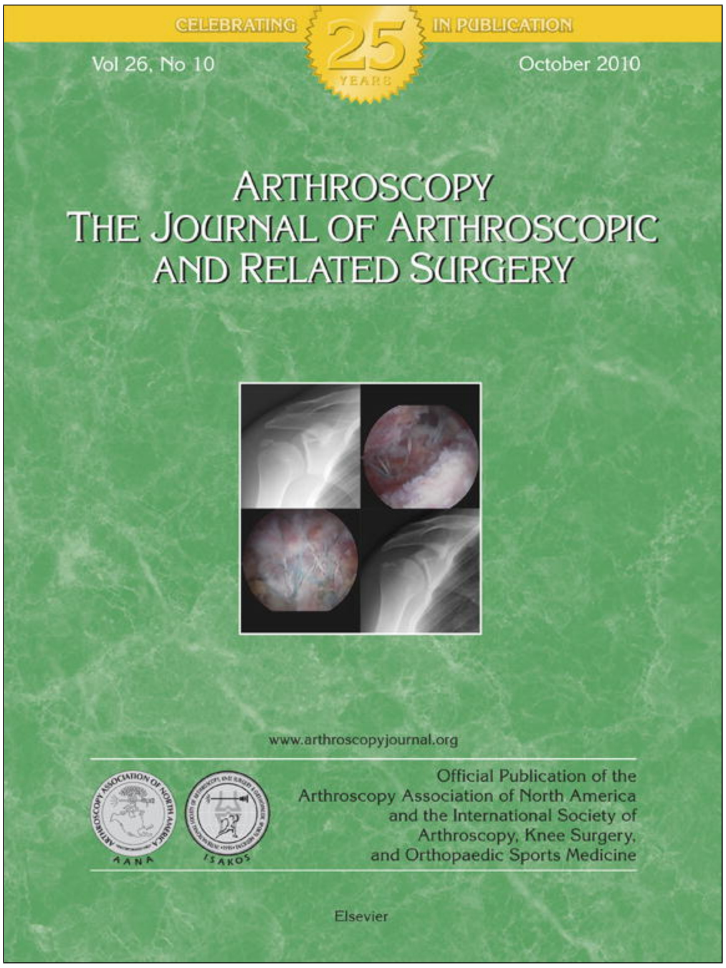
CELEBRATING 25 YEARS IN PUBLICATION
Vol 26, No 10
October 2010
ARTHROSCOPY
THE JOURNAL OF ARTHROSCOPIC AND RELATED SURGERY
www.arthroscopyjournal.org
Official Publication of the Arthroscopy Association of North America and the International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine
AANA
ISAKOS
Elsevier

Arthroscopic Debridement for First Metatarsophalangeal Joint Arthrodesis With a 2- Versus 3-Portal Technique: A Cadaveric Study

Tanawat Vaseenon, M.D., and Phinit Phisitkul, M.D.

Purpose: To evaluate the safety and efficacy of arthroscopic debridement for arthrodesis of the first metatarsophalangeal (MTP) joint using a 2-portal technique versus a 3-portal technique. **Methods:** Twelve cadavers, with a mean age of 60 years, were subjected to arthroscopic debridement of the first MTP joint. Dorsolateral and dorsomedial portals were used in 6 specimens, whereas a medial portal was added in the other 6 specimens. The articular cartilage was debrided on both the proximal and distal surfaces and stabilized with a K-wire. The surrounding neurovascular structures were evaluated for injuries and measured for the distance from the portals. The fusion contact areas were estimated and denuded surfaces were measured on both sides. Results between the 2- and 3-portal techniques were compared. Statistical significance was taken as $P < .05$. **Results:** The mean estimated fusion contact area was 180.19 mm^2 on the proximal phalanx and 180.21 mm^2 on the distal metatarsal articular surfaces. On the proximal phalanx, the percentage of denuded area was 94.71% with the 2-portal technique and 97.60% with the 3-portal technique. On the distal metatarsal, the percentage of denuded area was 93.31% with the 2-portal technique and 95.22% with the 3-portal technique. The 3-portal technique statistically increased the area of debridement on the plantar-medial surface of the distal metatarsal. The mean distance from the dorsolateral portal to the dorsolateral hallucal nerve was 3.4 mm. The mean distance from the dorsomedial portal to the dorsomedial hallucal nerve was 4 mm. The medial portal was, on average, 10.5 mm from the dorsomedial hallucal nerve and 13 mm from the plantar-medial hallucal nerve. There was no visible nerve injury detected. **Conclusions:** The 3-portal technique for arthroscopic-assisted arthrodesis of the first MTP joint allowed more complete cartilage debridement when compared with the 2-portal technique. The additional medial portal was found to be safe from the surrounding neurovascular structures. **Clinical Relevance:** Joint preparation for arthroscopic assisted arthrodesis of the first MTP joint can be safely and effectively performed using 3-portal technique, which may reduce the risk of non-union.

