The Journal of Foot & Ankle Surgery 58 (2019) 730–733

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Calcaneal Bone Graft Procedures: An Analysis of Postsurgical Complications

Davina J. Cross, DPM, AACFAS[1], Lawrence A. DiDomenico, DPM, FACFAS[2]

[1] *Resident, Heritage Valley Health Systems, Beaver, PA*
[2] *Section Chief, Department of Podiatry, Department of Surgery, St. Elizabeth Health Center, Youngstown, OH*

ARTICLE INFO

Level of Clinical Evidence: 3

Keywords:
autogenous bone graft
calcaneus
complication
donor site
hypertrophic scar
sural neuritis

ABSTRACT

The purpose of this article is to examine complications in patients who underwent bone grafting from the calcaneus between December 2001 and June 2010. This retrospective, single-practice study included 247 procedures in 242 patients, including 200 (82.64%) female and 42 (17.36%) male patients, ranging in age from 13 to 89 (median 49) years. Overall, the incidence of experiencing any form of complication was 2.43% (6 of 247); these included 5 (2.02%) feet that displayed donor site sural neuritis and 1 (0.41) that displayed a painful, hypertrophic scar at the donor site. The only statistically significant risk factor associated with the development of a calcaneal donor site complication was white race (being African American was protective). These findings indicate that procurement of autogenous bone graft from the calcaneus, as described in this report, is safe and dependable with a low incidence of complications, and irritation of the sural nerve is the most common complication associated with the procedure. Further clinical and long-term follow-up studies controlling for confounding variables need to be performed to fully determine the overall safety and efficacy of this procedure.

Bone grafting is used for numerous applications in foot and ankle surgery. Allogeneic materials are commonly used for this purpose, but numerous studies have demonstrated the benefits of using autogenous bone grafts (1–4). In general, the most common complication associated with the harvest of autogenous bone graft is pain at the donor site, with less frequent complications including nerve injury, hematoma, infection, and fracture at the donor site (5). Although commonly used for procurement of substantial amounts of corticocancellous or just cancellous graft, iliac crest bone harvest is responsible for significant morbidity (6). Furthermore, when corticocancellous or cancellous graft is required for use in the foot or ankle, procurement of proximal tibial bone is associated with a low incidence of complications and postoperative pain even when a substantial amount of autogenous bone is required (7). Because of complications commonly associated with extraction of bone from the iliac crest and other proximal donor sites, many surgeons consider the calcaneus to be a suitable donor site (4), especially when corticocancellous bone graft is to be used in the foot. A variety of methods have been used to perform bone harvesting from the calcaneus, both open and percutaneous (8–10). Despite the simplicity of procuring autogenous graft from the calcaneus, minor complications are not infrequent, with 13.8% of patients reporting some residual symptoms along the lateral border of the calcaneus when bone graft is obtained through an oblique incision (11).

Overall, it is thought that bone graft harvesting from the calcaneus is a safe and reliable procedure with few complications (8–10,12). However, the anatomy of the region does present the possibility for postsurgical sequelae (13). Specifically, with a lateral approach, several structures may be encountered, including the peroneal tendons, the calcaneofibular ligament, the sural nerve and its branches, and the short saphenous vein (13). Postoperative sequelae secondary to calcaneal bone graft harvesting were explored previously by Biddinger et al (14), who examined a cohort of 22 patients who had undergone calcaneal bone graft harvesting; they found that the procedure was safe with few complications. In this report, we carry on where previous investigators left off, with the use of a relatively large sample and an emphasis on complications after harvesting autogenous bone from the calcaneus.

