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Evaluation of stability of osteosynthesis with K-wires on an artificial model of tibial malleolus fracture

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ABSTRACT

Background: Paediatric ankle fractures comprise approximately 4% of all paediatric fractures and 30% of all epiphyseal fractures. Integrity of the ankle ''mortise'', which consists of tibial and fibular malleoli, is significant for stability and function of the ankle joint. Tibial malleolar fractures are classified as SH III or SH IV intra-articular fractures and, in cases where the fragments are displaced, anatomic reposition and fixation is mandatory.

Methods: Type SH III–IV fractures of the tibial malleolus are usually treated with open reduction and fixation with cannulated screws that are parallel to the physis. Two K-wires are used for temporary stabilisation of fragments during reduction. A third ''guide wire'' for the screw is then placed parallel with the physis. Considering the rules of mechanics, it is assumed that the two temporary pins with the additional third pin placed parallel to the physis create a strong triangle and thus provide strong fracture fixation. To prove this hypothesis, an experiment was conducted on the artificial models of the lower end of the tibia from the company ''Sawbones''. Each model had been sawn in a way that imitates the fracture of medial malleoli and then reattached with 1.8 mm pins in various combinations. Prepared models were then tested for tensile and pressure forces.

Results: The least stable model was that in which the fractured pieces were attached with only two parallel pins. The most stable model comprised three pins, where two crossed pins were inserted in the opposite compact bone and the third pin was inserted through the epiphysis parallel with and below the growth plate.

Conclusion: A potential method of choice for fixation of tibial malleolar fractures comprises three K-wires, where two crossed pins are placed in the opposite compact bone and one is parallel with the growth plate. The benefits associated with this method include shorter operating times and avoidance of a second operation for screw removal.

Introduction

Distal tibial and fibular physeal fractures comprise 25–38% of all fractures of the physis and are the second most common physeal fractures [1,2]. Only 4% of all ankle fractures affect the physis [2]. The individuals most affected are children aged between 8 and 15 years [3]. Tibial malleolar fractures are classified as SH III and SH IV fractures, which are caused by injury that involves supination and inversion of the foot, as described by Dias and Tachdjian [4]. Medial tibial malleolar fractures are intra-articular fractures that require anatomical repositioning of fracture fragments. Failure to achieve anatomical repositioning often causes arthrosis of the joint in later years because of articular incongruity [5]. Growth arrest and deformity may occur after such fractures due to injury to the growth zone, particularly if fracture fragments are treated roughly and the reposition is not anatomical [6]. The risk of growth arrest is dependent on the age of the child: a young child will have a higher risk of growth arrest than an older child in whom the physis is soon to be closed. In rare cases, treatment of tibial malleolar fractures can be achieved by closed reduction, but this is possible only if fracture displacement is minor. In cases where anatomic reduction cannot be obtained by

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[1] Retired.

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closed methods, open reduction with internal fixation should be performed [7]. During open reduction, usually to obtain anatomical position of a fragment, two K-wires are used for temporary fixation until one or two cannulated screws are placed in the epiphysis and metaphysis parallel with the growth plate. In smaller children there is barely enough space between the physis and the articular surface of the bone to place a screw.

The use of screws that are too big or are placed too close to the growth plate may cause damage to this structure. Using only K-wires minimises the risk of damage to the growth plate [7]. Three K-wires, two pins for fragment stabilisation and a third guide wire for the positioning of the screw are used in open reduction. This study assessed the stability of fragments that are fixated with only K-wires and considered various combinations of K-wires to establish the most stable combination.

Materials and methods

An artificial tibial bone model from "Sawbones" (Sawbones Europe AB©, Malmö, Sweden) was used in this study. This model is usually used in AO training exercises. The bone model is made of composite material with very similar mechanical characteristics to those of real bone [8]. Various combinations of constructions of K-wires were compared and the stability of the osteosynthesis was assessed.

Five models of osteosynthesis with K-wires were designed. Each bone was cut to imitate medial malleolus fracture: the cut was between the upper and medial articular surface of the tibial malleolus with an angle of 5° in the coronal plane. An electric drill was used to induce 1.8 mm thick K-wires at the same angle.

