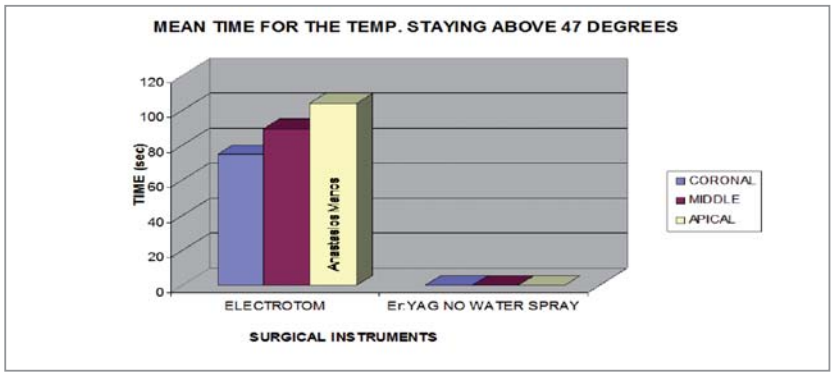
The parameters used in this study was:
The power used in electrotome in the scale of 10 was 5. That means 50 % of the maximum power of the electrotome (50 watts) which is 25 watts. The tip of the electrotome had a diameter of 0.40 mm.

The energy used in the Er:YAG laser was 150 mJ, with the pulse frequency of 20 Hz and the pulse duration in 700 µsec (long pulses).

The incision was made 3 mm away from the attached gingival in a depth up to 15 mm from the surface of the frenulum.

_Results and statistical analysis

The results that were registered have shown that the temperature rising was much higher in the frenectomies with the electrotome than with the Er:YAG laser without the water spray. On the other hand in the frenectomies with the Er:YAG with water spray the temperature dropped under the physiological temperature of 37 °C creating hypothermia in the tissues.



	Electrotom	Er:YAG No Water Spray
Coronal	74.6	0
Middle	89.4	0
Apical	104.0	0
95% Confidence Interval		

Fig. 2 & Tab. 2_Mean time of the temp. staying above 47 °C.

The statistical analysis was done with SPSS 13 statistical package and Bonferroni method. The results have shown that the temperature changes between the Er:YAG laser with water spray and without water spray have great differences. While in the frenectomies with the Er:YAG laser with water spray we have found a drop of the temperature under the physiological temperature of the living tissue down to 34.1 °C, in the frenectomies with the Er:YAG laser without water spray we could see a temperature elevation in the subperiostal bone up to 40.3 °C.

The mean of the maximum temperature rising/dropping had significant differences between the three diffrerent techniques that were used for the frenectomies in this study. These differences can be seeing in the Tab. 1 and Fig. 1.

The mean time of the temperature staying above the threshold time level of 1min gave significant differences between the electrotome and the Er:YAG laser without the water spray. In the frenectomies with the electrotome the time of the temperature staying above the 47 °C always exceeded the time threshold of 1min. while in the frenectomies with the Er:YAG laser this time threshold was never exceeded. These results can be seeing in the Tab 2 and Fig. 2.

The mean of the cooling time gave also big differences with the longer cooling time in the apical part of the frenectomies with the electrotome and the shortest cooling time in the coronal part of the frenectomies with the Er:YAG laser.

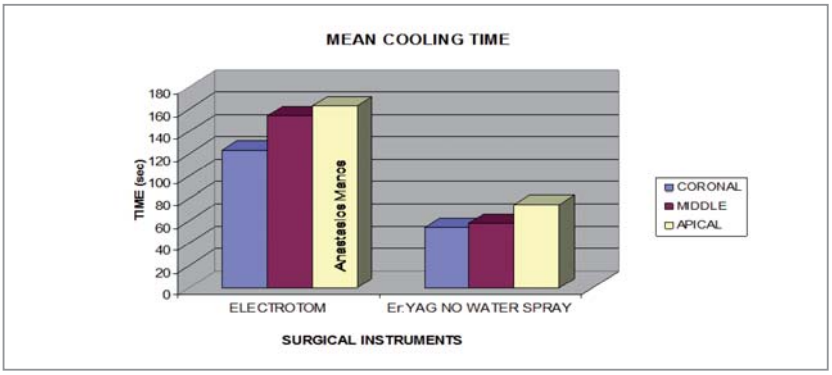


Fig. 3 & Tab. 3_ The mean cooling Time.

