"A to P" Screw Versus Posterolateral Plate for Posterior Malleolus Fixation in Trimalleolar Ankle Fractures

Timothy J. O'Connor, MD, Benjamin Mueller, MD, PhD,* Thuan V. Ly, MD,* Aaron R. Jacobson, DC,* Eric R. Nelson, MD,† and Peter A. Cole, MD**

Objectives: To compare radiographic and clinical midterm outcomes of posterior malleolar fractures treated with posterior buttress plating versus anterior to posterior lag screw fixation.

Design: Retrospective case series.

Setting: Level I trauma center.

Patients/Participants: Between January 2002 and December 2010, patients with posterior malleolar fractures were identified by Current Procedural Terminology code and their charts reviewed for eligibility.

Intervention: Posterior malleolar fixation using either anterior to posterior (AP) lag screws or posterior buttress plating.

Main Outcome Measurements: Demographic data, length of follow-up, range of motion, and postoperative Short Musculoskeletal Function Assessment (SMFA) scores were the main outcome measurements. Immediate postoperative radiographs for residual gap/step-off and final follow-up radiographs for the degree of arthritis that developed were evaluated.

Results: Thirty-seven patients were eligible for the study, and 27 chose to participate. Sixteen patients underwent posterior buttress plating, and 11 underwent AP screw fixation with mean follow-up times of 54.9 and 32 months, respectively. Demographic data were similar between groups. The posterolateral plating group demonstrated superior postoperative SMFA scores compared with the AP screw group with statistically significant differences in the SMFA bother index (26.7 vs. 9.2, $P = 0.03$) and trends toward improvement in the mobility (28.3 vs. 12.9, $P = 0.08$) and functional indices (20.2 vs. 9.4, $P = 0.08$). There were no significant differences in the range of motion or the development of ankle arthritis over time.

Conclusions: Patients with trimalleolar ankle fractures in whom the posterior malleolus was treated with posterolateral buttress plating had superior clinical outcomes at follow-up compared with those treated with AP screws.

Key Words: trimalleolar ankle fractures, posterior malleolus, ankle fracture, surgical fixation, posterolateral approach, trauma

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

(*J Orthop Trauma* 2015;29:e151–e156)

INTRODUCTION

Fractures of the posterior malleolus are relatively commonly occurring in 7%–44% of rotational ankle fractures.[1–3] The classic treatment recommendation has been surgical fixation for fractures involving greater than 25% of the articular surface. This value has been questioned more recently as studies have demonstrated the importance of even small posterior malleolar fragments to ankle stability, and surgical indications have expanded.

Generally, posterior malleolar fragments are fixed either with percutaneous anterior to posterior (AP) screws or through a posterolateral (PL) approach using screws and/or a buttress plate. Fixation with AP screws relies on reduction of the posterior malleolus through ligamentotaxis of the posterior inferior tibiofibular ligament with reduction of the fibula,[4] whereas fixation through a PL approach allows direct reduction of the fracture. In essence, a posterior malleolar fragment is an AO type B articular injury. As a principle, the majority of AO type B injuries in other areas are treated with buttress plating rather than screw fixation from the opposite side. We felt there may be advantages to PL buttress plating over percutaneous AP screw fixation but were unable to find any comparative studies on outcomes in the literature.

Ankle fractures involving the posterior malleolus have been shown to have worse outcomes compared with ankle fractures without posterior malleolar involvement.[1]

Perhaps, better understanding of the optimal surgical techniques would lead to greater understanding of this variable and ultimately improved outcomes. The purpose of this article is to compare outcomes of 2 common methods of posterior malleolar fixation: percutaneous anterior to posterior screws and buttress plating through a PL approach.

PATIENTS AND METHODS

This retrospective comparative study was performed at a single level I trauma center. After institutional review

Accepted for publication August 14, 2014.

From the *Department of Orthopaedic Surgery, Regions Hospital, St Paul, MN; and †Department of Orthopaedic Surgery, Prevea Health St Mary's, Green Bay, WI.