Arthroscopic diagnosis and treatment of the first metatarsophalangeal (MTP) joint were described by Watanabe[1,2] in 1972 and Bartlett[3] in 1988. Arthroscopy of the first MTP joint has been used for the treatment of various pathologies including degenerative disease with early osteophytosis, chondromalacia, osteochondral defects, loose bodies, arthrofibrosis, synovitis, gouty arthritis, and intra-articular fracture.[4,5] Proposed advantages of arthroscopic techniques are decreased bleeding, infection rate, and scarring, along with improved cosmesis and faster recovery.[6,7] Along with advancements in the technique, however, understanding of the gross and arthroscopic anatomy of the first MTP joint is lacking.

Debnath set al.[5] reported in 2006 that arthroscopy of the first MTP joint was not suitable for patients with extensive degenerative changes and large osteophytes

From the Department of Orthopaedics and Rehabilitations, University of Iowa Hospitals and Clinics, Iowa City, Iowa, U.S.A.
The authors report no conflict of interest.
Received September 4, 2009; accepted February 12, 2010.
Address correspondence and reprint requests to Tanawat Vaseenon, M.D., Department of Orthopaedics and Rehabilitation University of Iowa Hospitals and Clinics, Iowa City, IA 52242, U.S.A. E-mail: tvaseenon@yahoo.com
Published by Elsevier Inc. on behalf of the Arthroscopy Association of North America
0749-8063/9531/$00.00
doi:10.1016/j.arthro.2010.02.015

because the joint was very stiff and the large osteophyte was inaccurately excised. However, a limited number of investigators have reported a surgical technique and good results for arthroscopic-assisted arthrodesis of the first MTP joint in advanced-stage osteoarthritis.[8,9] The indication for arthroscopic-assisted arthrodesis of the first MTP joint is currently limited because of the severity and deformity of the joint as well as the complexity of the surgical technique. With improvements in the arthroscopic instruments and familiarity in small joint arthroscopy, arthroscopic-assisted arthrodesis of the first MTP joint may be technically possible in cases without considerable joint ankylosis.

This study was designed to (1) evaluate how completely each articular surface could be denuded and (2) evaluate the distance from each arthroscopic portal to the neurovascular structures at risk. We hypothesized that the arthroscopic debridement of the first MTP joint would be able to adequately debride the cartilage surface for the arthrodesis, and the additional medial portal can help facilitate joint preparation in certain areas.

METHODS

We subjected 12 cadaveric feet (5 men and 7 women) with a mean age of 60 years (range, 51 to 73 years) to arthroscopic first MTP joint arthrodesis. There were 5 right feet and 7 left feet. The inclusion criteria were adult age and no deformity, ligament injuries, or articular degeneration of the first MTP joint. The exclusion criteria were subjects with a history of hallux surgery or a surgical scar around the joint. Each specimen was thawed at room temperature for 24 hours before testing. The tibial part of the specimen was secured to the arthroscopic table in a vertical position. The ankle was free and allowed full passive motion as in a standard surgical setup. The arthroscopic surgery was done by 1 investigator (T.V.).

Surgical Technique

The great toe was distracted with a Chinese finger trap with traction of 2 kg over a pulley attached to the surgical table. A 30°, 2.7-mm arthroscope (Dyonics system; Smith & Nephew Endoscopy, Andover, MA) was used for visualization. A 3-mm arthroscopic shaver (Smith & Nephew Endoscopy) was used for cartilage debridement. A 2-portal approach (dorsolateral and dorsomedial portals) was used in 6 feet. The portals were made by inserting 18-gauge needles followed by a hemostat into the MTP joint just lateral and medial to the extensor hallucis longus (EHL) tendon at the level of the joint. The other 6 feet were subjected to a 3-portal approach (dorsolateral, dorsomedial, and medial portals). The additional medial portal was made by use of the same technique midway between the most dorsal and the most plantar aspects of the first MTP joint at the level of the joint line[8-10] (Fig 1). Cartilaginous surfaces on the distal metatarsal and the proximal phalanx were debrided with the arthroscopic shaver (Fig 2). Both dorsolateral and dorsomedial portals were used interchangeably for visualization and instrumentation, but the medial portal was added only for instrumentation.

