Morphology of the Tibialis Anterior Muscle and Its Implications in Minimally Invasive Plate Osteosynthesis of Tibial Fractures

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abstract

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We examined the variation in the origin of the tibialis anterior muscle from the lateral aspect of the tibial shaft and interosseous membrane as well as the variation in the morphology of its musculotendinous junction. Forty cadaveric lower leg specimens (20 right and 20 left) were dissected to reveal the anterior compartment. The origin of the tibialis anterior muscle and its relation to the lateral tibial shaft and interosseous membrane were determined. The position of the musculotendinous junction relative to the medial malleolus was also measured. Tibial length ranged from 29.5 to 45 cm (mean, 36.5±3.1 cm). The distal limit of the muscle origin was 5.9 to 20.5 cm (mean, 12.1±3.3 cm) from the tip of the medial malleolus. The distance between the musculotendinous junction and the medial malleolus ranged from 1.4 to 10.8 cm (mean, 6.1±1.9 cm). The attachment of the muscle belly ends between 15.3 and 31.8 cm (mean, 24.4±4.1 cm) distally from the joint line at the knee. There was no statistical correlation between tibial length and muscle morphology.

This variation warrants consideration in the percutaneous insertion of screws in the distal end of long plates, as the neurovascular bundle may be injured in patients with a shorter muscle belly. We advocate an open distal approach to protect the neurovascular bundle during insertion of the plate and distal screws.
Percutaneous fixation of tibial fractures using a Less Invasive Stabilization System (Synthes GmbH, Solothurn, Switzerland) is becoming increasingly common. Diaphyseal fractures may be fixed percutaneously with angular stable plates bridging the fracture. The indication for the use of these plates also extends to metaphyseal fractures with or without intra-articular involvement. Closed reduction of diaphyseal fractures is performed with fluoroscopic control. The plate is then applied to the lateral surface of the tibia between the tibialis anterior muscle and the periosteum through a 50-mm incision running distally from Gerdy’s tubercle. The distal screws are placed through stab incisions. Damage to neurovascular structures has been described with longer plates, requiring placement of distal screws.

We examined the variation in the origin of the tibialis anterior muscle from the lateral aspect of the tibial shaft and interosseous membrane as well as the variation in the morphology of the musculotendinous junction in relation to the medial malleolus. In the percutaneous technique for tibial osteosynthesis, the plate is inserted between the muscle and periosteum. This protects the neurovascular bundle as it lies within the muscle belly. Shorter muscle bellies protect the neurovascular bundle for a smaller portion of their proximal course in the anterior compartment, increasing the chances of injury with the insertion of longer plates.

**Materials and Methods**

Forty cadaveric lower-leg specimens (20 left and 20 right, unpaired), prepared by the Thiel method, were used. The specimens were ages 55 to 83 years (mean, 71.5 years). Twenty-two specimens were from men and 18 from women. None of the specimens had had previous surgery or sustained injuries. The absence of previous bony injuries was confirmed with radiographs. The length of the tibia was measured as the distance between the center of the medial joint line at the knee and the tip of the medial malleolus. A mathematical method employing stature regression formulae correlates tibial length with body height.

Following the removal of the skin and superficial fascia, the anterior osteofascial compartment of the lower leg was identified. The deep fascia was then removed. The tibialis anterior and extensor hallucis longus muscles were dissected out (Figure 1). The distal limit of the tibialis anterior muscle origin was identified with a magnifying glass. This was then marked with a needle, and the vertical distance to the level of the medial malleolus was measured with a sliding gauge. The distal tip of the transition zone was identified with a magnifying glass and taken as the musculotendinous junction, and its vertical distance to the level of the medial malleolus was measured with a sliding gauge. The data were recorded and analyzed using Microsoft Excel 2003 (Microsoft, Redmond, Washington). Student *t* test was used for statistical analysis of the data. *P* values < .05 were regarded as statistically significant.

**Results**

The length of the tibiae ranged from 29.5 to 45 cm, with a mean of 36.5 cm and standard deviation of 3.1 cm. The distal limit of the muscle origin was 5.9 to 20.5 cm (mean, 12.1 ± 3.3 cm) from the tip of the medial malleolus. In 7 specimens, these distal fibers were attached to the interosseous membrane, and in 33 to the lateral tibial cortex. The variation of the muscle origin (lateral tibial cortex and interosseous membrane) does not seem to be clinically relevant here. The distance between the musculotendinous junction and the medial malleolus ranged from 1.4 to 10.8 cm (mean, 6.1 ± 1.9 cm). The muscle origin extended 15.3 to 31.8 cm (mean, 24.4 ± 14.1 cm) distal to the level of the joint line at the knee. The mean muscle length was 22.7 ± 3.2 cm in female specimens and 25.8 ± 4.2 cm in male specimens (*P* = .01). There was no statistical correlation between tibial length and muscle morphology (musculotendinous junction, *P* = .09; distal fibers of muscle origin, *P* = .39).

**Discussion**

The use of minimally invasive techniques with angular stable plates is fast becoming part of the standard armamentarium of the trauma surgeon, with ever-increasing indications. These plates are inserted percutaneously between the tibialis anterior muscle and the periosteum, and thus the neurovascular bundle is protected by the muscle belly. The tibialis anterior is situated on the lateral side of the tibia; it is thick and fleshy above and tendinous below. It arises from the lateral condyle and upper half or two-thirds of the lateral surface of the body of the tibia; from the adjoining part of the interosseous membrane; from the deep surface of the fascia; and from the intermuscular septum between it and the extensor digitorum longus. The fibers run vertically downward and end in a tendon, which is apparent on the anterior surface of the muscle at the lower third of the leg. After passing through the most medial compartments of the transverse and cruciate crural ligaments, it is inserted into the medial and under the surface of the first cuneiform bone and the base of the first metatarsal bone. This muscle overlaps the anterior tibial vessels and deep peroneal nerve in the upper part of the leg. The anterior tibial artery descends on the anterior surface...
of the interosseous membrane, gradually approaching the tibia; at the lower part of the leg, it lies on this bone. The anterior tibial artery is accompanied by a pair of veins that lie on either side of the artery and the deep peroneal nerve; at approximately the middle of the leg, the nerve is in front of the artery, and at the lower part it is generally again on the lateral side.  

Articles reporting the risks of iatrogenic nerve injury in the lower leg caused by orthopedic procedures are rare. Deangelis et al. examined the course of the superficial peroneal nerve in relation to tibial and the deep peroneal nerve; at approximately the middle of the leg, the nerve is in particular at risk with this technique.  

We advocate an open technique for the insertion of 11- and 13-hole Less Invasive Stabilization System plates to position the implant over the peristeme under direct vision. This may be achieved through extension of the distal incision to ensure the apposition of the plate to the bone and to avoid interposition of the neurovascular bundle beneath the plate.

REFERENCES