P. A. Cole receives consulting fees/honoraria from AONA and AO International, is a consultant to J&J (Synthes-Depuy), and has stock/stock options with BoneFoams Inc, LLC. T. V. Ly receives honoraria from AONA. The remaining authors report no conflict of interest.

Reprints: Peter A. Cole, MD, Department of Orthopaedic Surgery, University of Minnesota, Regions Hospital, 640 Jackson St, St Paul, MN 55101 (e-mail: peter.a.cole@healthpartners.com).

board approval, we identified all patients with Current Procedural Terminology codes specific to ankle fracture (27,823, 27,822, 27,816, 17,814, and 27,818) from January 2002 through December 2010. These patients' electronic medical records and radiographs were screened to identify candidates meeting inclusion criteria of (1) age 18 years or older at the time of surgery, (2) ankle fracture that underwent surgical stabilization of all 3 malleolar fragments, and (3) posterior malleolus was surgically fixed with either anterior to posterior lag screws (AP screw) or PL plate fixation. Patients were excluded if they had (1) additional ipsilateral or contralateral lower extremity injury, (2) pilon-type trimalleolar fracture (AO-OTA 43 C Type), and/or (3) history of a lower extremity fracture. These criteria yielded 37 patients meeting study inclusion/exclusion criteria (Fig. 1). Twenty-one received PL plate fixation, and 16 patients received AP screw fixation.

These patients were asked to participate in a research examination consisting of goniometric motion assessment, self-administered Short Musculoskeletal Function Assessment (SMFA),[5] and radiographic analysis. x-Rays from the first postoperative visit were analyzed for residual step or gap in the articular reduction. The degree of arthritis was evaluated on final follow-up x-rays by Bargon[6] reference criteria (Table 1). For analysis, Bargon grades 0 and 1 were combined representing no or mild arthritis, whereas grades 2 and 3 were combined representing more significant arthritis. Additionally, medical records were reviewed to obtain patient, injury, and surgical characteristics.

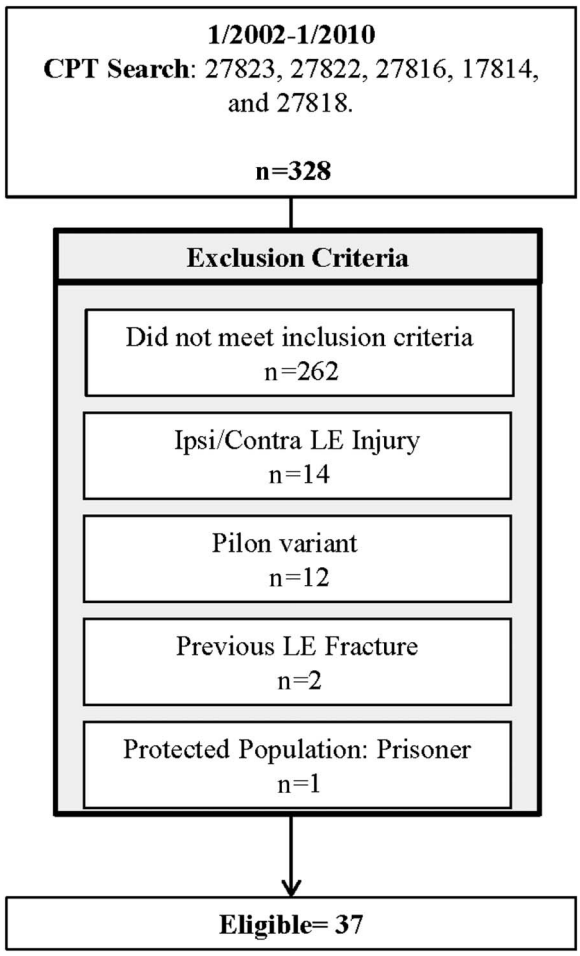

FIGURE 1. Study inclusion and exclusion criteria.