Anatomic Study

The joint was fixed with a 0.045 K-wire in 15° of dorsiflexion and 10° of valgus direction relative to the

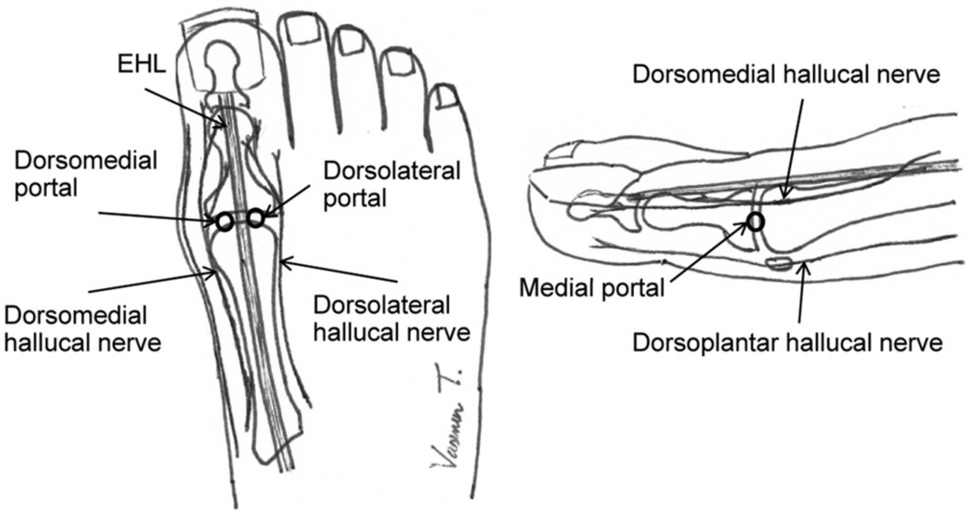

FIGURE 1. Arthroscopic portal placement for debridement of first MTP joint and surrounding anatomic structures at risk. The dorsolateral and dorsomedial portals were created just lateral and medial to the extensor hallucis longus (EHL) tendon. The medial portal was created midway between the most dorsal and most plantar aspects of the first MTP joint at the level of the joint line.

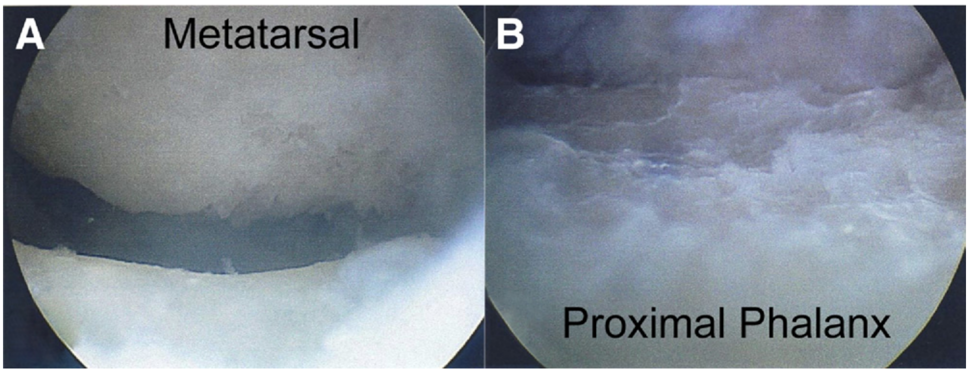

FIGURE 2. Arthroscopic views from the dorsolateral portal showed that most of the cartilage of the articular surfaces on the (A) distal metatarsal and (B) proximal phalanx was removed while the subchondral bone was preserved.

metatarsal.[8] The skin around the great toe was then removed while the relation of the bones and the K-wire was not disturbed. Surrounding periarticular soft-tissue structures, including nerves, vessels, and ligaments, were explored, and the distance corresponding to each arthroscopic portal was measured. A Vernier caliper with 0.01-mm precision was used for all the measurements, and the tolerance of the soft-tissue structures was considered to be ±1 mm. The articular surfaces on both sides of the first MTP joint were exposed after all the anatomic measurements had been completed. The estimated fusion contact areas were marked on both the distal metatarsal head and proximal phalanx by use of a scalpel and blue ink. Those areas were measured by paper mapping and scanning pictures with a high-resolution scanner and were analyzed with ImageJ software (National Institutes of Health, Bethesda, MD).[11] The ratio of denuded area to total contact area was calculated.

