Cortical Bone Drilling Induced Heat Production with Common Drill Devices

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Purpose: This study was designed to compare the heat produced during cortical bone drilling for various sizes of three common drill devices—standard twist drills, Kirschner-wires (K-wires), and a comparable cannulated drill. Previous studies have shown a threshold for thermal osteonecrosis to be 47°C. Significant data exist regarding heat production of standard twist drills; however, there is a paucity of data regarding cannulated drills and K-wires, both of which are used in many different sizes for many different situations. It was hypothesized that peak temperature would increase with bit size, with standard drills producing the least amount of heat followed by cannulated drills and lastly K-wires.

Methods: Three standard drill bits (2.0, 2.5, and 3.5 mm), three K-wires (1.25, 1.6, and 2.0 mm), and one cannulated drill bit (2.7 mm) were employed for comparison. Drill bits were driven by a Stryker hand drill secured on a servo-controlled linear actuator to provide a constant advancing speed of 1 mm/sec. The advancing speed was chosen after motion-testing a senior and resident surgeon. Bone samples were prepared from non-embalmed human tibia and moisturized at 37±1°C prior to drilling. To measure temperature, two thermocouples were embedded 2 mm into the cortical bone at distances of 0.5 mm and 1.5 mm from the drill hole margin. At least eight tests were performed for each drilling tool based on an initial power analysis.

Results: The peak temperature was extracted from each trial for comparison (Figures 1a and 1b). Standard twist drill data exhibited a positive trend between bit size and heat production. The bit size effect was shown to be less significant in K-wire drilling with no statistical difference between the sizes tested ($P > 0.05$). Comparing across different tools (Figure 1c), it can be seen that K-wires result in significantly ($P = 0.008$ at 0.5 mm) higher peak temperatures than standard twist drills of the same size ($\Delta T = 48.7 \pm 4.5$°C vs. $\Delta T = 35.1 \pm 9.3$°C). Figure 1d shows that a 2.7-mm cannulated drill produced more than double the temperature rise of a 2.5-mm twist drill ($\Delta T = 66.8 \pm 10.8$°C vs. $\Delta T = 33.1 \pm 8.4$°C).

Conclusion: Standard twist drills were found to be the most effective drilling devices, producing the smallest temperature rise among all bit types. For K-wires, all sizes reached substantial temperatures to cause instant thermal osteonecrosis. With an insignificant change in heat produced as K-wire size was increased, it was concluded that thermal effects should not be a reason for choosing K-wire size and that the largest size needed can be used. The cannulated drill showed significantly higher temperatures when compared with similar sized standard drills, reaching maximal temperatures comparable to those of a K-wire. This should be considered when choosing to use a standard versus cannulated drill.

See pages 99 - 147 for financial disclosure information.

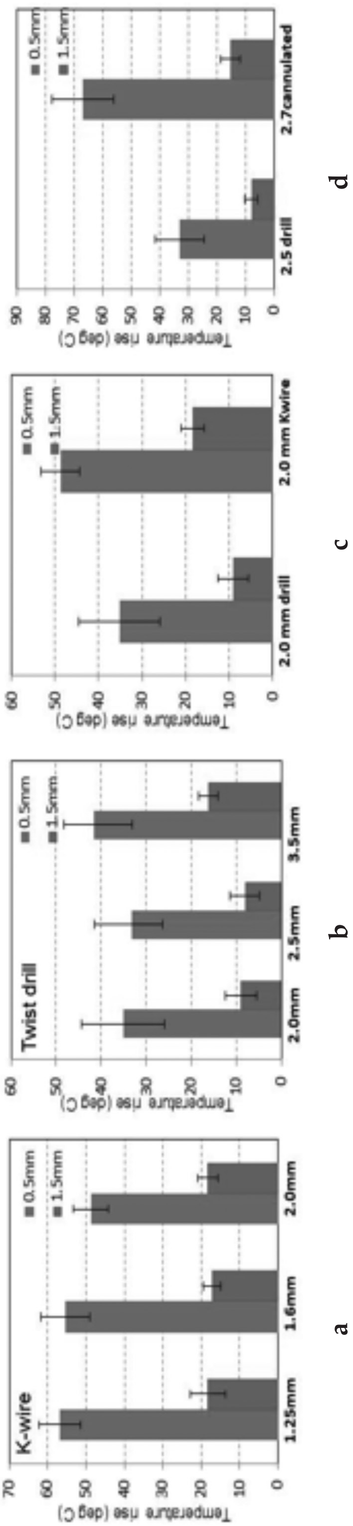

Figure 1. Experimental data with initial temperatures offset to zero.

- The FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an "off label" use). For full information, refer to page 600.