20077723

Request # 20077723

JUN 01, 2006

filled 6/2

Email (PDF) To: clarinda.pocchia@ebimed.com

Mrs. Clarinda Pocchia
EBI, L.P. 100 Interpace Parkway
Attention: Clarinda Pocchia
Parsippany, NJ 07054

DOCLINE: Journal Copy EFTS Participant

Title:	Foot & ankle international / American Orthopaedic Foot and Ankle Society [and] Swiss Foot and Ankle
Title Abbrev:	Foot Ankle Int
Citation:	2001 Sep;22(9):731-3
Article:	Tibiotalocalcaneal arthrodesis: a biomechanical an
Author:	Mann MR;Parks BG;Pak SS;Miller SD
NLM Unique ID:	9433869 Verify: PubMed
PubMed UI:	11587390
ISSN:	1071-1007 (Print)
Publisher:	Data Trace Publishing Co., Baltimore Md
Copyright:	Copyright Compliance Guidelines
Authorization:	JRusso
Need By:	JUN 02, 2006
Maximum Cost:	**Any cost**
Patron Name:	Pocchia, Mrs. Clarinda
Referral Reason:	Not owned (title)
Library Groups:	NJHSN,BHSL7,CBLC,FreeShare,BHSL
Phone:	1.973.429-6240
Fax:	1.973.316-2452
Comments:	**Please fax & email the article selected. Fax number(973) 316-2452 & email clarinda.pocchia@ebimed.com**
Routing Reason:	Received Jun 02, 2006 08:23 by NJUSBM in Serial Routing - prefixed

Bill to: NJUMHM
Mountainside Hospital
Health Sciences Library
1 Bay Avenue
Montclair, NJ 07042

FOOT & ANKLE INTERNATIONAL

Tibiotalocalcaneal Arthrodesis: A Biomechanical Analysis of the Rotational Stability of the Biomet Ankle Arthrodesis Nail

Michael R. Mann, M.D.; Brent G. Parks, MSc; Shane S. Pak, M.D.; Stuart D. Miller, M.D.
Baltimore, MD

ABSTRACT

We hypothesized that the posterior-to-anterior (PA) calcaneal interlocking screw of the Biomet Ankle Arthrodesis Nail would increase rotational stability secondary to increased bone purchase compared with the standard lateral-to-medial (transverse) screw. Each of 10 fresh human cadaver lower limbs (five matched pairs) were stabilized with a nail inserted retrograde through the calcaneus, talus, and tibia according to standard technique. One limb of each pair was fixed with a transverse calcaneal screw; the contralateral limb, with a PA calcaneal screw. Each limb was then subjected to torsional testing on an MTS Mini Bionix load frame. The PA screw construct was significantly stiffer than the transverse screw construct: 1.96 and 1.41 Nm/E, respectively ($P < 0.036$).

INTRODUCTION

Excellent results have been reported[5,12] with an intramedullary nail (designed for supracondylar femur fracture fixation) for tibiotalocalcaneal arthrodesis. The success of this early experience with the nail led to the development of a second-generation intramedullary nail for extended hindfoot fusion. The Biomet Ankle Arthrodesis Nail (Biomet, Warsaw, IN) is a device that allows for the placement of a posterior-to-anterior (PA) interlocking screw through the calcaneus, as well as the more traditional transverse (lateral-to-medial) screw placement. It also allows for compression across the arthrodesis site. In the current study, we hypothesized that the mechanical bending and torsional properties of this design would increase the rotational stability of the intramedullary nail because of the better purchase of a PA screw compared with that of the standard lateral-to-medial (transverse) screw.

MATERIALS AND METHODS

Five matched pairs of fresh-frozen cadaver lower limbs were obtained and stored frozen until testing. The tissue was thawed at room temperature for 24 hours before testing. In each sample, the Biomet Ankle Arthrodesis Nail (length .15 cm and diameter 10 mm) was surgically implanted by the same surgeon according to standard technique. In one leg of each pair, the calcaneal screw was inserted in a PA direction; in the contralateral side, the calcaneal screw was inserted in the more traditional transverse (lateral-to-medial) direction. All screws were 5.0 mm in diameter. The PA screw was 75 mm long, and the lateral-to-medial screw was 35 mm long.

