Evaluation of heat generated with drill tip K-wires

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Thermal necrosis has been cited in reference to pre-drilling and insertion of wires and pins used in orthopaedic fixation. The purpose of this study was to evaluate a new K-wire design with a fluted drill tip as compared with the commonly used trocar tip in terms of insertion efficiency and thermal effects. The study utilized a new thermal imaging temperature measurement technique to achieve a more precise and more holistic picture over traditional thermocouple technology.

Testing was conducted on fresh frozen human cadaveric tibiae. Two groups of 2.0mm K-wires were tested: trocar tipped and drill tipped. All wires were chucked into a custom testing machine and inserted perpendicular to the medial face of the tibia. Insertion was conducted at 700 RPM with a constant axial load of 24 lbs applied via a pulley system and weights. The speed and load were used to simulate typical use of a surgical drill. However in some of the trocar tipped wires small increments of weight were added if insertion was not achieved in 60 seconds. All the tests were performed under the same ambient temperature condition. Time to insertion, which was defined as penetration of both cortices, and maximum temperature of the far bone side were measured. Temperature measurements were recorded by a thermal imaging camera (FLIR P60) and analyzed by ThermaCam Reporter 8 software. This method allowed for temperature acquisition of the K-wire as well as qualitative analysis of the surrounding bone temperature.

The insertion time for the trocar tip wire was 126.5 (±95.9) seconds while the insertion time for the drill tip wire was 4.8 (±0.8) seconds. These results showed a 96% decrease in insertion time (p < 0.05) and a decrease in variance with drill tipped wires compared to trocar tipped wires (Figure 1). For the drill tipped wire there was also a 56% decrease in maximum temperature (p < 0.05) (Figure 2) and a visual decrease in the distance of heat transmitted radially (Figure 3).

The results gathered from this study indicated that the fluted drill tip K-wire achieved improved insertion efficiency and thermal effects. Additionally, it was observed that the distance of transmission of heat was reduced with faster insertion time of the drill tip K-wires. Thus, the fluted drill tip K-wire would be expected to provide a better alternative than the trocar tip in considering bone thermal necrosis during pre-drilling and insertion of wires and pins in orthopaedic fixation.
Figure 1: Time to insertion graph

Figure 2: Maximum insertion temperature

Figure 3: Infrared image of temperature distributions by (a) drill tip and (b) trocar tip wire
References

1 Augustin, Goran. Thermal Osteonecrosis and Bone Drilling Parameters Revisited. Arch Orthopaedic Trauma Surgery. 128 2008:71-77