

### **Shear's Role in Nonunion: Defining the Mean Angle of Long Bone Multifragmentary Nonunions**

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**Purpose:** Both mechanical and biological theories have been proposed in the development of nonunion. With respect to mechanical theory, it is specifically the strain environment of a fracture that may predispose it to nonunion. In multifragmentary fractures, a nonunion may form along any of the original fracture lines; however, the plane that experiences the highest strain is at 45°—the shear plane. We hypothesize that in multifragmentary fractures the initial fracture line that most often fails to unite will tend toward 45°. The aims of this study are (1) to define the mean angle of nonunion in a cohort of tibial and femoral multifragmentary fractures and (2) to define the mean angle of initial fracture planes within tibial and femoral multifragmentary fractures that go on to form a nonunion.

**Methods:** A retrospective cohort study of patients requiring treatment for diaphyseal or metaphyseal nonunions in the tibia or femur was performed. Those with multifragmentary fractures were included. A published technique was utilized to measure fracture and nonunion angles. The initial fracture and nonunion radiographs were compared to determine which initial fracture plane matched the plane of the nonunion. Both the initial fracture angles and resultant angle of established nonunions were recorded from AP and lateral radiographs. The mean angle of both the initial fracture plane resulting in a nonunion and the mean angle of nonunion were calculated.

**Results:** 183 nonunions were screened; after exclusions, 68 patients (mean age 46 years, range 20-84, M:F 52:16) were included. 40% of the fractures had 4 or more fragments. 33% of the fractures were femoral and 67% tibial. The mean angles of initial multifragmentary fracture planes resulting in nonunion were 49° (standard deviation [SD] 18) on AP and 48° (SD 17) on lateral views. The mean angles of nonunion were 50° (SD 19) for both AP and lateral views.

**Conclusion:** In patients with multifragmentary fractures that go on to nonunion, both the angle of the initial fracture that goes on to nonunion and the nonunion angle tend toward 45°. This supports the mechanical theory that strain from the shear plane is an important factor in the formation of nonunions.