Patients and Methods

The operative technique used to harvest the bone graft was performed at the lateral aspect of the calcaneus to minimize encounters with tendinous, ligamentous, neural, and vascular structures. The patient was placed in a supine position with or without an ipsilateral hip bump or in a lateral decubitus position, allowing for the lateral body of the calcaneus to be exposed. The landmarks used to target the procurement site consisted of the distal fibula; the posterior, plantar, and inferior cortices of the calcaneus; the peroneal tendons and the peroneal trochlea; glabrous skin lines; and sural nerve. A stab incision was made within a naturally occurring skin line on the lateral aspect of the calcaneus, posterior and inferior to the sural nerve and the peroneal tendons (Fig 1). It was important to place the incision anterior to the posterior cortex and proximal to the inferior cortex of the calcaneus, to avoid weakening the cortex and predisposing to fracture. The thick plantar tissues of the foot can distort the actual percutaneous localization of the

Financial Disclosure: None reported.
Conflict of Interest: None reported.
Address correspondence to: Lawrence A. DiDomenico, DPM, FACFAS, The Ankle and Foot Care Centers, 8175 Market Street, Boardman, OH 44512.
E-mail address: ld5353@aol.com (L.A. DiDomenico).

1067-2516/$ - see front matter © 2018 by the American College of Foot and Ankle Surgeons. All rights reserved.
https://doi.org/10.1053/j.jfas.2018.12.004

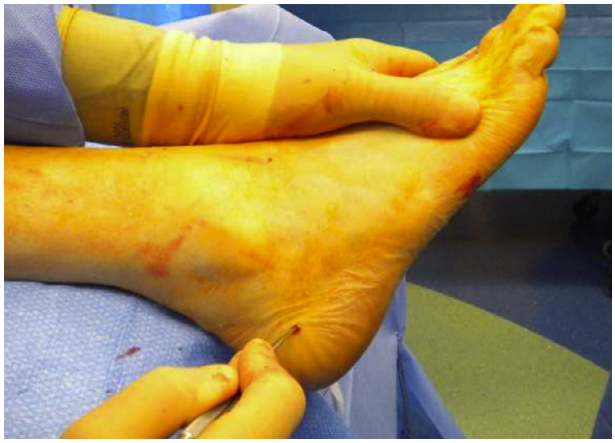

Fig. 1. A stab incision is made on the lateral wall of the calcaneus within a naturally occurring skin line inferior and posterior to the sural nerve and peroneal tendons, and a periosteal elevator is used to free the soft tissue off the lateral wall of the calcaneus.

calcaneal cortices, so the operating surgeon needs to keep this in mind. To assist in accurate localization of the harvest site, a periosteal elevator was inserted and carried directly to the lateral wall of the calcaneus to reflect the periosteum. Next, a 3.5-mm drill was inserted perpendicular to the lateral wall of the calcaneus and used to penetrate only the lateral cortex (Fig 2). A #3 curette was then inserted into the drill hole, and cancellous autogenous bone graft was harvested from the body of the calcaneus (Fig 3). The precise amount of bone harvested was based on the volume of bone needed for transplantation, and larger curettes (#4 or #5) were used as needed. It has been the experience of the authors that larger curettes are easier to use for cancellous bone graft harvest than smaller instruments. Once graft harvest was completed (Fig 4), the harvest site was visually and manually inspected for any residual bone fragments remaining within the soft tissues, which were removed and used in the transplant procedure. A simple interrupted suture technique was then used to reapproximate the skin.

A systematic review of patient charts (N = 242) was undertaken to evaluate calcaneal harvesting sites in patients who had undergone a variety of surgical procedures augmented with autogenous calcaneal graft material. One of the coauthors (D.J.C.) searched the files of the senior author (L.A.D.), using surgical procedure codes 20900, 20902, and 28322 (Current Procedural Terminology, American Medical Association, Chicago, IL). For each of the patients included in the analysis, postoperative radiographs were taken until satisfactory bone healing was noted at the donor and recipient sites. Typically, radiographs were taken at the first postoperative visit and at biweekly follow-up visits. Despite the availability of more technologically advanced imaging techniques, such as computerized tomographic scans, we considered standard radiographs to be the gold standard for our assessment of bone graft donor and recipient sites throughout the postoperative healing course (15). Recipient site healing was determined by the presence of bony trabeculation bridging between the native bone and the graft, with at least 3 cortices showing contiguous bony bridging. Similarly, the donor site was healed when bony trabeculation traversed the harvest site and cortical bridging was evident secondary to periosteal new bone formation. The postoperative course for each of the patients was determined by their primary procedure, as determined by the senior author (L.A.D.), and the patients

