



Original
Contributions

CONSERVATIVE THERAPY OF PLANTAR PUNCTURE WOUNDS

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Abstract—In order to define the natural history and complication rate of plantar puncture wounds receiving conservative initial therapy, a prospective, uncontrolled case series study with standardized protocol was conducted in a university hospital emergency department. The eligible patients were between the ages of 18-59 years and presented within 24 hours of sustaining an uncomplicated plantar puncture wound without preexisting impediments to wound healing or wound assessment. Patients were treated with surface cleansing alone and were kept non-weight bearing for 24 hours. Patients were followed by telephone at 48 hours, 1 week, 1 month, and 6 months. Five infections and two retained foreign bodies occurred in 63 patients, for a complication rate of 11.9%. Only the presence of symptoms 48 hours postinjury was associated with a higher risk of complication. No findings at initial presentation predicted a subsequent complication.

Keywords — wounds; penetrating; wound infection; foot

INTRODUCTION

The management of plantar puncture wounds is controversial. Strategies advocated in the literature range from aggressive debridement, with liberal use of radiographs and antibiotics, to less invasive and less expensive methods of care (1-8). Current treatment recommendations are based on anecdote, empiric data, or retrospective uncontrolled series (1,3,4). There are no prospective, controlled studies of the

natural history, evaluation, or treatment of plantar puncture wounds. A comprehensive review of this topic concluded that future studies are needed to define the natural history as well as the appropriate evaluation and treatment of these wounds (8). Accurate assessment of the natural history of plantar puncture wounds is a logical starting point, and would provide information relevant to the design of future controlled trials. The purpose of this study was to define the complication rate after conservative initial management of plantar puncture wounds in healthy adults presenting to an emergency department within 24 hours of injury.

MATERIALS AND METHODS

This study utilized a prospective case series design with a defined treatment protocol. It was performed in a university hospital emergency department with an annual census of approximately 58,000. Within the emergency department, ambulatory adults with minor illness or injury (including plantar puncture wounds) are seen in the "fast-track" area; these patients comprise 20% of the total annual census. Each patient is initially evaluated by a nurse practitioner. Although the practitioners work under treatment protocols, nearly all patients are seen briefly by the attending physician. The study was conducted within this "fast-track" area.

Original Contributions is coordinated by John A. Marx, MD, of Carolinas Medical Center, Charlotte, North Carolina

RECEIVED: 23 May 1994; FINAL SUBMISSION RECEIVED: 24 August 1994;
ACCEPTED: 29 August 1994

Patients between the ages of 18 and 59 years and who presented within 24 hours of injury were considered for enrollment. Those with a history of diabetes mellitus, peripheral vascular disease, immunosuppressive illness, immunosuppressive treatment (including corticosteroid usage), or antibiotic usage within the previous 48 hours were excluded. Patients with through-and-through wounds, associated fracture, embedded foreign body detected on initial evaluation, or existing evidence of infection were also excluded.

Treatment Protocol

A detailed history of the injury was recorded, including information regarding the object causing injury, time of injury, footwear, circumstances (walking, running, jumping, etc.), the patient's assessment of depth of injury, and likelihood of retained foreign body. Any treatment rendered by the patient or others prior to presentation was noted. Inspection of the wound (with removal of visible foreign body) was performed. Wound location was noted on a drawing attached to the data sheet. The presence of swelling, erythema, tenderness, drainage, or pain with passive range of motion of the toes was recorded. The presence of any of these signs was considered abnormal and analyzed as a potential "high risk" finding. Tenderness beyond the usual expected for a minor wound (in the opinion of the examining physician) was considered abnormal. No debridement or unroofing of the wound was done. A dilute (1:10) povidone-iodine/saline solution was applied to the wound surface for 60 seconds, the wound was washed with saline, and a dry dressing was applied. Radiographs were obtained in all patients who believed an embedded foreign body was present, either because of incomplete removal of the object at the time of injury or due to foreign body sensation. Otherwise, radiographs were obtained at the examining physician's discretion. Patients were given crutches, and instructed not to bear weight on the injured foot for 24 hours.