The results were recorded, and the outcome measurements for this study were analyzed by use of an unpaired t test, providing more than 80% statistical power to detect a difference 1.05 times as large as the standard deviation (with α level at 0.05 when the correlation between measurements is 0.5).

RESULTS

On the articular surface of the proximal phalanx, the mean estimated fusion contact area was 180.19 mm^2. The percentage of denuded area with the 2-portal technique was 94.71% ± 4.55% (mean ± SD). The 3-portal technique increased the denuded area to 97.60% ± 2.64%. The remaining cartilage of both groups was primarily found at the medial and lateral articular surfaces.

The estimated fusion contact area on the distal metatarsal articular surface was 180.21 mm^2 on average. The denuded area averaged 93.31% ± 3.79% with the 2-portal technique but averaged 95.22% ± 2.12% with the 3-portal technique. The remaining cartilage of both groups was mainly on the plantar-medial and plantar-lateral articular surfaces (Fig 3).

On the distal metatarsal articular surface, the amount of remaining cartilaginous area on the medial half was significantly greater (P = .01) with the 2-por-

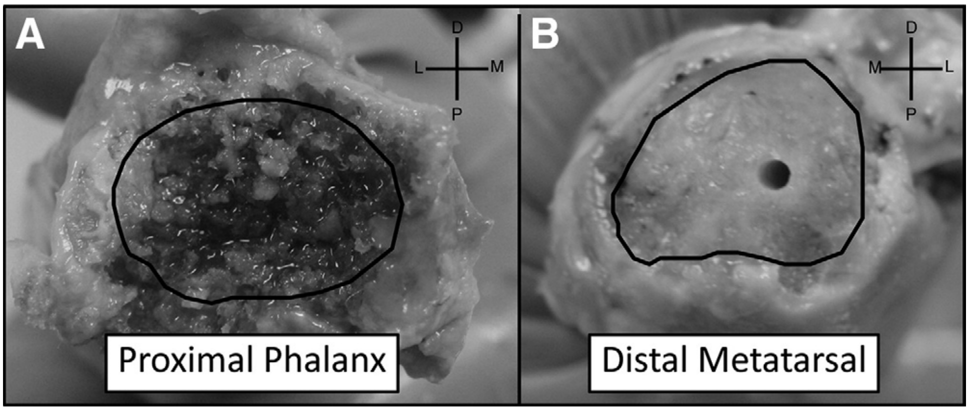

FIGURE 3. Estimated fusion contact areas of (A) proximal phalanx articular surface and (B) distal metatarsal articular surface after arthroscopic debridement. These are the areas that would be in contact and stabilized in the desired position of fusion. (D, dorsal; M, medial; L, lateral; P, plantar.)