TABLE 1. Bargon Criteria for Grading Posttraumatic Arthritis

Grade 0	Sclerosis in the weight-bearing zone
	No narrowing of joint space
Grade 1	Sclerosis in the weight-bearing zone
	Slight narrowing of joint space
	Appearance of osteophytes
Grade 2	Sclerosis in the weight-bearing zone
	Marked narrowing of joint space
	Appearance of osteophytes
	Surface irregularity of subchondral bone
Grade 3	Complete narrowing of joint space
	Defects in the subchondral bone
	Presence of cysts

Statistical Analyses

Mann–Whitney *U* test was used for null hypothesis testing of SMFA. Fisher exact and Mann–Whitney *U* tests were used to identify significant differences between the 2 groups.

Surgical Techniques

Patients were treated with either AP lag screws or PL plate fixation. In the AP lag screw group, the fibula was fixed and the posterior malleolus reduced by ligamentotaxis. A pointed reduction clamp was placed behind the fibula to clamp the posterior malleolus, and then 1 or 2 percutaneous 3.5-mm lag screws were placed from anterior to posterior into the posterior malleolus (Fig. 2). In the PL plate fixation group, patients were positioned either prone or lateral. A PL approach was made to the posterior malleolus between the peroneal tendons and flexor hallucis longus. The posterior malleolus was reduced directly and provisionally fixed with K wires. It was then fixed with either a small fragment T plate or 1/3 tubular plate applied in a buttress technique (Fig. 3). The fibula was then fixed through the same incision. Surgeries were performed by 5 attending surgeons, all with either trauma or foot and ankle fellowship training. Fixation choice was dictated by surgeon preference for fixation of each individual fracture.

The postoperative protocol, though not formally standardized for this retrospective study, is, however, consistent across the treating surgeons in our center. The postoperative course for the treatment of ankle fractures is to remain in the initial splint for 2 weeks and then transition to a boot for weeks 2–6 while allowing range of motion (ROM) and stretching exercise. Patients are instructed to begin weight bearing at 6 weeks with full weight bearing by 12 weeks. Fixation method does not alter our postoperative rehabilitation schedule.

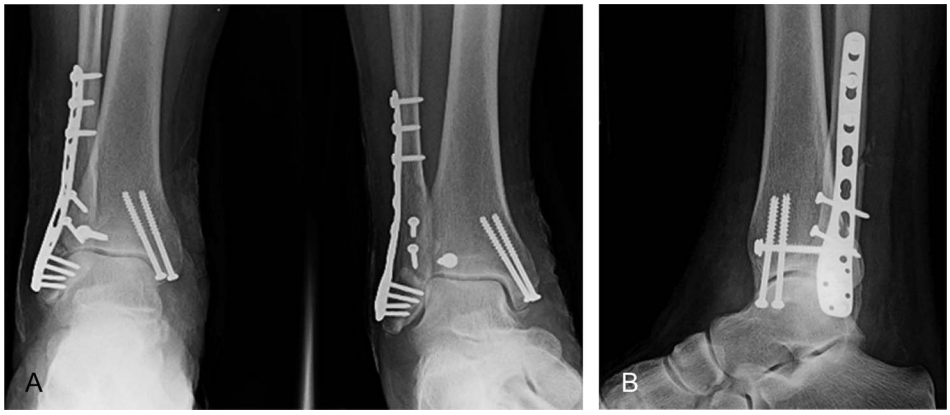

FIGURE 2. A, AP, mortise, and (B) lateral ankle radiographs of a trimalleolar ankle fracture with AP screw fixation of the posterior malleolus.

RESULTS

Of the 37 patients eligible for the study, 27 (73%) agreed to participate, with 16 undergoing fixation with a PL plate and 11 undergoing AP screw fixation. The follow-up rate was 72.3% in the PL plate group and 73.3% in the AP screw group ($P = 0.73$). The mean duration of follow-up was 54.9 (19.5–99.5) months in the PL plate group and 32 (14.9–48.8) months in the AP screw group ($P = 0.06$). Patients were similar in both cohorts with regard to age, gender, smoking status, syndesmotic injury, presence of radiographic comminution of the medial or posterior malleolus, and the percentage of the plafond involvement (Table 2).