Patients were contacted by telephone at 48 hours, 1 week, and 6 months after the initial visit. During the initial follow-up conversation, patients were asked about their compliance with the recommendation for 24 hours of nonweight bearing, and whether the initial pain had increased or decreased. During subsequent follow-up conversations, patients were asked whether they were experiencing any pain. The patient's assessment of the presence of erythema, swelling, drainage, or foreign body sensation was re-

corded during each follow-up conversation. Patients were advised to return for reevaluation for increased or persistent pain, or the presence of any of the signs or symptoms of complications.

During each follow-up conversation, patients were also asked whether they had taken any medications or seen a physician for any reason since sustaining the puncture wound. All medications were recorded, and names of physicians were noted. With the patient's permission, these physicians were contacted for confirmation of any medications prescribed, and for details of care related to the puncture wound. Any patient receiving antibiotics within 1 month of injury was removed from the study, unless the antibiotics were prescribed for the puncture wound. This was done to eliminate inadvertent treatment of wound infection with antibiotics prescribed for another reason.

A complication was defined as a problem requiring physician intervention, and included infection (cellulitis, abscess, osteomyelitis, pyarthrititis, osteochondritis) or retained foreign body requiring removal. All complications not treated by the study physicians were confirmed through direct contact with the treating physician.

All patients experiencing complications were followed up at 6 months by telephone, and their charts were reviewed at 6 months for evidence of ongoing problems related to the puncture wound. Patients lost to telephone follow up were sent letters containing the follow-up questions at 1 and 6 months. Charts of patients lost to follow up and eligible patients not entered into the study were reviewed at 6 months in an attempt to detect additional complications, although these patients were not included in the data analysis. The study was approved by the institution's Human Investigations Committee.

STATISTICAL ANALYSIS

Fisher's Exact Test was utilized to compare nominal clinical characteristics between the complication and no complication groups. A two-tailed Student's *t*-test was utilized to compare interval clinical data between the complication and no complication groups. The 95% confidence interval for observed differences was calculated for all comparisons. For all analyses, $P < 0.05$ defined statistical significance. All statistical analyses were performed on a Macintosh LCIII, utilizing *Primer of Biostatistics: The Program*, version 3.01 (Stanton A. Glantz, McGraw-Hill Inc., New York, 1993).

RESULTS

During the study period (from May 1990 to October 1992), 78 patients fulfilled criteria for enrollment in the study; 6 were not enrolled, improperly enrolled, or refused to comply with the protocol. Of the 72 remaining, 9 were lost to follow up, leaving 63 available for analysis. None of the patients lost to follow up returned any of the follow-up letters.

There were seven complications (11.9%; 95% CI: 4.9–22.9%). These included four cases of simple cellulitis, all of which responded to treatment with standard antibiotic therapy for soft-tissue infections. One patient developed a superficial abscess that was treated by incision and drainage alone. These complications were all apparent within 1 week of injury. None of these infected wounds were cultured. Two patients required removal of a retained foreign body; both patients had persistent pain one week postinjury, and had foreign bodies removed at 10 and 16 days postinjury. In one patient, a glass foreign body was detected radiographically; in the other, a small, unidentifiable foreign body was suspected clinically and removed. Radiographs were not obtained. Neither patient had radiographs taken on the initial visit. Table 1 summarizes the clinical course for patients developing complications.

The demographic data and clinical characteristics of the complication vs. no complication groups are demonstrated in Table 2. Both groups were similar in terms of age, time from injury to presentation,

estimated depth of wound, footwear, and object causing injury. The zone of injury, presence of a superficial foreign body, and pain with toe range-of-motion were not associated with an increased incidence of complications. Only the presence of symptoms at 48 hours postinjury was found to be associated with a higher risk of complication (sensitivity 71%, specificity 85%, $P = 0.005$).

The examining physician ordered radiographs on seven patients during the initial evaluation. All were ordered based on the patient's suspicion of a foreign body. None of the radiographs detected a foreign body, and none of these patients developed a complication. The patient with a positive radiograph on follow-up evaluation reported no foreign body sensation on initial evaluation.