The long axis of the tibia was aligned with and secured to the hydraulic actuator of a MTS Mini Bionix load frame (MTS Systems, Eden Prairie, MN). Distally, the forefoot was secured, in neutral position, to a wooden base with Steinmann pins to prevent rotation. A 700-N load was applied axially, and then torque (external rotation) was applied about the long axis of the tibia at a rate of 3 N-m/sec to 10 N-m/sec. Torque and angular deformation data were then recorded and plotted as curves (Fig. 1), and the average stiffnesses of the constructs (Fig. 2) were determined from the slope of the initial linear portion of the curves in external rotation.

A paired Student's t-test was used to determine if observed differences were significant ($P < 0.05$).

RESULTS

The two constructs were significantly different in torsion. The PA screw construct was 40% stiffer than the transverse screw construct: average torsional stiffness,

Unrestricted funds were provided by Biomet, Inc., to the Department of Orthopaedic Surgery of Union Memorial Hospital for research laboratory purposes. In addition, the senior author (SDM) continues to receive royalties as a developer of the Biomet ankle arthrodesis nail.

Address all correspondence to:
Stuart D. Miller, M.D.
c/o Lyn Camire, Editor
Union Memorial Orthopaedics
The Johnston Professional Building, #400
3333 North Calvert Street
Baltimore, MD 21218
Phone: (410) 554-6668
Fax: (410) 554-2832
E-mail: lync@helix.org

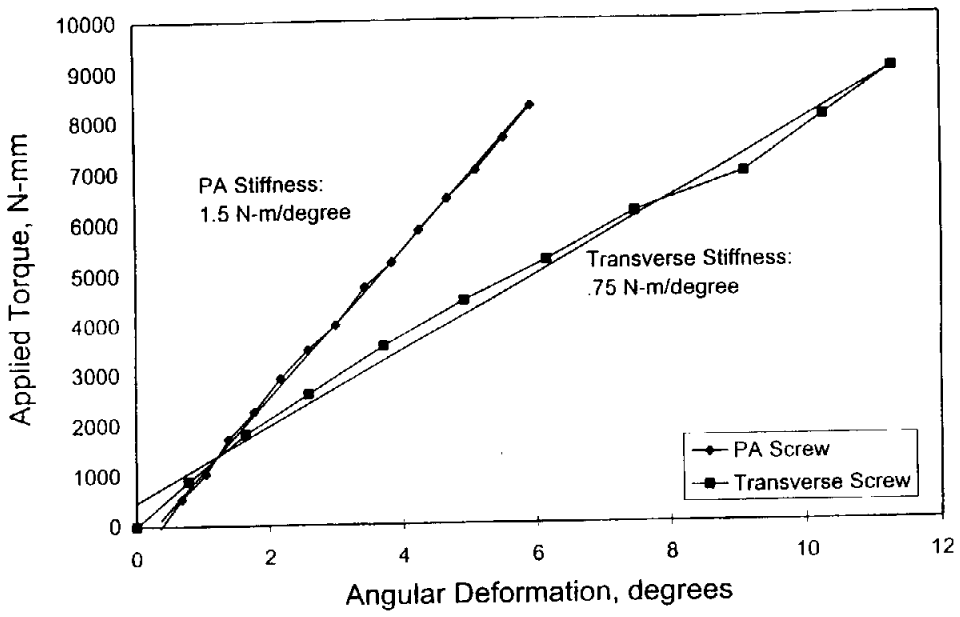

Fig. 1: Torque-angular deformation curves for the PA and transverse screws.