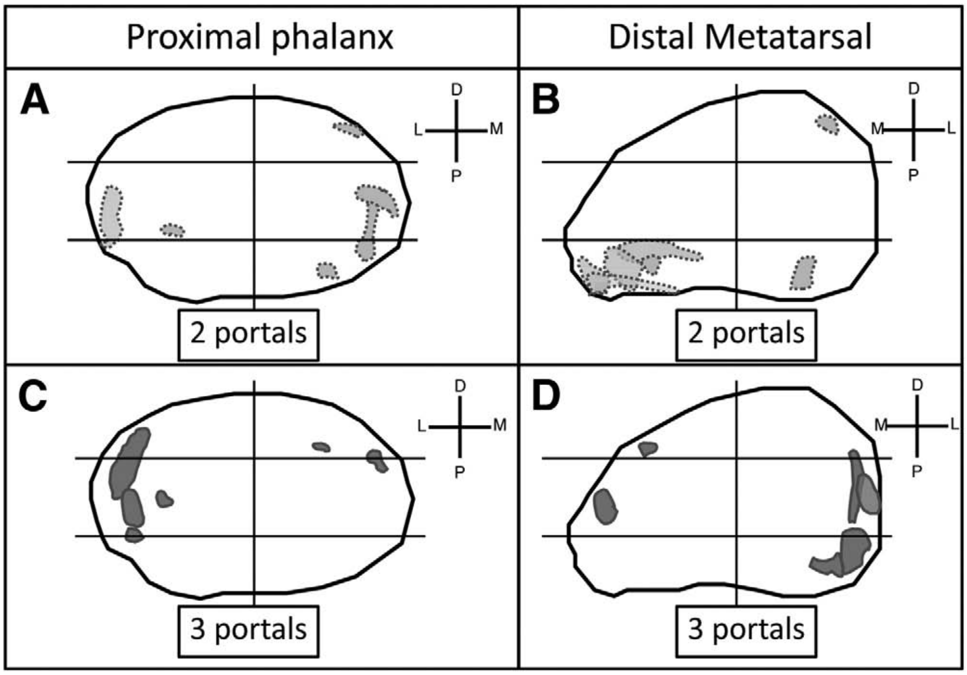

FIGURE 4. The remaining cartilage (gray areas) after arthroscopic debridement of the first MTP joint on the proximal phalanx and distal metatarsal surfaces was shown on cumulative diagrams divided into 6 areas (dorsomedial, dorsolateral, central-medial, central-lateral, plantar-medial, and plantar-lateral) with the (A and B) 2-portal versus (C and D) 3-portal arthroscopic debridement techniques. There was less cartilage remaining on the plantar-medial segment of the distal metatarsal with the 3-portal technique. (D, dorsal; M, medial; L, lateral; P, plantar.)

tal technique (9.55 mm^2) when compared with the 3-portal technique (1.27 mm^2). The amount of remaining cartilaginous area was significantly decreased in the plantar-medial area with the 3-portal technique compared with the 2-portal technique (P = .01). On the proximal phalanx, the difference in the amount of remaining cartilaginous area between both techniques was not significant (Fig 4).

The mean distance from the center of the dorsolateral portal to the dorsolateral hallucal nerve was 3.42 mm, and that from the center of the dorsomedial portal to the dorsomedial hallucal nerve was 4.0 mm. The dorsomedial hallucal nerve was on average 10.50 mm dorsal to the center of the medial portal, and the plantar-medial hallucal nerve was on average 13.00 mm plantar to the center of the medial portal (Table 1). The dorsomedial and dorsolateral hallucal nerves were always found medial to the dorsomedial portal and lateral to the dorsolateral portal, respectively.

DISCUSSION

Arthrodesis of the first MTP joint is a common procedure for advanced degenerative changes. Nonunion, malunion, and iatrogenic nerve injury have been reported with the open technique, which is a widely used approach.[12] Arthroscopic-assisted first MTP joint arthrodesis has received less attention in the literature. Carro and Vallina[9] reported a case of advanced degenerative change of the first MTP joint that was successfully treated by arthroscopic-assisted first MTP joint arthrodesis with a 30°, 2.7-mm arthroscope. Stroud[8] also reported a technique of arthroscopic arthrodesis of the first MTP joint using a 30°, 1.9-mm arthroscope with a 3-portal technique. Our experimental data clearly showed a high amount of denuded cartilaginous area on the proximal phalanx and distal metatarsal articular surface: 94% for the 2-dorsal portal technique and 97% for the 3-portal technique.

TABLE 1. *Distances From Dorsolateral, Dorsomedial, and Medial Portals to Surrounding Neurovascular Structures*

Parameter	Mean (mm)	SD (mm)	Range (mm)
Dorsolateral portal to dorsolateral hallucal nerve	3.42	1.00	2-5
Dorsolateral portal to dorsolateral hallucal vessel(s)	9.50	2.20	6-13
Dorsomedial portal to dorsomedial hallucal nerve	4.00	1.76	2-7
Dorsomedial portal to dorsomedial hallucal vessel(s)	7.33	2.19	3-10
Medial portal to dorsomedial hallucal nerve	10.50	1.97	8-14
Medial portal to plantar-medial hallucal nerve	13.00	2.45	10-16

The remaining cartilage was commonly found in the plantar one-third of the distal metatarsal articular surface with the 2-dorsal portal technique. This could be explained by the convexity of the metatarsal head, which limited the access from the straight arthroscopic instrument. An additional medial portal allowed the instrument to debride the remaining plantar cartilage. The remaining cartilage on the proximal phalanx articular surface was primarily found on the articular rim and medial and lateral aspects, with both the 2-portal and 3-portal techniques. This might be because of the concave articular morphology of the proximal phalanx. It is possible that the angle of the arthroscope prevented us from seeing all cartilage surfaces on the proximal phalanx articular rim when viewed from the dorsal portals, leading to inadequate debridement. The cartilage debridement at the proximal phalanx articular rim may be improved by using the 70° arthroscope, multi-angle curettage, or increasingly more joint distraction.