None of the patients developing complications had further complaints at 6-month telephone follow-up. No patient was removed from the study for taking antibiotics within 1 month of entry into the study. Chart review of patients lost to follow up or not entered properly revealed no complications documented at the study institution.

DISCUSSION

This is the first prospective study of the natural history of plantar puncture wounds managed conservatively. The data suggest a complication rate of 12%, with an infection rate of 8%. This compares with

Table 1. Clinical Course of Complications

Pt #	Age	Sex	Footwear	Clinical Course
1	18	M	Shoe, sock	Presented 1.5 hrs after stepping on glass. Injury over 2nd metatarsal head. Normal 48 hr follow up. Pain, swelling, erythema at 1 week—retained foreign body identified by X-ray 16 days postinjury. Removed in OR.
2	53	F	Slippers	Presented 5 hrs after stepping on nails. Injuries over 4th, 5th metatarsal shafts. Returned at 24 hrs with pain, swelling and lymphangitis. Treated with IM ceftriaxone and PO amoxicillin/clavulanate with resolution.
3	29	M	Tennis shoe, socks	Presented 3 hrs after stepping on nail. Injury over metatarsal shaft. Normal 48 hr follow up. Developed swelling, erythema at 96 hrs, had abscess I & D at one week. No cultures taken, resolved without antibiotic therapy.
4	49	F	Shoe	Presented 5.5 hrs after stepping on nail. Injury over midfoot. Persistent pain at 48 hrs (not seen). Seen in clinic at 5 days, begun on cephalexin for erythema, pain, and swelling. Complete resolution.
5	30	F	Barefoot	Presented 0.5 h after stepping on wood. Injury over 3rd metatarsal head. Redness at 48 hrs (not seen). Pain and redness at 8 days, small foreign body removed (no X-ray). No antibiotics given. Complete resolution.
6	28	M	Tennis shoe	Presented 2.75 hrs after stepping on nail. Injury in 1st webspace. Seen at 48 hrs with erythema and tenderness. X-ray negative. Treated with IM ceftriaxone and PO cephalexin. Complete resolution.
7	26	F	Sock	Presented 2 hrs after stepping on nail. Injury over 4th metatarsal base. Redness and pain at 48 hrs (not seen). Seen in clinic at 96 hrs, begun on cephalexin for erythema and pain. Complete resolution.

Table 2. Clinical Predictors of Complications

Clinical Characteristics	Complications (n = 7)	No (n = 56)	P
Mean age (yrs)	33.3 ± 12.8	28.6 ± 9.3	NS
Mean time from injury (hr)	2.9 ± 1.8	6.1 ± 5.8	NS
Mean estimated depth (cm)	1.7 ± 1.4	1.2 ± 1.0	NS
Rubber soled shoe	2	26	NS
Sock	2	25	NS
Visible foreign body	1	4	NS
Abnormal initial exam	7	48	NS
Injury zone I	3	33	NS
Injury zone II	2	13	NS
Injury zone III	2	10	NS
Abnormal 48 hour followup	5	2	.005

retrospective data that suggest a subsequent infection rate of 2–8% in patients presenting uninfected within 24 hours of injury (1,4,6). These earlier studies could not control initial management, and included patients who received aggressive initial care and prophylactic antibiotics.

The current study identified no historical or physical examination characteristics that were predictive of complications. Patient age and delayed presentation (within 24 hours) did not correlate with subsequent complications. Patients presenting after 24 hours have been reported to develop complications in over 50% of cases (4); it is unclear, though, whether the complication itself prompted the delayed visit. The current study excluded such “high-risk” patients. This study also does not support the concept that punctures through socks or shoes, including rubber-soled tennis shoes, are more likely to become complicated. Previous reports have implicated tennis shoes as a source of *Pseudomonas aeruginosa*, and have suggested that such footwear constitutes a higher risk for infection (9,10). Such retrospective analysis of complications ignores the large number of patients sustaining puncture wounds through tennis shoes who never seek medical care or develop infection.