Mean SMFA scores for each group are listed in Table 3. The PL plate group had significantly better scores for the SMFA bother index ($P = 0.03$). There was also a trend toward improved outcomes for the PL plate group in the SMFA functional index ($P = 0.08$) and the mobility subscore ($P = 0.08$). No significant differences were noted in ROM at final follow-up when measured as a percentage of the uninjured side (Table 4). There were no nonunions or revisions in either cohort. One patient in each group underwent removal of all ankle hardware as they were felt to have hardware-related pain. In neither case was pain specifically related to the posterior malleolar fixation.

Radiographic evaluation revealed no significant differences in the amount of residual articular gap or step between the 2 groups on postoperative x-rays. Two patients in each group had a residual gap/step-off of $\geq$2 mm ($P = 0.63$). The remainder of the patients in both groups had articular reductions $<$2 mm. Final follow-up x-rays showed no loss of reduction in any patient in either group. There was no significant difference in the percentage that developed postoperative arthritis between groups. Two patients (20%) developed significant postoperative arthritis (Bargon grade 2 or 3) in the AP screw group versus 6 patients (37.5%) in the PL plate group ($P = 0.42$).

DISCUSSION

To our knowledge, this is the first study comparing midterm outcomes in patients with posterior malleolar fractures treated with posterior buttress plating versus percutaneous anterior to posterior screws. Patients in our series had superior clinical outcomes when treated with posterior buttress plating. Patients in the PL group had significantly better scores in the SMFA bother index and a trend toward improvements in the SMFA functional index and mobility subscores. These differences were revealed even in a study with relatively low numbers in each group. The clinical improvement did not correlate with improved radiographic outcomes as there was no significant difference in the percentage of patients who developed arthritis postoperatively

FIGURE 3. A, AP, mortise, and (B) lateral ankle radiographs of a trimalleolar ankle fracture with a PL buttress plate fixation of the posterior malleolus.

TABLE 2. Demographics and Injury Characteristics

	AP Screw (n = 11)	PL Plate (n = 16)	*P*
Demographics			
Age	45.5 (21.1–61.5)	47.8 (26.5–67.1)	0.57
Male gender	4 (36.3%)	7 (43.8%)	1.00
Smokers	1 (9.1%)	4 (25%)	0.61
Body mass index	32.6 (27.3–36.8)	29.6 (20.5–37.7)	0.37
Injury characteristics			
% Plafond	21.5 (14.2–41.2)	22.6 (12.8–40.6)	0.90
Comminution*	5 (45.4%)	6 (37.5%)	0.71
Syndesmotic fixation	5 (45.4%)	2 (12.5%)	0.19

*Comminution of the posterior and/or medial malleoli.

between groups. Additionally, there was no significant difference in the ROM at final follow-up.

Although fixation of a partial articular injury with buttress plating makes intuitive sense, variations in practice patterns are seen among surgeons treating these injuries. Gardner et al[7] surveyed 400 orthopaedic surgeons regarding preference and indications for choice of fixation between PL plating and AP screws. Seventy-two percent of trauma-trained orthopaedic surgeons preferred direct open reduction versus 53% of foot and ankle trained and only 39% of surgeons who were not subspecialty trained in trauma or foot and ankle. Despite the majority of trauma-trained surgeons choosing a direct open approach, only 56% chose PL plating as their preferred method of fixation. In addition, there was a discrepancy regarding the operative indications and size threshold requiring fixation.