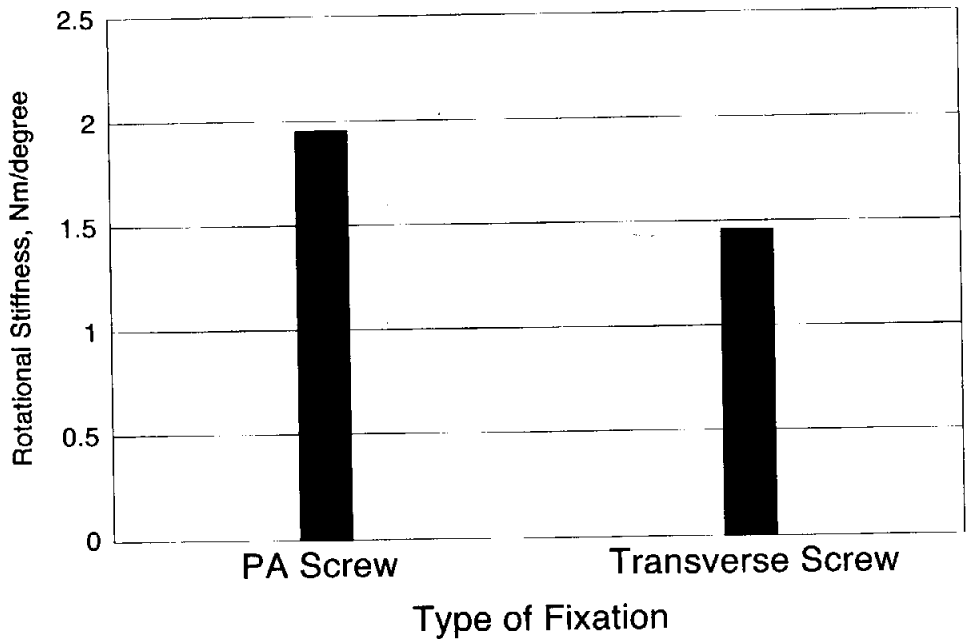

Fig. 2: Average rotational stiffness for the PA and transverse screws.

1.96 N-m/° (range, 0.5 to 2.8 N-m/°) and 1.41 N-m/° (range, 0.5 to 2.3 N-m/°) ($P<0.036$), respectively. The angular deformation curve (Fig. 1) and average stiffness (Fig. 2) demonstrate the difference between a short screw placed lateral to medial and a longer screw placed in the posterior to anterior direction.

DISCUSSION

Tibiotalocalcaneal fusion is a technically demanding procedure but can be an effective modality for treating a multitude of painful and disabling deformities of the hindfoot. Various methods of intramedullary fixation have been used to obtain successful tibiotalocalcaneal fusion, including cadaveric bone, ivory pegs, Steinmann pins, screws, plates, and nails.[1,4] Kuntscher[6] advocated placing a nail through the foot, across the knee, and into the femur to perform concurrent ankle and knee arthrodeses.

Extended hindfoot and ankle arthrodeses can have high rates of complications. In a series of 78 ankle arthrodeses, Frey et al.[3] reported a 56% complication rate, including nonunion and delayed union rates of 41% and 12%, respectively. The senior author (SDM) has employed large cannulated screws in securing ankle and pantalar arthrodeses. A previous study from our institution of 13 tibiocalcaneal and eight pantalar arthrodeses had a 14% nonunion rate and a 24% malunion rate.[9]

More recently, Kile et al. reported successful fusion after using a retrograde femoral nail through a plantar incision for tibiotalocalcaneal arthrodesis. Another group reported good results with using this nail in 19 ankles: 14 successful fusions and five asymptomatic pseudarthroses.[8] They reported only one broken nail, which occurred at the site of an unfused subtalar joint. Berend et al.[2] found intramedullary fixation of the ankle to be biomechanically stiffer than crossed lag screws in all bending and torsional directions. In that study, the authors tested nails with transversely placed locking screws.

Use of the intramedullary nail is not without problems, including difficulties in nail placement.[7,11] The authors of one study reported difficulty in locking the nail distally and noted that a lateral-to-medial screw did not obtain good bone purchase unless it inserted into the sustentaculum tali region.[11] The authors also noted that "it is very unlikely that a locking screw can consistently be placed from the lateral calcaneal body, through the rod, and into the sustentaculum tali."[11] Such considerations led to the development of the second-generation ankle arthrodesis nail. A subsequent study confirmed the new design, reporting that turning the standard retrograde locked nail 90° during revision arthrodesis procedures took advantage of the large calcaneal bone mass.[10]

Even with the relative clinical success of the arthrodesis procedures and studies that indicate the intramedullary nail is biomechanically superior, one study[9] reported high nonunion and malunion rates associated with extended hindfoot arthrodesis (15% and 24%, respectively).

