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BASIC RESEARCH

Infrared thermographic evaluation of temperature modifications induced during osteotomies performed with Er:YAG laser, piezosurgery and surgical drill – an animal study

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Background: Bone healing processes following osteotomy may vary according to the type of selected surgical procedures. Frictional heat caused by traditional bur osteotomies may result in thermal osteonecrosis if the temperature arises above the critical temperature of 47° C. Therefore, less invasive and precise tools for bone tissue surgery with reduced collateral tissue thermal trauma, force and friction are developed: laser-assisted bone surgery and piezoelectric surgery.

Aim/Hypothesis: The purpose of the present in vivo experimental study was to determine the thermal changes of the bone tissue following osteotomies performed by piezoelectric surgery, surgical drill and Er:YAG laser-assisted ablation used in contact and NO-contact modes using infrared thermographic camera.

Materials and Methods: A total number of 24 Wistar rats were randomly divided into 4 groups, each consisting of 6 rats (I- sacrificed immediately after surgery; II- 7 days after surgery; III-14 days after surgery; IV- 21 days after surgery). Osteotomies on both rat's tibiae were performed under general anesthesia and always in the same sequence: digitally controlled NO-contact Er:YAG laser (7.5 W, 750 mJ, 10 Hz, QSP mode), piezosurgery (round diamond tip, 1.2 mm diameter, average pressure 15 N), low-speed surgical drill (1200 rpm, round steel surgical bur 2 mm diameter) and contact Er:YAG laser (H-14N handpiece, fiber of core diameter of 940 µm, 7.5 W, 375 mJ, 20 Hz, MSP mode). The osteotomies were 5 mm away from each other and ~2 mm deep, with a diameter ranging between 1.5–2.0 mm. Temperature measurements during each osteotomy were done using an infrared thermographic camera with a detection range of -20° to + 650° C, a thermal sensitivity of < 50 mK, and IR resolution of 320x240 pixels.

Results: For each osteotomy a thermal camera movie was recorded and movie frames were extracted as thermal camera images, and the position of the osteotomy was determined by visual inspection. Temperature readout was performed for this point in all recorded movie frames, providing the information on the temperature at the position of osteotomy while osteotomy was performed. Time evolution of the bone temperature at the point of osteotomy was measured. For each measurement, baseline temperature (Tbase), and maximum temperature measured during the osteotomy (Tmax) were determined. ΔT=Tmax-Tbase was then calculated for each measurement. Mean baseline temperature for each group of osteotomies was 29.96°C for non-contact laser, 27.98°C for contact laser, 28.34°C for surgical drill and 29.39°C for piezosurgery. Mean Tmax for contact laser was 29.92 °C (ΔT=1.94 °C), for non-contact laser was 79.11°C (ΔT=49.15 °C), for surgical drill was 27.36°C and 29.15 °C (ΔT=-0.24 °C) for piezosurgery.

Conclusions and Clinical Implications: The results of the present study showed beneficial effects of the piezosurgery and Er:YAG laser used in contact mode of working on heat generation of bone tissue during osteotomy, reducing potential overheating of the bone as registered by means of infrared thermography. Digitally controlled non-contact Er:YAG laser results in the production of temperature that is higher than the allowed border for bone tissue during osteotomy.

Keywords: infrared thermography, healing, piezosurgery