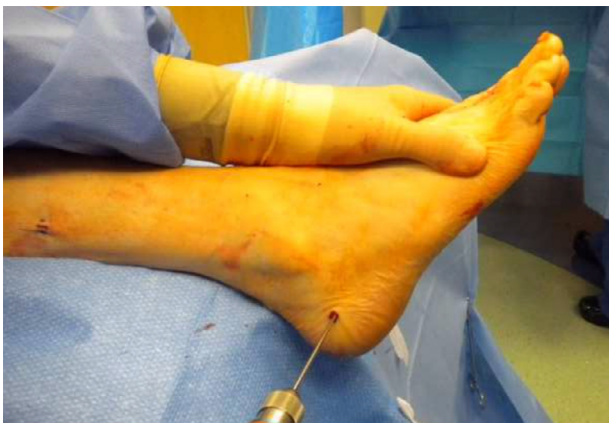

Fig. 2. A 3.5-mm drill penetrates the near cortex (lateral wall only), creating an opening to harvest the cancellous bone.

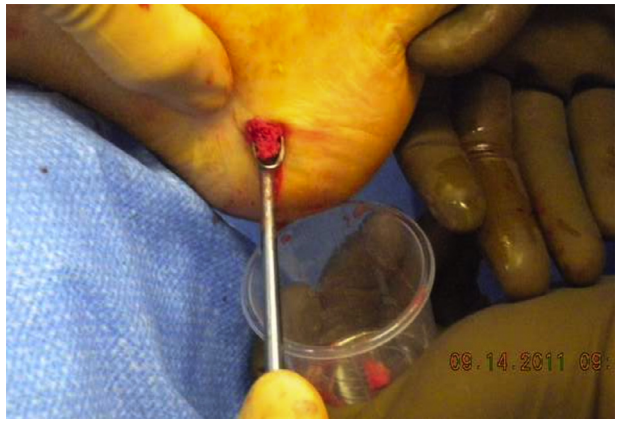

Fig. 3. A curette harvests the autogenous cancellous bone graft from the incision site of the lateral calcaneus.

were generally started on a course of non-weightbearing and gradually progressed to partial weightbearing over time. At approximately 5 to 6 weeks postoperatively, the patients initiated a course of physical therapy and converted to full weightbearing if they were deemed to be clinically and radiographically ready.

The statistical plan involved inspection of the data with attention paid to type and distribution, and the demographic features of the cohort were described in statistical terms. Independent risk factor variables of interest included age and age category (<20, 20 to 44, 45 to 64, and ≥65 years), sex, race (African American, white, or other), anatomic side, bilateral foot surgery (not simultaneous), any medical comorbidity, combined comorbidities (hypertension, heart disease, cerebrovascular accident), diabetes mellitus, renal disease or gout, varicose veins or deep vein thrombophlebitis, connective tissue disease, any other comorbidity, ≥3 comorbidities, surgeon, and follow-up duration (days). We defined "any comorbidity" as an individual having any of the following comorbidities (which were observed in our cohort): arthritis, hyperlipidemia, gastroesophageal reflux disorder, elevated prostate specific antigen, hypertension, heart disease, varicose veins, history of deep vein thrombophlebitis, cephalgia, cerebral palsy, diabetes mellitus, asthma, hepatitis C, gout, renal disease, thyroid disorder, sinusitis, fibromyalgia, anemia, cancer, or cerebral vascular accident. Other comorbidities were defined specifically as hyperlipidemia, gastroesophageal reflux disorder, elevated prostate specific antigen, cephalgia, cerebral palsy, asthma, hepatitis C, thyroid disorder, sinusitis, anemia, or cancer. Outcomes of interest included any complication related to the autogenous calcaneal bone graft harvest site. Tests of the null hypothesis were used to compare the prevalence of independent risk factors by outcome, namely the presence or absence of a calcaneal donor site complication. Univariate and multiple variable logistic regression models, using the presence of any donor site complication as the dependent variable, were analyzed to identify statistically significant risk factors associated with the outcome. To test the potential influence that an unmeasured variable could have had on the results, a Greenland sensitivity analysis (16) was also conducted. The data were analyzed using Stata/SE 9.2 for Macintosh (Stata Corporation, College Station, TX), and statistical significance was defined at the 5% ($p \leq .05$) level.

