

Survey on plantar puncture injury in the emergency department

AYC Siu, TW Wong, CC Lau

Objective: This survey aimed at identifying the characteristics of plantar puncture injury in our locality.

Methods: This was a prospective consecutive case study. All patients presenting with plantar puncture injury were recruited and the characteristics of the injury were documented. **Results:** 64 patients (M: 50; F:14) suffering from plantar puncture injury were recruited from 1st July 1998 to 30th November 1998. Forty nine (76.6%) cases involved metallic nails and 40 (62.5%) cases occurred in construction site. Forefoot and hindfoot were the parts where injuries were usually found. There were signs suggestive of infection in 10 patients (15.6%) on presentation. No bone infection was found. The patients were prescribed 3 days of prophylactic or a full course of therapeutic antibiotics. Fourteen patients (22%) turned up for follow up after one week and no infective complications were identified. **Conclusions:** Serious complications due to plantar puncture injury were uncommon in our group of subjects. Plantar puncture injuries were most prevalent at construction sites. Construction site workers should be better educated in the occupational protection and first aid of such injuries. (*Hong Kong j.emerg.med.* 2000;7: 197-205)

Keywords: Plantar puncture injury, survey, emergency department, infection, antibiotic, penetration depth

Introduction

Plantar puncture injury is a common minor foot injury encountered in the emergency department (ED). Despite the apparent insignificant appearance, major complication, e.g. osteomyelitis can still occur. It was reported that the infection rate was up to 15%.¹ However, there was no previous local report on this specific type of injury. This survey aimed at defining the characteristics of local patients with plantar puncture injuries.

Methods

The study was a prospective survey from 1st July

1998 to 30th November 1998. All patients with plantar puncture injuries, irrespective of the object causing the injury, were recruited into the study. Demographic data and past medical health were recorded. Detailed history regarding where the incidence had occurred, the time interval between injury and presentation to ED, and the type of footwear worn were taken. Patients were also asked about the object causing injury and the estimated depth of penetration. The site of injury was noted and the wound was assessed for signs suggestive of infection or impacted foreign body. Forefoot was defined as the area between the metatarsal heads and toes. Midfoot was the area just distal to the heel to the metatarsal heads. Hindfoot was defined as the heel area. X-ray was performed only if retained foreign body or bone infection was clinically suspected.

The wound was cleansed with aqueous chlorhexidine solution and then sprayed with Opsite (Acrylic Copolymer 3.6% w/w). No further out-patient dressing was ordered unless the wound was discharging. The patients were all discharged with paracetamol as analgesics and ampicillin & cloxacillin for three days as prophylactic antibiotics

Correspondence to:

Siu Yuet Chung, Axel, MBChB(CUHK), FRCS(Edin)

North District Hospital, Accident and Emergency Department, 9 Po Kin Road, Fanling, N.T., Hong Kong
Email: axel@hknet.com

Pamela Youde Nethersole Eastern Hospital, Accident and Emergency Department, Chaiwan, Hong Kong
Wong Tai Wai, MBBS(HK), FHKCEM, FHKAM(Emergency Medicine)
Lau Chor Chiu, MBBS(HK), FHKCEM, FHKAM(Emergency Medicine)

for non-infected wound. Full course of antibiotics (7 days) would be prescribed if the clinical signs were compatible with infection at the initial assessment. Follow-up for wound inspection and compliance monitoring was arranged one week after injury.

The descriptive analysis was performed with the SPSS PC statistical package.

Results

There were 64 patients recruited into the study from 1st July 1998 to 30th November 1998. (Table 1) More than three quarter of them were male (Male:

50; Female: 14). Their ages range from 2 to 87 (Mean age: 37.6). Thirty seven (57.8%) punctures occurred on the left side and 27 (42.2%) on the right. There was no bilateral involvement in our survey. More than half of the injuries involved the forefoot (36/56.3%). (Figure 1) Midfoot and hindfoot injuries occurred in 16 (25.0%) and 11 (17.1%) patients respectively. Toes were rarely involved in our series.

Most of the incidents occurred at construction sites (40/62.5%). Only 8 cases were from other workplaces. (Figure 2) Forty nine patients (76.6%) were injured by either clean or rusted nails. (Table 2) The lengths of the nails were known in 36 cases and they range from 8 to 100 mm (Mean=34.8 mm).