First MTP joint arthroscopy is a technically demanding procedure. Inherent risks are associated with the surrounding neurovascular structures to portal sites. Although first MTP joint arthroscopy has been reported for 20 years, the arthroscopic anatomy has not been described in the literature.[1,3-5,8-10] Understanding the anatomy surrounding the arthroscopic portal sites is important for preventing neurovascular injuries.[13] In our study the distances from the dorsolateral and dorsomedial nerves to the dorsolateral and dorsomedial portals were not great: 3.42 mm and 4.0 mm, respectively. We therefore consider that both the dorsolateral and dorsomedial portals should be created just lateral and medial to the EHL tendon at the joint line to avoid injury to the dorsolateral and dorsomedial hallucal nerves, respectively. Because the diameter of the arthroscope is 2.7 mm, it may be theoretically safer to use a 1.9-mm arthroscope with the same approach. In addition, a vertical incision through the skin only, with careful blunt dissection, should be performed to expose the joint capsule to avoid injury to the nerves and EHL tendon. For the medial portal, the mean distances from the portal to the dorsomedial and plantar-medial hallucal nerves were 10.50 mm and 13 mm, respectively. Therefore the risk of nerve injury with medial portal placement should be considered minimal.

In terms of clinical implications, the pathology of the first MTP joint that is associated with osteoarthritis has sclerotic bone and osteophyte formation. Arthroscopic-assisted first MTP joint arthrodesis is more challenging and technically demanding. Appropriate case selection and surgical experience are particularly important in severe osteoarthritis cases. In addition, we recognize the limitations of our cadaveric studies. First, we could not detect traction or small injuries without visible damage and might have underestimated the true risk of nerve injury. Second, the specimens had no severe arthritic changes, for which fusion is typically indicated, because we needed intact cartilage before arthroscopic debridement to analyze our data. The arthroscopic-assisted first MTP joint arthrodesis may be difficult because of the lack of joint space and large osteophytes.

CONCLUSIONS

Arthroscopic-assisted first MTP joint arthrodesis is a minimally invasive procedure in the treatment of advanced degenerative changes of the joint. The 3-portal technique for arthroscopic-assisted arthrodesis of the first MTP joint allowed more complete cartilage debridement when compared with the 2-portal technique. The additional medial portal was found to be safe from the surrounding neurovascular structures.

REFERENCES

1. Watanabe M. *Arthroscopy of Small Joints.* Tokyo: Igaku-Shoin, 1985.
2. Watanabe M. Present status and future of arthroscopy. *Geka Chiryo* 1972;26:73-77 (in Japanese).
3. Bartlett DH. Arthroscopic management of osteochondritis dissecans of the first metatarsal head. *Arthroscopy* 1988;4:51-54.
4. Ferkel RD, Scranton PE Jr. Arthroscopy of the ankle and foot. *J Bone Joint Surg Am* 1993;75:1233-1242.
5. Debnath UK, Hemmady MV, Hariharan K. Indications for and technique of first metatarsophalangeal joint arthroscopy. *Foot Ankle Int* 2006;27:1049-1054.
6. Morgan CD, Casscells CD. Arthroscopic-assisted glenohumeral arthrodesis. *Arthroscopy* 1992;8:262-266.
7. Myerson MS, Quill G. Ankle arthrodesis. A comparison of an arthroscopic and an open method of treatment. *Clin Orthop Relat Res* 1991:84-95.
8. Stroud CC. Arthroscopic arthrodesis of the ankle, subtalar, and first metatarsophalangeal joint. *Foot Ankle Clin* 2002;7:135-146.
9. Carro LP, Vallina BB. Arthroscopic-assisted first metatarsophalangeal joint arthrodesis. *Arthroscopy* 1999;15:215-217.
10. Carreira DS. Arthroscopy of the hallux. *Foot Ankle Clin* 2009;14:105-114.
11. Phisitkul P, Tochigi Y, Saltzman CL, Amendola A. Arthroscopic visualization of the posterior subtalar joint in the prone position: A cadaver study. *Arthroscopy* 2006;22:511-515.
12. Kelikian AS. Technical considerations in hallux metatarsalphalangeal arthrodesis. *Foot Ankle Clin* 2005;10:167-190.
13. Ferkel RD, Small HN, Gittins JE. Complications in foot and ankle arthroscopy. *Clin Orthop Relat Res* 2001:89-104.