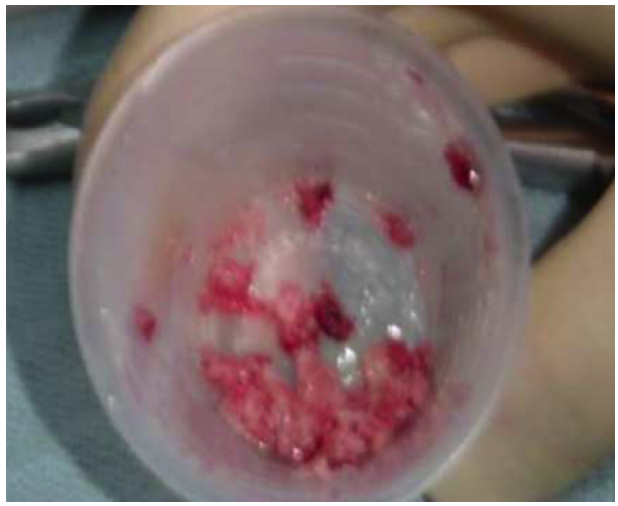

Fig. 4. A sampling of autogenous cancellous bone that was harvested from the calcaneus.

Results

Overall, the cohort of 242 patients included 200 (82.64%) female and 42 (17.36%) male patients, ranging in age from 13 to 89 (median, 49) years, and a total of 247 bone grafts were harvested from the calcaneus in these patients. Overall, the incidence of experiencing any form of complication was 2.43% (6 of 247), and these included 5 (2.02%) feet that displayed donor site sural neuritis and 1 (0.41) that displayed a painful, hypertrophic scar at the donor site. No other donor site complications were observed. A statistical description of the cohort, stratified by the presence or absence of calcaneal donor site morbidity, is depicted in the Table. When the prevalence of categorical risk factors, as well as the continuous numeric exposures, were compared based on the outcome of interest, the mean (± standard deviation) duration of follow-up in the uncomplicated group was 1.55 ± 0.55 years, that in the complicated group was 1.66 ± 0.2 years ($p = .6088$), and only race was observed to be statistically significantly associated with donor site morbidity (Cuzick's nonparametric test for trend across groups, $p = .037$). Similarly, the results of the univariate and multiple variable logistic regression models, using the presence of any donor site complication as the dependent variable, did not identify any statistically significant associations between the risk factors (exposures) that we recorded and the outcome of interest (any calcaneal donor site complication), with the exception of white race, which displayed an odds ratio (confidence interval) of 8.1 (1.4, 49.05). Finally, the results of the Greenland sensitivity analysis revealed our effect estimates to be resistant to the potential influence of a hypothetical exposure, with the estimated odds ratio for white race failing to change by >10% up to an odds ratio of nearly 8 for the unmeasured confounder by the outcome.

Table
Comparison of demographic variables by donor site morbidity (N = 247 feet in 242 patients)

Risk Factor (Exposure)	No Donor Site Morbidity (n = 240)	Any Donor Site Morbidity (n = 6)	*p* Value
Age (years)	48.9 ± 15.32	52 ± 4.11	.6219
Age category (years)			.722
<20	17 (7.08)	0	
20 to 44	59 (24.58)	2 (33.33)	
45 to 64	134 (55.83)	4 (66.67)	
≥65	30 (12.5)	0	
Female sex	194 (80.83)	6 (100)	.235
Race			.037*
African American	49 (20.42)	0	
White	124 (51.67)	2 (33.33)	
Other	67 (27.92)	4 (66.67)	
Right side	118 (49.17)	3 (50)	.9679
Bilateral foot surgery (not simultaneous)	7 (2.92)	0	.6719
Any comorbidity	192 (80)	5 (83.33)	.159
Current smoker	77 (33.48)	1 (20)	.460
HTN/HD/CVA	30 (12.5)	0	.3564
Diabetes mellitus	60 (25)	2 (33.33)	.6431
Renal disease or gout	13 (5.42)	0	.5588
Varicose veins or DVT	23 (9.58)	1 (16.67)	.5643
Connective tissue disease	91 (37.92)	2 (33.33)	.8195
Other comorbidity	133 (55.42)	4 (66.67)	.5845
≥3 comorbidities	72 (30)	2 (33.33)	.8607
Surgeon = DiDomenico	6 (2.56)	0	.5752
Follow-up duration			.6088
Days	564.33 ± 200.9	606.5 ± 74.29	
Years	1.55 ± 0.55	1.66 ± 0.2	

