PARADOXICAL MOTION OF DISTAL FIBULA BY PARTIAL RESECTION OF FIBULA
-BIOMECHANICAL STUDY-

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Introduction
The fibula is a common donor site in patients undergoing bone grafting, and partial resection is a common procedure in limb lengthening and high tibial osteotomy. We had been unable to find the clear-cut guidelines for the amount of bone that can be harvested safely (2, 3, 4). Our study (1) showed the 6 cm of the distal fibula was essential for the ankle stability, however, mechanical role of fibula was unclear. The current study examined the motion of the tibia, fibula and talus applying inversion force in different residual fibula length. Here, we focused on the motion the residual fibula to investigate the mechanism of the instability of the ankle joint complex.

Materials and Methods
Six normal fresh-frozen cadaveric legs (4 male, 2 female) were studied. Mean age was 81 years (range 71-88 years). Motion of the tibia, fibula and talus were measured (Fig. 1). The specimens were cut through the distal one third of the femur and mounted on the wooden zig. The foot was mounted to the distal fixture using two 5-mm diameter Steinmann pins through the calcaneous and the metatarsal bones. Knee joint was fixed extension position using 5mm pin and the pin was mounted to the proximal fixture. Electromagnetic sensors (3 space FASTRAK; Polhemus, Colchester, Vermont) were attached to the tibia, fibula, and talus. Data collection was done with special software (Medisens Inc, Saitama, Japan).

Fibula was cut sequentially, proximal 3cm from the fibula head, distal 10cm, 6cm, 4cm, 3cm from the lateral malleolus, and angular motion of each bone was measured when medial and lateral load 19.6 newton was applied to the 30cm proximal of tibia from the calcaneous fixation position in the frontal plane. Motion of tibia fibula and talus against calcaneous were measured. Discrepancy of inversion angle between tibia and fibula (FTA-I), rotational angle (FTA-R) were also measured. Three trials were done for each loading condition. Statistical analysis was performed with analysis of variance with repeated measures with significant level p<0.05.

Results

• Inversion angle of tibia, fibula and talus: (Fig. 2)
  Distal 4-cm cut significantly increased the inversion angle of tibia (p=0.0353) and fibula (p=0.0371). Sequential resection of fibula gradually increased the inversion angle of tibia and fibula, but the angle of talus was almost constant (Fig. 1). The specimens were cut through the distal one third of the femur and mounted on the wooden zig. The foot was mounted to the distal fixture using two 5-mm diameter Steinmann pins through the calcaneous and the metatarsal bones. Knee joint was fixed extension position using 5mm pin and the pin was mounted to the proximal fixture. Electromagnetic sensors (3 space FASTRAK; Polhemus, Colchester, Vermont) were attached to the tibia, fibula, and talus. Data collection was done with special software (Medisens Inc, Saitama, Japan).

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Discussion
Our study showed paradoxical motion of fibula against tibia when fibula was cut at 4 cm from the lateral malleolus, that means fibula gave up to cooperate to stabilize the ankle joint. Distal 4 cm cut might damaged the syndesmosis of the tibiofibular joint and caused instability of the ankle joint. Lang (4) measured fibulal displacement, and recommended 6 cm distal fibula is required to get the stability of ankle joint. Our results support their study. Pacelli (2) applied 700 N axial load and concluded only 10%(mean 3.9 cm) was needed to maintain ankle stability. Our study did not added axial load to the leg, however, transition from swing phase to stance phase in gait-cycle is very unstable phase without axial load. Stability of ankle especially valgus/varus stability is important to keep good alignment of hindfoot. It is essential for good heel contact on various terrain conditions. Kanaya (3) reported in clinical study, even 10 cm residual fibula increased valgus deformity in children.

Our study suggests that at least 6 cm of distal fibula is essential to get the good stability of the ankle joint. As abnormal motion of fibula causes instability of the ankle joint, fixation of distal fibular joint or bracing is recommended to prevent the sprain of ankle joint, especially when residual fibular length is less than 6 cm.

References

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