Most authors and surgeons consider posterior malleolar fractures of 25%–30% of the tibial plafond the threshold for fixation.[8–11] This threshold is largely related to early findings that there was a risk of posterior talar displacement in fractures greater than 25%.[11] Biomechanical studies would argue, however, that as long as the lateral column (fibula and anterior tibiofibular ligament) and the medial column (medial malleolus and deltoid ligament) are intact, as would be the case with fixation of these fractures, then there is no risk of posterior displacement of the talus regardless of size.[9,12]

Other studies would argue for fixation based on the findings that contact pressures are increased with increasing size of the posterior malleolar fragment.[9,10] Hartford et al[9] found that tibiotalar contact areas were decreased by 4%, 13%, and 22% in a model of posterior malleolar osteotomies of 25%, 33%, and 50%. This would suggest that fractures of 25% or smaller do not need to be fixed based on concerns regarding contact area, whereas larger fractures do. On the other hand, Langenhuijsen[13] found that it was not the size of the fragment that affected outcome rather whether a congruent reduction was obtained, even in posterior malleolar fractures making up only 10% of the joint surface.

Suffice it to say that the indications for fixation of posterior malleolar fracture depend on the study method and outcome variables. However, we do know that fractures with posterior malleolar involvement do worse than similar fractures without posterior malleolar involvement.[1,11,14] In a retrospective review of 142 patients, 52.5% of patients without posterior malleolar involvement had excellent results compared with only 24.2% with posterior malleolar involvement.[1] Similarly, Broos and Bisschop[14] found that good or excellent results occurred in 81% of patients without posterior malleolar involvement compared with only 66% with posterior malleolar involvement. By extrapolation, these studies could be interpreted to mean that the instability rendered in a posterior malleolar fracture is in fact an important variable in the outcome of patients. Furthermore, we know that the posterior-inferior tibiofibular ligament is attached to the posterior malleolus in the majority of cases and that this structure is the strongest stabilizer of the syndesmosis; therefore, left unfixed in injuries involving complete syndesmotic disruption and with no other syndesmotic fixation would lead to syndesmotic instability. Additionally, fixation of the posterior malleolus may obviate the need for further syndesmotic fixation. Secondly, the posterior capsule is another structure attached to the posterior malleolus; thus, between the capsule and the posterior-inferior tibiofibular ligament, postoperative therapy in the early postoperative period places stress on the ankle and its syndesmosis such that instability of the Volkman fragment would lead to greater pain if not instability if not fixed.

More recently, the role of posterior malleolar fixation in providing syndesmotic stability has been evaluated. Gardner et al[15] compared posterior malleolar fixation with syndesmotic fixation in a pronation-external rotation 4 model. They found 70% restoration of stiffness with posterior malleolar fixation versus 40% with syndesmotic fixation. In a prospective study of outcomes of syndesmotic injuries with posterior malleolar fractures, Miller et al[16] found that posterior malleolar fixation was equivalent to fixation with syndesmotic screws or combined fixation. Postoperative foot and ankle outcome scores were similar in all 3 groups. Likewise, there were no differences in regard to postoperative tibiofibular clear space or loss of reduction. The results of these studies would lead to the conclusion that even small posterior malleolar fractures should be repaired in ankle fractures with syndesmotic disruption.

Although there has been recent discussion over the indications for fixation, few studies have evaluated the best approach and method of fixation. PL buttress plating has

TABLE 3. SMFA Scores

Mean SMFA Scores						
	Function Index	**Arm/Hand**	**Daily Activities**	**Emotional Status**	**Mobility**	**Bother**
AP screw	20.2 (SD = 16.8)	2.8 (SD = 2.9)	19.6 (SD = 21.6)	30.8 (SD = 22.5)	28.3 (SD = 22.3)	26.7 (SD = 24.1)
PL plate	9.4 (SD = 9.0)	3.1 (SD = 8.9)	7.28 (SD = 8.8)	15.2 (SD = 16.0)	12.9 (SD = 13.7)	9.2 (SD = 12.9)
P	0.08	0.18	0.14	0.13	0.08	0.03

TABLE 4. ROM at Follow-Up

Injured/Contralateral ROM	Dorsiflexion (%)	Plantar Flexion (%)	Inversion (%)	Eversion (%)
AP screw	13.9/17.8 (78.1% SD = 21.3)	39.7/45.0 (88.2% SD = 15.5)	19.6/23.0 (85.2% SD = 23.1)	14.7/18.8 (78.2% SD = 28.3)
PL plate	15.3/16.5 (92.8% SD = 15.8)	39.3/39.7 (99.0% SD = 27.5)	21.5/25.1 (85.7% SD = 25.2)	16.2/19.1 (84.8% SD = 20.6)
P	0.13	0.22	0.47	0.47