In model A, two parallel K-wires were induced diagonally from the tip of the malleolus to the opposite compact bone (Fig. 1).

In model B, two crossed K-wires were induced from the tip of the malleolus to the opposite compact bone. The solid angle between the wires was 27°, and the angle in the lateral direction was 61° (Fig. 2).

In model C, one K-wire was induced from the tip of the malleolus diagonally to the opposite compact bone and the other K-wire was induced laterally through the malleolus and epiphysis beneath and parallel with the growth plate. The solid angle between the wires was 27° in the coronal plane and 48° in the laterolateral (LL) plane (Fig. 3).

In model D, two parallel K-wires were induced diagonally from the tip of the malleolus to the opposite compact bone and the third wire was induced laterally through the malleolus and epiphysis parallel with the growth plane (Fig. 4).

In model E, two crossed K-wires were induced diagonally through the malleolus in the opposite compact bone and the third wire was induced laterally through the malleolus and epiphysis parallel with the growth plane. The solid angle between the

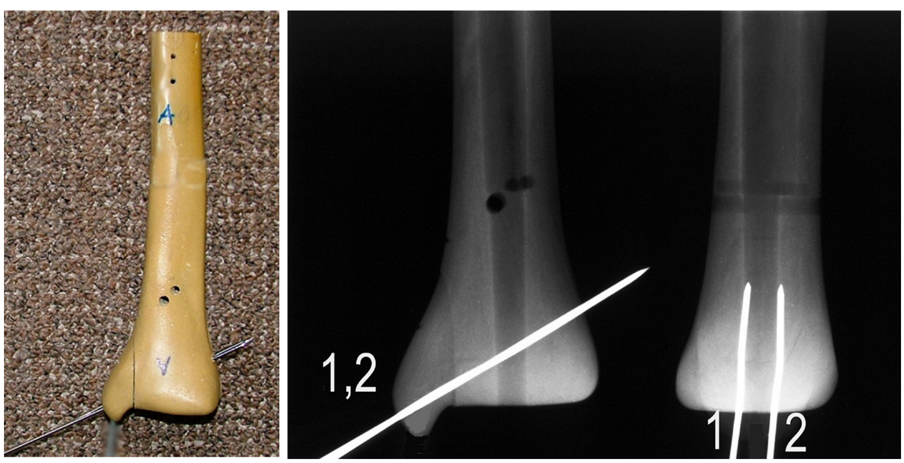

Fig. 1. Model A – two parallel k-wires are pined thru the malleolus into opposite corticalis.

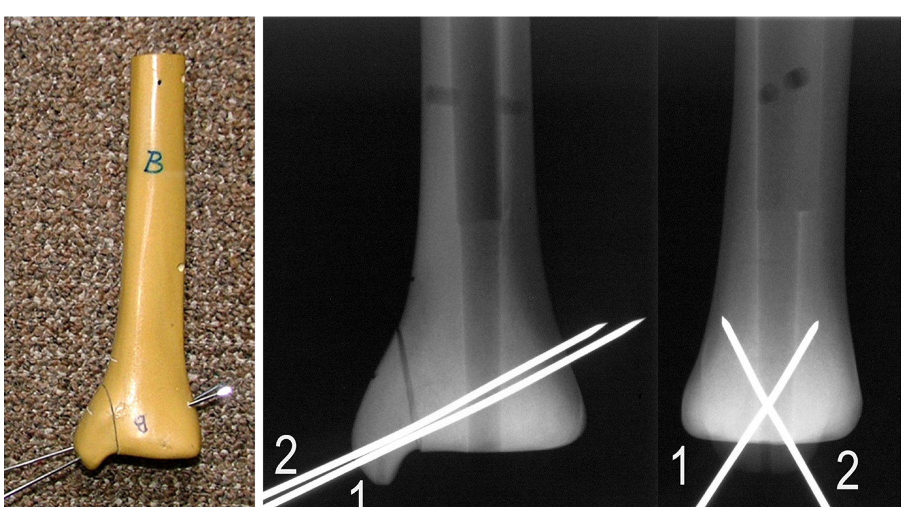

Fig. 2. Model B – two crossed k-wires are pined thru the malleolus into opposite corticalis.