Abbreviations: CVA, cerebrovascular accident; DVT, deep vein thrombophlebitis; HD, heart disease; HTN, hypertension.
Data are mean ± standard deviation or n (%). *p* Value was determined by the Student's *t* test for continuous numeric variables, the Wilcoxon rank-sum (Mann-Whitney *U*) test for categorical variables, and Cuzick's nonparametric test for trend across groups with >2 ordered categories (the data were assessed for normality and skew).
* Statistically significant at the 5% ($p \leq .05$) level.

Treatment of the 6 (2.43%) complications varied in accordance with the specific complication observed and was determined by the senior author (L.A.D.). The patient that sustained the hypertrophic scar (0.41% of grafts, 16.7% of complications) was treated with cross-fiber massage and vitamin E applied topically. Two of the patients with sural neuritis (0.81% of cases, 33.3% of complications) were treated with ethanol sclerosing injections; 1 (0.41% of grafts, 16.7% of complications) was treated with an injection of 0.5% bupivacaine combined with dexamethasone phosphate; and 2 (0.81% of cases, 33.3% of complications) had symptoms that resolved without focal therapy. All patients who experienced donor site morbidity had symptom resolution within the observed 1.66 ± 2-year follow-up duration.

Discussion

The results from the analysis of the surgical and follow-up data suggest that calcaneal bone grafting is a safe and dependable procedure, with only a small risk of postoperative complications. Interestingly, this conclusion is supported by other previously conducted studies, which have demonstrated that tibial or calcaneal bone grafts are advantageous to use over iliac crest grafts (13,15,17,18). Similarly, Roukis et al (19), in their study of 530 patients undergoing autogenous bone marrow aspirate harvest at a variety of lower-extremity locations, found no incidence of noteworthy complications. Our finding that white individuals were statistically significantly more likely to sustain a postoperative complication after procurement of calcaneal cancellous graft was interesting; however, based on our analyses, we were not able to precisely elucidate the reason for this finding. It is our suspicion that this was likely confounded by another covariate, or multiple covariates, although our assessments of risk factor interaction and effect modification failed to reveal statistically significant combinations of terms that markedly (>10% to 15%) altered the associations that we considered. It is possible that we did not have adequate statistical power to more accurately explain this observation.

The incidence of observed complications (n = 6) in our cohort of 247 bone graft procedures was 2.43%. Interestingly, it is unlikely that the sural nerve and hypertrophic scar complications were directly owing to any alteration of the calcaneus secondary to harvesting bone from it; rather, such complications could be seen with any surgery that entails dissection of the lateral aspect of the heel. The observed complications were successfully resolved through routine treatment, and the patients successfully completed recovery from the bone graft procedure.

Unfortunately, the retrospective methods used for this study limit the strength of conclusions that were developed. Specifically, the study was conducted using retrospective analyses, with no direct controls for confounding variables or patient characteristics, although sensitivity analyses were used and indicated that the results were resistant to the potential influence of an unmeasured variable. We also did not use health measurements known to produce valid information, such as a foot-related quality-of-life score or visual analog scale pain score. Moreover, exposures such as the duration of surgery, method of hemostasis, use of local anesthetic injected at the donor site, and other conditions that reasonable surgeons would consider relevant to the development of complications at the site of a calcaneal bone graft harvest, were not considered. We also realize that our list of comorbidities may not have been mutually exclusive in all instances (e.g., a patient with elevated prostate specific antigen could have also been diagnosed with prostate cancer); however, we did not have the precise information to ascertain mutual exclusivity. Finally, like all reports based on chart review, our investigation was subject to coding and information biases inherent in the patient records. Future research should seek to address these issues by developing prospective studies tracking larger samples of patients from intake through follow-up, with control of possible confounding variables. Future

studies might also explore how other variables affect healing times or complication rates, including the size of the bone graft site. It is our hope that the results of this investigation could be used in the development of more rigorous studies in the future.

