STABILITY OF THE FIRST METATARSAL BASE WEDGE OSTEOTOMY

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INTRODUCTION

Base wedge osteotomies are a well-established surgical indication for patients presenting with hallux valgus deformities. Proximal osteotomies are indicated for severe deformities in cases when the intermetatarsal angle is greater than 15 degrees (Landsman and Vogel, 1992). Numerous base wedge procedures have been identified to correct hallux valgus deformity, all requiring internal fixation.

First metatarsal base wedge osteotomies are subject to instability due to their inability to resist bending from vertical ground reaction forces upon weight bearing. This results in dorsal elevation of the metatarsal head with progressive angulation at the fixation site (Fillinger et al., 1998). Previous studies have attempted to quantify the stability of proximal osteotomies (Campbell et al., 1998; Lian et al., 1992); however, most have concentrated on the fixation technique rather than the geometry of the osteotomy alone.

The purpose of the current study was to assess the strengths of various first metatarsal base wedge reduction methods. This will be accomplished by using a relative comparison of osteotomy fracture force to an intact bone. By using such a ratio, a clearer understanding of the most stable base wedge osteotomy can be ascertained.

METHODS

For the current analysis, thirty, first metatarsal Sawbone® bone models (Pacific Research Laboratories, Inc., Vashon Island, WA) were divided into five groups: (a) Intact bone, (b) Juvara osteotomy fixated with one screw, (c) Juvara osteotomy fixated with two screws, (d) Sglartto box hinge osteotomy and (e) Sglartto non-hinged box wire method. These osteotomies were chosen because it is believed that they represent the greatest degree of stability in base wedge procedures.

Each model was mounted in the base of Instron® Model 8521(Instron, Inc., Canton, MA) at a 15 degree angle to simulate the orientation of the bone during weight bearing (Figure 1). Force was applied to the bone through a block of PMMA molded to fit across the sesmoids under the metatarsal. The force transducer was advanced at a rate of 3 millimeters per second until fracture occurred. These parameters were chosen based on similar studies found in the literature (Fillinger et al., 1998).

Figure 1: Experimental Set Up

Maximum force at fracture was recorded for each bone. Peak forces for the surgically prepared bones were divided by average force for the intact bone in order to create an index of stability for each osteotomy.

RESULTS

Results show considerably smaller loads throughout all osteotomy groups compared to that of the intact bone (Table 1).

Table 1: Fracture Load and Stability Index

Osteotomy Type	Average Force (N)	Stability Index (%)
Juvara Single (n=5)	35 (±22)	12.3
Juvara Double (n=5)	55 (±43)	19.4
Sglartto Hinge (n=5)	20 (± 3)	7.2
Sglartto Non-Hinge (n=4)	25 (±22)	8.9
Intact Bone (n=10)	282 (±71)	--

The stability index ranged from 7 to 20% with the Sglartto Non-Hinge Osteotomy being the least stable. Larger sample sizes are necessary to determine if these differences are statistically significant.

Failure modes were similar within a given osteotomy type. The Juvara type osteotomy showed an oblique fracture distal to fixation point. For the Sglartto type, stress risers were found at the insertion site of the wire fixation. In all cases, distal migration of the metatarsal head was noted (Figure 2).

DISCUSSION

This initial study utilized Sawbones® due to their isotropic nature. In this case, anticipated differences in the results could be interpreted to be a factor of the osteotomy geometry and its internal fixation alone. Future studies will include bilateral cadaveric metatarsals with one side being used as the control.

Results from these data should provide reliable measures of the stability of base wedge reduction procedures. As more types of osteotomies are introduced, it will become possible to objectively assess their stability and outcome in the surgical patient.

(a) Sglartto Osteotomy

(b) Juvara Osteotomy

Figure 2: Failure Modes for Osteotommies

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