Table 1. Demographic data of the subjects.

| | Number |
|-----------------------------|----------------|
| Sex (male/female) | 50/14 |
| Mean age (range) | 37.6 (2 to 87) |
| Smoking | 22 (33.4%) |
| Diabetes mellitus | 1 (1.6%) |
| Alcohol use | 7 (10.9%) |
| Usage of steroid | 0 (0.0%) |
| Peripheral vascular disease | 0 (0.0%) |
| Immunocompromised status | 0 (0.0%) |

Table 2. Objects involved in plantar puncture injury.

| Agents | Number (percentage) |
|-----------------|---------------------|
| Clean nail | 3 (4.7%) |
| Rusted nail | 46 (71.9%) |
| Thumb pin | 1 (4.6%) |
| Glass | 3 (4.7%) |
| Metallic object | 5 (7.8%) |
| Others | 2 (3.1%) |
| Unknown | 4 (6.3%) |

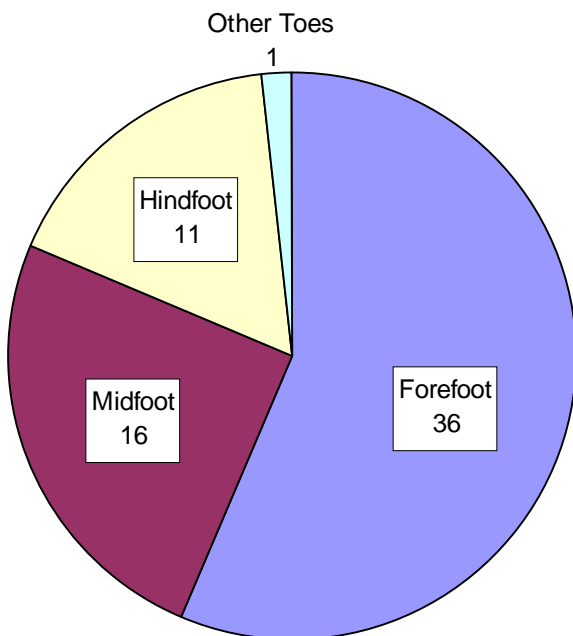


Figure 1. Location of plantar puncture wounds.

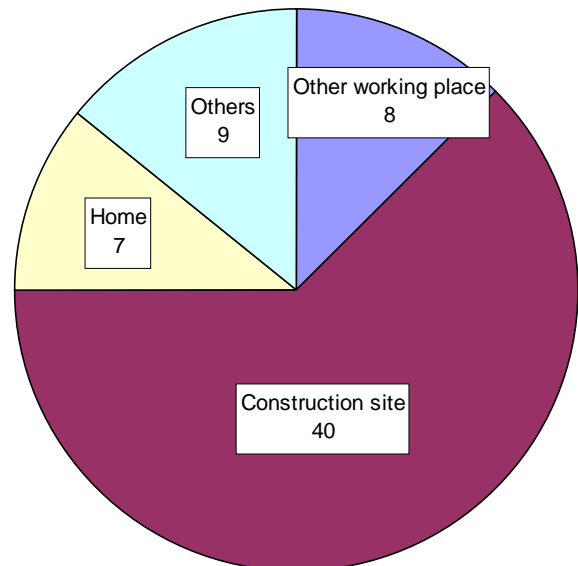


Figure 2. Site of injury occurrence.

The depth of the penetration by the object varied with no specific predominance. (Figure 3) Twenty patients (31.3%) wore sport shoes at the time of injury. Eleven patients wore leather shoes while 12 patients wore sandals. Ten patients (15.6%) did not have any footwear. (Table 3)

More than 50% of patients presented to our department from 9am to 5pm. (Figure 4) Only one patient attended between 12 midnight and 9am. Most patients attended ED within 6 hours of injury (35/54.7%) and only 9 (14.1%) presented after 24 hours. (Figure 5) Pain was the most prevalent symptoms reported (63/98.4%). Eleven patients (17.2) complained of wound swelling. Numbness, foreign body sensation, redness and wound discharge were not commonly noted. (Table 4) Wound squeezing, topical antiseptic and adhesive dressing were the commonest first aid treatment by patients. (Table 5) However, 18 patients (28.1%) did not perform any treatment before consultation. Clinical signs compatible with wound infection were found in 10 patients (15.6%).