Similarly, the zone of injury was not found to correlate with development of infection. Patzakis et al. have previously reported a high prevalence of zone 1 (toes to metatarsal shaft) injuries in patients admitted for infected puncture wounds (10). Although they conclude that a zone 1 injury is more likely to develop infection, their retrospective study design did not include any estimate of the number of patients sustaining zone 1 injuries who do not develop infection. While the small sample size of the current study cannot positively exclude such an association, the data do not support an association between a zone 1 injury and development of infection.

Indeed, no physical examination finding was found to correlate with development of complications.

The optimal initial management of plantar puncture wounds is a source of ongoing controversy. Recommendations for coring and probing of wounds have not been substantiated by prospective investigations (1,3–6,11,12). These interventions significantly increase treatment time, cost, and patient discomfort, and can only be justified if therapeutic efficacy can be shown. It is unknown whether probing provides an accurate estimation of depth, and more importantly, whether foreign material and bacteria might be pushed deeper into tissues by this activity. Coring followed by high-pressure irrigation also has unproven efficacy and the potential for inoculation of bacteria into the damaged tissues. The conservative treatment regimen chosen for this study represents an alternative approach, avoiding any intervention that might increase the risk of complication. Although the application of dilute povidone-iodine solution to puncture wounds surfaces has unproven efficacy, this technique has been shown to reduce bacterial counts in other types of wounds without adversely affecting healing (13). At a minimum, it provides surface cleansing without increasing the risk of infection.

A 24-hour period of nonweight bearing was felt to be the longest practical period for a seemingly minor wound. Most patients readily accepted this recommendation, and all reported that they were able to comply without difficulty. Two patients refused to comply with this recommendation, and were not entered into the study. Previous recommendations for longer periods of nonweight bearing (4,6) are not supported by data, and were felt to be impractical.

Telephone follow-up was utilized in this study; such follow up has been criticized by Seaman and Lammers, who found a 48% rate of undiagnosed infection by patient self-assessment (14). They rec-

commend follow-up examination for all but "very low risk" wounds. In the study presented here, patients' ability to assess specific wound characteristics was not evaluated, but the data indicate that the long-term outcome for patients not identifying problems was uniformly good. In fact, two patients refused to return for reevaluation despite the presence of erythema or persistent pain, and had complete resolution of their symptoms without treatment. The data suggest that the unrecognized infection rate is low, and that physician intervention is not required in the absence of symptoms. Scheduling unnecessary follow-up visits increases cost, patient inconvenience, and emergency department overcrowding.

The follow-up data also suggest that patients who report continued symptoms 48 hours postinjury are at higher risk for complications. Such patients should return for reexamination, although specific management recommendations cannot be given, since this study did not evaluate any follow-up protocol.

Limitations of this study include the small sample size, which is reflected in the wide confidence interval for the complication rate. Assuming a true complication rate of 12%, a sample size of approximately 500 patients would be required to narrow the confidence interval to 9–15%. Because of the small sample size, the power of this study to exclude an association between a given clinical characteristic and development of complications is low. In addition, no study patients developed osteomyelitis, pyarthrits, or osteo-

chondritis. The reported incidence of such complications ranges from less than 0.1–2% (1,3,4). A larger sample would be much more likely to include patients with these more significant complications.

The study design did not allow for detection of asymptomatic foreign bodies, since all patients did not undergo imaging procedures. The long-term outcome suggests that removal of any foreign bodies that remain asymptomatic is not clinically necessary.

Future studies should compare this conservative approach with more aggressive management, such as probing, coring, and irrigation. The role of prophylactic antibiotics and radiographic examination in the management of plantar puncture wounds should also be investigated.

CONCLUSIONS

In this study, the complication rate after conservative initial management of plantar puncture wounds in healthy adults presenting within 24 hours of injury is 12%. Patients whose symptoms persist beyond 24 hours postinjury are at higher risk for the development of complications.

Acknowledgment—This paper was presented at the 1993 Annual Meeting of the Society for Academic Emergency Medicine, San Francisco, California.

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