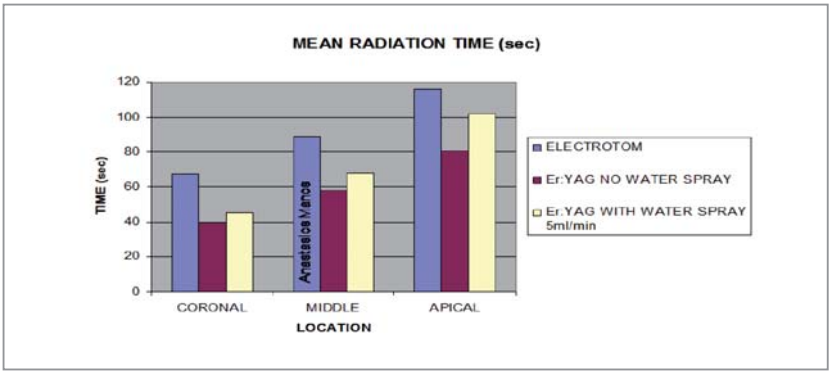
	Electrotom	Er:YAG No Water Spray
Coronal	123	54
Middle	154	58
Apical	163	75
95% Confidence Interval		

These results can be better seeing in the Tab. 3 and Fig. 3. The mean irradiation (or working) time was also registered and show significant differences between the three frenectomy techniques used in this study. The longest working time was in the frenectomies with the electrotome and the shortest in the frenectomies with the Er:YAG laser without the water spray. These differences can be seeing in the Tab. 4 and Fig. 4.

_Discussion

There has been a lot of research in the temperature elevation on the living tissues both in Medicine[3,4,14,16,19], Dentistry[2,4,5,6,7,9,10,12,15,20] and biophysics[1].

Fig. 4 & Tab. 4_The mean radiation time.



	Electrotom	Er:YAG No Water	Er:Yag with Water
Coronal	67.75	39.96	45.34
Middle	88.66	57.96	67.90
Apical	115.79	80.86	101.96
95% Confidence Interval			

Researchers are trying to investigate the temperature rising and its effects on the living tissues after the use of mechanical instruments, Lasers or electrotomes for different surgical procedures.

In 1983, Eriksson and Albrektsson with their research project have define the thermal threshold level for bone necrosis in 47 °C for 1 min.[3]

In 1989, Walsh et al. were investigating the thermal effect of a q-switched Er:YAG laser on the skin, cornea, aorta and bone. They could see that the thermal damage had a penetration 5–10 μm.[19]

In 1992, Prokova et al. were investigating the thermal effects of the CO_2 laser during surgical incisions on the bone tissue. They found that when the power density was rising the temperature was rising also. They also found that the temperature rising was dropping in a logarithmic rate to the distance from the incision point. The temperature dropping was depending on the tissue thermal conductivity.[14]

In the same year, Perry et al. were investigating the results after irradiation of the oral soft tissue with Nd:YAG laser. They found that if the applied power was grater than 5 W there was an increase of the temperature rising without any rising in the incision speed .[13]

In 1993, Sardar et al. found in their research that the thermal effect on the tissues is depended of the absorption and diffusion of the laser beam on the biological tissues and of the energy fluence on them.[16]

In our project we could also see that the thermal damage was influenced by the physical and optical properties of the tissues and of the power that was applied on them. Looking in our results we can see that the much stronger power of the electrotome did not speed up our incision on the tissues but on the other hand gave a much higher temperature on them. This is in agreement with the results found by Perry et al. in 1992. There must be a threshold point in the applied power (electrical or electromagnetic) from which and after that the only given effect in the tissues is the temperature rising and the risk of thermal trauma. Also in our project we could see the temperature dropping when we used the water spray cooling with the Er:YAG laser. This was happening because part of the applied laser energy was absorbed from the water in the water spay. The energy fluence on the tissues became much smaller giving us longer incision speed and also a cooling effect on them. This is in agreement with the results found by Miserendino et al. in 1993 and Frenzen et al. in 2003 in their research.[11,4]

The temperature rising in our experiments was depended on the power applied on the tissues. The time

for the temperature staying above the threshold point for thermal damage (47 °C) is depending not only in the applied power but also in the energy fluence, the absorption, the diffusion of that energy in the tissues and the tissue conductivity.[16, 14] The energy fluence applied on the tissues was giving the temperature rising while the energy diffusivity in the tissues and the tissue conductivity were giving the cooling time of the tissues. Because the diffusivity and conductivity in the oral tissues of the same species (sheep) can be consider having the same value we can say that the higher the applied energy fluence the longer the cooling time.

_Conclusions

For conclusions we can say that:

The threshold point of 47 °C for bone necrosis has been exceeded in all the frenectomies with the electrotome (a rate of 100 %) while this never happen in the Frenectomies with Er:YAG laser (a rate of 0 %).

The mean time for the temperature staying above 47 °C was always more than 60 sec with the electrotome presenting risk for thermal damage in the subperiostal bone tissue, while the mean time for the temperature staying above 47 °C with the Er:YAG laser was 0 sec. The cooling time was significant longer with the electrotome. The mean irradiation (or working) time was significant longer with the electrotome. It is safe to use the Er:YAG laser for frenectomies using the parameters used in this study.

It is expected to have less temperature rising in living tissues due to the blood microcirculation in the surrounding tissues _

_contact | laser

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