Percentages were attained by dividing the injured ankle ROM by the contralateral ankle ROM.

demonstrated superior biomechanical strength compared with AP screw fixation and achieves anatomic reduction more frequently.[8,17] Huber et al[18] compared the quality of reduction in a consecutive series of patients with posterior malleolar fractures treated with percutaneous AP screws versus open reduction internal fixation with a posterior antiglide plate. They found that anatomic reduction was achieved in 8/30 patients treated with percutaneous anterior to posterior screws and 25/30 patients treated with posterior antiglide plating.[18] To our knowledge, this is the only other study comparing AP screw and PL plate fixation of posterior malleolar fragments.

Only a few other series report on the outcomes of patients treated with PL plating.[19–21] Abdelgawad[19] also found a high rate of anatomic reduction in a retrospective review of 12 patients with posterior malleolar fractures involving greater than 30% of the joint surface fixed with PL plating, in which 10 had reductions within 2 mm.[19] Forberger[20] retrospectively reviewed 45 patients in whom posterior malleolar fractures were treated with PL plating. They found no secondary displacement on follow-up, an average American Academy of Orthopaedic Surgeons foot and ankle score of 93, and restored nearly normal ROM, within 3 degrees of normal in all planes.

Open reduction internal fixation through a PL approach can pose some technical challenges. Huber et al[18] commented that in the 5 fractures in their series that did not achieve anatomic reduction through PL antiglide plating, 2 of them were caused by the posterior plate being placed too proximal that did not contain the posterior malleolar fragment. Their series also had 3 cases in which the medial malleolus was malreduced requiring revision. This may be because of operating in the prone or lateral position, which is an unfamiliar position for medial malleolar fixation for most surgeons. In our series, there were 2 fractures that had slight malreductions of the posterior malleolus even with a direct PL approach and buttress plating.

Our perspective is that the PL approach has several advantages over anterior to posterior fixation.[21] The fracture is directly addressed, and an anatomic reduction can be achieved. This may be especially important in delayed fixation of posterior malleolar fractures in allowing the interposed callus and periosteum to be removed from the fracture site. The PL approach also allows for fixation of smaller fracture fragments that could not be well fixed with AP screws. There is also improved biomechanical stability of the fracture in fixation with a buttress plate that can resist shear. Although there was no loss of reduction of the posterior malleolus in either group in our series, this may give the surgeon confidence, especially with smaller fragments, that motion may be allowed earlier.

This study seems to support that clinical outcomes may be improved when posterior malleolar fractures are treated with a direct open reduction. Advantages of this approach include direct inspection of the joint, with debridement of osseous or chondral debris, lag screw fixation of the Volkman fragment, and buttress plating. However, we recognize some limitations of our study. Selection bias enters any study in which patients are not randomized, and this could influence choice of fixation, treating surgeon, and even fracture severity. In fact, one could argue that worse fracture patterns would have been more likely to undergo open reduction and posterior plating, which would favor the AP screw group. This may explain that radiographic arthrosis was slightly worse at final follow-up in the PL group, despite having better clinical outcomes. Finally, the follow-up for the 2 groups was different, with a follow-up in the PL plate group of 54 versus 32 months for the AP screw group. Despite these limitations, we believe this is the first level III comparative study for these approaches to trimalleolar ankle fractures and thus provides useful information for the evolution of ankle fracture treatment.

CONCLUSIONS

Although the results of this study failed to demonstrate a significant difference in radiographic outcomes and ROM, they do suggest a possible clinical benefit of PL buttress plating over anterior to posterior screw fixation of posterior malleolar fractures as measured by SMFA score.

