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Insertion of K-wires by hammer generates less heat

A study of drilling and hammering K-wires into bone

Vidmantas Zegunis[1], Søren Toksvig-Larsen[2] and Robertas Tikuisis[3]

Laboratory tests were carried out on cadaver animal bones to evaluate the thermal effect of inserting K-wires with a pneumatic hammer as compared to drilling. The mean maximum bone temperature 0.5 mm from the K-wires was 34 (22–72) °C using the hammer and 54 (19–100) °C for drilling, 1.0 mm from the K-wire the mean maximum temperature was 31 (19–52) °C for hammering and 47 (17–91) °C for drilling. The mean time for the temperature exposure in the cases of drilling was 50 s and for hammering 41 s. The hammering device may reduce the risk of heat-induced injury.

[1]Department of Orthopedics, Klaipeda City Hospital, Liepojos 15, Klaipeda, Lithuanian Republic, [3]Department of Surgery, Klaipeda Children's Hospital, and [2]Department of Orthopedics, University Hospital, Lund, Sweden
Tel +370–61 50946. Fax –61 55895
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The Kirschner-wires provide the key element for successful use of the Ilizarov technique for external fixation. Late frame instability is generally caused by loosening at the wire/bone interface, if wires are not properly inserted (A.S.A.M.I. Group publication 1991). Heat generated by the tip during insertion can damage bone and soft tissue (Matthews and Hirsch 1972, Linsom and Scott 1978, Green 1983).

Earlier investigations have shown that temperatures high enough to cause bone necrosis may arise when preparing bone with power tools (Tetsch 1974, Matthews and Hirsch 1972, Eriksson et al. 1984, Ludewig 1987, Toksvig-Larsen and Ryd 1989). Eriksson (1984) showed that heating to 44–47 °C during 1 minute severely impaired bone formation.

We determined the temperature response while inserting K-wires in bone, using a new hammering instrument compared with drilling.

Material and methods

Ox-bone was used in 11 tests (cortical thickness 5–7 mm), pig-bone in 16 (cortical thickness 3–5 mm), and sheep bone in 13 tests (cortical thickness 5 mm). Using ox-bone, only the anterior cortex was penetrated while both the anterior and posterior cortex in the pig and sheep bone were penetrated with the K-wires. The bone samples were taken from freshly killed animals and deep-frozen until they were thawed for the experiments.

The temperature was measured with copper-constantan thermocouples (Exacon CN 7, Exacon Scientific Instruments Aps, Roskilde, Denmark) connected to a pen recorder (BBC SE 460, Brown Bovery Goerz Metrawatt, Vienna, Austria), with a measuring range of 0–100 °C (accuracy ± 1 °C). The initial temperature was about 20 °C both in the bone and in the surrounding air.

A guide instrument was made (Figure 1) to place the thermocouples 0.5 and 1.0 mm from the K-wire. Using this guide instrument, canals for the thermocouples, 1 mm in diameter, were predrilled into the anterior cortical bone. Whenever possible 3 thermocouples were placed around the K-wire to be inserted, 2 of

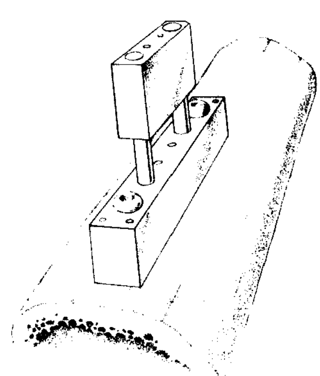

Figure 1. The guide instrument.

Table 1. Maximum temperatures (range) °C at 0.5 and 1.0 mm from K-wires inserted by drilling and hammering

	Drilling	Hammering	*P*-value
0.5 mm			
Ox-bone	51 (19–100)	37 (22–68)	0.1
Pig-bone	58 (32–100)	35 (25–72)	< 0.001
Sheep-bone	51 (32–75)	30 (22–41)	< 0.001
All bones	54 (19–100)	34 (22–72)	< 0.001
1.0 mm			
Ox-bone	43 (17–72)	34 (19–52)	0.02
Pig-bone	51 (28–91)	30 (24–34)	< 0.001
Sheep-bone	45 (33–72)	29 (24–41)	< 0.001
All bones	47 (17–91)	31 (19–52)	< 0.001

them at the 0.5 mm distance. When the thermocouples were in place, the mobile part of the instrument was mounted to protect the thermocouples during the insertion of the K-wires and to steer the K-wire. The 2 guide holes, 1 for drilling and 1 for hammering, were situated 9 mm from each other, so each pair of tests was performed in bone of the same size, configuration, and cortical thickness. K-wires were drilled with an air-powered 3M Maxi Driver (Orthopedic Products Division 3M, St. Paul, MN, U.S.A.) in all experiments with a maximal rotation of 850 rpm.

For hammering the K-wires into the bone a special instrument was used. It consists of an air-powered pneumatic hammer and a wire-driving device. The rate of hammering depends on the air pressure in the hammer. It rises from 47 Hz when pressure is 1500 mmHg to 53 Hz when pressure is 4000 mmHg. The wire-driving device protects the K-wire from side-bending and makes it possible to hammer the wire into the bone without bending or breakdown.

In experiments 1–12, commercially available 2-mm K-wires were used. In drilling, it had a diamond point configuration and in hammering the point was changed into a pencil sharp configuration. In the experiments 13–30, the same K-wires, 1.6 mm in diameter, with trocar point configuration (Howmedica, Rutherford, NJ, U.S.A.) were used for both methods. The duration of each experiment was counted from the beginning of the procedure until the K-wire had penetrated the bone. The mean duration of drilling was 50 sec and of hammering 41 sec. The temperature in the bone reached its peak at the moment of penetration, and when the procedure stopped the temperature dropped immediately.

The statistical test used was the paired *t*-test.

Results

The mean maximum bone temperature 0.5 mm from the K-wire was 34 °C when using the hammering device and 54 °C when drilling, respectively (Table 1), and the corresponding values 1.0 mm from the K-wires were 31 °C and 47 °C, respectively.

Discussion

The machining on bone has been practiced since prehistoric times. Hippocrates recognized the disadvantage of mechanical bone cutting with the possible thermal damage. He recommended to drill slowly, to remove the tool frequently and plunge it in cold water to cool the tool and prevent the bone from heating (Phillips 1973, Majno 1975).

When preparing bone with power tools during operative procedures, high temperatures may arise and cause bone necrosis, (Ludewig 1971, Matthews and Hirsch 1972, Tetsch 1974, Krause et al. 1982, Eriksson et al. 1984, Matthews et al. 1984, Andersen and Bruun 1989). Since the time when K-wires named after the German surgeon Martin Kirschner (1879–1942) were introduced, drilling has been used to insert them into the bone. However, Ilizarov recommends pushing or hammering the K-wire with a manual hammer whenever it is possible (personal communication).

Our new pneumatic hammer solved the problem of side-bending of the K-wires which occurs in manual hammering. In fragile and small bones, the power produced by the pneumatic hammer should be lowered to prevent fracture. The hammering device lowers the heat generation and may reduce the risk for ring sequestrum formation, loosening of wires, and the risk of pin tract infections.

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