In the current study, we examined the Biomet Ankle Arthrodesis Nail, which incorporates a PA locking screw. This PA screw, which replaces one of the transversely placed screws in the traditional intramedullary nail configuration, has two distinct advantages. First, it passes through the calcaneus in a longitudinal fashion, providing substantially more bony purchase than does the transverse screw it replaces. Second, the PA screw can engage stronger bone, e.g., the sustentaculum tali. The results of the current study have indicated that use of a PA nail affords 40% more stiffness than traditional tibiotalocalcaneal arthrodesis fixation techniques. This increased rotational stability may provide improved union rates for tibiotalocalcaneal arthrodesis.

The Biomet nail is also equipped with a device that allows compression across the arthrodesis site after placement of the two proximal tibial screws. Although this feature was not evaluated in the current study, it is possible that it would increase the construct's stiffness and, thus, the resulting fusion rates. This hypothesis is currently under investigation.

ACKNOWLEDGMENTS

We wish to express our thanks to Bob Linder and Biomet for providing the intramedullary nails and locking screws.

REFERENCES

1. **Abidi, NA; Gruen, GS; Conti, SF**: Ankle arthrodesis: indications and techniques. J. Am. Acad. Orthop. Surg., **8**:200-209, 2000.
2. **Berend, ME; Glisson, RR; Nunley, JA**: A biomechanical comparison of intramedullary nail and crossed lag screw fixation for tibiotalocalcaneal arthrodesis. Foot Ankle Int., **18**:639-643, 1997.
3. **Frey, C; Halikus, NM; Vu-Rose, T; Ebramzadeh, E**: A review of ankle arthrodesis: predisposing factors to nonunion. Foot Ankle Int., **15**:581-584, 1994.
4. **Katcherian, DA**: Treatment of ankle arthrosis. Clin. Orthop., **349**:48-57, 1998.
5. **Kile, TA; Donnelly, RE; Gehrke, JC; Werner, ME; Johnson, KA**: Tibiotalocalcaneal arthrodesis with an intramedullary device. Foot Ankle Int., **15**:669-673, 1994.
6. **Kuntscher, G**: Arthrodesis by intramedullary nailing. Practice of Intramedullary Nailing [translated by HH Rinne], Springfield (IL), Charles C Thomas, 1967, pp. 192-218.
7. **McGarvey, WC; Trevino, SG; Baxter, DE; Noble, PC; Schon, LC**: Tibiotalocalcaneal arthrodesis: anatomic and technical considerations. Foot Ankle Int., **19**:363-369, 1998.
8. **Moore, TJ; Prince, R; Pochatko, D; Smith, JW; Fleming, S**: Retrograde intramedullary nailing for ankle arthrodesis. Foot Ankle Int., **16**:433-436, 1995.
9. **Papa, JA; Myerson, MS**: Pantalar and tibiotalocalcaneal arthrodesis for post-traumatic osteoarthrosis of the ankle and hindfoot. J. Bone Joint Surg., **74A**:1042-1049, 1992.
10. **Pinzur, MS; Kelikian, A**: Charcot ankle fusion with a retrograde locked intramedullary nail. Foot Ankle Int., **18**:699-704, 1997.
11. **Pochatko, DJ; Smith, JW; Phillips, RA; Prince, BD; Hedrick, MR**: Combined subtalar and ankle arthrodesis with retrograde intramedullary rod: anatomic structures at risk. Presented at the 25th Annual Meeting of the American Orthopaedic Foot and Ankle Society, Orlando (FL), February 19, 1995.
12. **Quill Jr., GE**: Tibiotalocalcaneal arthrodesis. Tech. Orthop., 11:269-273, 1996.