REFERENCES

1. Jaskulka RA, Ittner G, Schedl R. Fractures of the posterior tibial margin: their role in the prognosis of malleolar fractures. *J Trauma.* 1989;29:1565–1570.
2. Koval KJ, Lurie J, Zhou W, et al. Ankle fractures in the elderly: what you get depends on where you live and who you see. *J Orthop Trauma.* 2005;19:635–639.
3. Court-Brown CM, McBirnie J, Wilson G. Adult ankle fractures—an increasing problem? *Acta Orthop Scand.* 1998;69:43–47.
4. Denham RA. Internal fixation for unstable ankle fractures. *J Bone Joint Surg Br.* 1964;46:206–211.
5. Swiontkowski MF, Engelberg R, Martin DP, et al. Short musculoskeletal function assessment questionnaire: validity, reliability, and responsiveness. *J Bone Joint Surg Am.* 1999;81:1245–1260.
6. Bargon G. Röntgenmorphologische Gradeinteilung der posttraumatischen Arthrose im oberen Sprunggelenk. *Hefte Unfallheilkd.* 1978;133:28–34.
7. Gardner MJ, Streubel PN, McCormick JJ, et al. Surgeon practices regarding operative treatment of posterior malleolus fractures. *Foot Ankle Int.* 2011;32:385–393.
8. De Vries JS, Wijgman AJ, Sierevelt IN, et al. Long-term results of ankle fractures with a posterior malleolar fragment. *J Foot Ankle Surg.* 2005;44:211–217.

9. Hartford JM, Gorczyca JT, McNamara JL, et al. Tibiotalar contact area. Contribution of posterior malleolus and deltoid ligament. *Clin Orthop Relat Res.* 1995;320:182–187.
10. Macko VW, Matthews LS, Zwirkoski P, et al. The joint-contact area of the ankle. The contribution of the posterior malleolus. *J Bone Joint Surg Am.* 1991;73:347–351.
11. McDaniel WJ, Wilson FC. Trimalleolar fractures of the ankle. An end result study. *Clin Orthop Relat Res.* 1977;122:37–45.
12. Raasch WG, Larkin JJ, Draganich LF. Assessment of the posterior malleolus as a restraint to posterior subluxation of the ankle. *J Bone Joint Surg Am.* 1992;74:1201–1206.
13. Langenhuijsen JF, Heetveld MJ, Ultee JM, et al. Results of ankle fractures with involvement of the posterior tibial margin. *J Trauma.* 2002;53:55–60.
14. Broos PL, Bisschop AP. Operative treatment of ankle fractures in adults: correlation between types of fracture and final results. *Injury.* 1991;22:403–406.
15. Gardner MJ, Brodsky A, Briggs SM, et al. Fixation of posterior malleolar fractures provides greater syndesmotic stability. *Clin Orthop Relat Res.* 2006;447:165–171.
16. Miller AN, Carroll EA, Parker RJ, et al. Posterior malleolar stabilization of syndesmotic injuries is equivalent to screw fixation. *Clin Orthop.* 2010;468:1129.
17. Li YD, Liu SM, Jia JS, et al. Choice of internal fixation methods for posterior malleolus fracture in both biomechanics and clinical application. *Beijing Da Xue Xue Bao.* 2011;43:718–723.
18. Huber M, Stutz P, Gerber C. Open reduction and internal fixation of the posterior malleolus with a posterior antiglide plate using a postero-lateral approach—a preliminary report. *Foot Ankle Surg.* 1996;2:95–103.
19. Abdelgawad AA, Kadous A, Kanlic E. Posterolateral approach for treatment of posterior malleolus fracture of the ankle. *J Foot Ankle Surg.* 2011;50:607–611.
20. Forberger J, Sabandal PV, Dietrich M, et al. Posterolateral approach to the displaced posterior malleolus: functional outcome and local morbidity. *Foot Ankle Int.* 2009;30:309–314.
21. Talbot M, Steenblock TR, Cole PA. Posterolateral approach for open reduction and internal fixation of trimalleolar ankle fractures. *Can J Surg.* 2005;48:487–490.