In conclusion, this study suggests that calcaneal bone grafting can be a safe and useful technique in diverse surgical procedures, resulting in a relatively uniform healing time, across diverse patient populations. The complications related to the procedure appear to be relatively minimal and, when present, represent common risks associated with any surgical dissection.

Acknowledgments

The authors appreciate the assistance of D. Scot Malay, DPM, MSCE, FACFAS, regarding the statistical analyses used in this investigation.

References

1. Hahne J, Chiodo C, Wilson M, Glowacki J. Autogenous bone grafts in foot and ankle surgery. Orthop J Harv Med Sch 2007;9:113–116. Accessed September 25, 2010.
2. Hofbauer M, Delmonte R, Scripps M. Autogenous bone grafting. J Foot Ankle Surg 1996;35:386–390.
3. Schade V, Roukis T. Percutaneous bone marrow aspirate and bone graft harvesting techniques in the lower extremity. Clin Podiatr Med Surg 2008;25:733–742.
4. Lindsey RW, Miclau T, Probe R, Perren S. A defect in continuity in the canine femur: an in vivo experimental model for the study of bone graft incorporation. Yale J Biol Med 1993;66:157–163.
5. Myeroff C, Archdeacon M. Autogenous bone graft: donor sites and techniques. J Bone Joint Surg Am 2011;93:2227–2236.
6. Costa Mendes L, Sauvigné T, Guiol J. [Morbidity of autologous bone harvesting in implantology: literature review from 1990 to 2015]. Rev Stomatol Chir Maxillofac Chir Orale 2016;117:388–402.
7. Chou LB, Mann RA, Coughlin MJ, McPeake WT 3rd, Mizel MS. Stress fracture as a complication of autogenous bone graft harvest from the distal tibia. Foot Ankle Int 2007;28:199–201.
8. Feeney S, Rees S, Tagoe M. Tricortical calcaneal bone graft and management of the donor site. J Foot Ankle Surg 2007;46:80–85.
9. DiDomenico L, Haro A. Percutaneous harvest of calcaneal bone graft. J Foot Ankle Surg 2006;45:131–133.
10. Mendicino V, Leonheart E, Schromoff P. Techniques for harvesting autogenous bone grafts of the lower extremity. J Foot Ankle Surg 1996;35:428–435.
11. O'Malley MJ, Sayres SC, Saleem O, Levine D, Roberts M, Deland JT, Ellis S. Morbidity and complications following percutaneous calcaneal autograft bone harvest. Foot Ankle Int 2014;35:30–37.
12. Dehne R. Congenital and acquired neurologic disorders. In: R Dehne, MJ Coughlin, RA Mann, CL Saltzman, eds. *Surgery of the Foot and Ankle*. Mosby Elsevier, Philadelphia, 2007.
13. Mahan K. Calcaneal donor bone grafts. J Am Podiatr Med Assoc 1994;84:1–9.
14. Biddinger K, Komenda G, Schon L, Myerson M. A new modified technique for harvest of calcaneal bone grafts in surgery on the foot and ankle. Foot Ankle Int 1998;19:322–326.
15. Nigro N, Grace D. Radiographic evaluation of bone grafts. J Foot Ankle Surg 1996;35:378–385.
16. Greenland S. Basic methods for sensitivity analysis of biases. Int J Epidemiol 1996;25:1107–1116.
17. Geiderman W, Farly J, Brodsky J. Clinical results of harvesting autogenous cancellous graft from the ipsilateral proximal tibia for use in foot and ankle surgery. Foot Ankle Int 2004;25:451–455.
18. Raikin S, Brislin K. Local bone graft harvested from the distal tibia or calcaneus for surgery of the foot and ankle. Foot Ankle Int 2005;26:449–453.
19. Roukis T, Hyer C, Philbin T, Berlet G, Lee T. Complications associated with autogenous bone marrow aspirate harvest from the lower extremity: an observational cohort study. J Foot Ankle Surg 2009;48:668–671.