In the past medical history, most did not have any predisposing factors to infection. None of them had history of chronic steroid use, peripheral vascular disease or other immuno-compromised state. Twenty two patients (34.4%) were chronic smokers and 7 patients (10.9%) were chronic alcohol

Table 3. Foot protection of patients with plantar puncture injury.

| Foot protection | Frequency (percentage) |
|--------------------------------------------------|------------------------|
| Bared foot | 10 (15.6%) |
| Sandals | 12 (18.8%) |
| Leather shoes | 11 (17.2%) |
| Sport shoes | 20 (31.3%) |
| Other shoes (including special protective shoes) | 11 (17.2%) |

Table 4. Presenting symptoms of the patients.

| Presenting symptoms | Frequency (percentage) |
|------------------------|------------------------|
| Pain | 63 (98.4%) |
| Numbness | 1 (1.6%) |
| Redness | 5 (7.8%) |
| Swelling | 11 (17.2%) |
| Discharge | 3 (4.7%) |
| Foreign body sensation | 3 (4.7%) |

Table 5. Choice of first aid treatment by patients.

| Initial treatment | Frequency (percentage) |
|--------------------|------------------------|
| Adhesive dressing | 15 (23.4%) |
| Topical antiseptic | 17 (26.6%) |
| Topical herbs | 5 (7.8%) |
| Wound squeezing | 15 (23.4%) |
| Wound probing | 4 (6.3%) |
| No treatment | 18 (28.1%) |

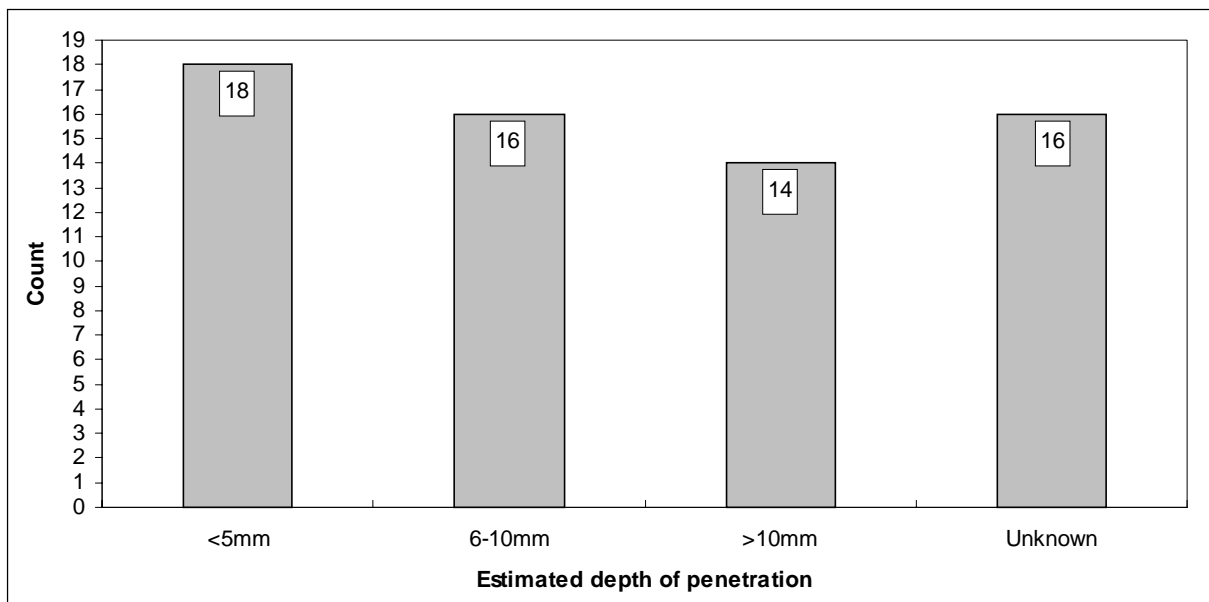


Figure 3. Estimated depth of penetration of the wound.

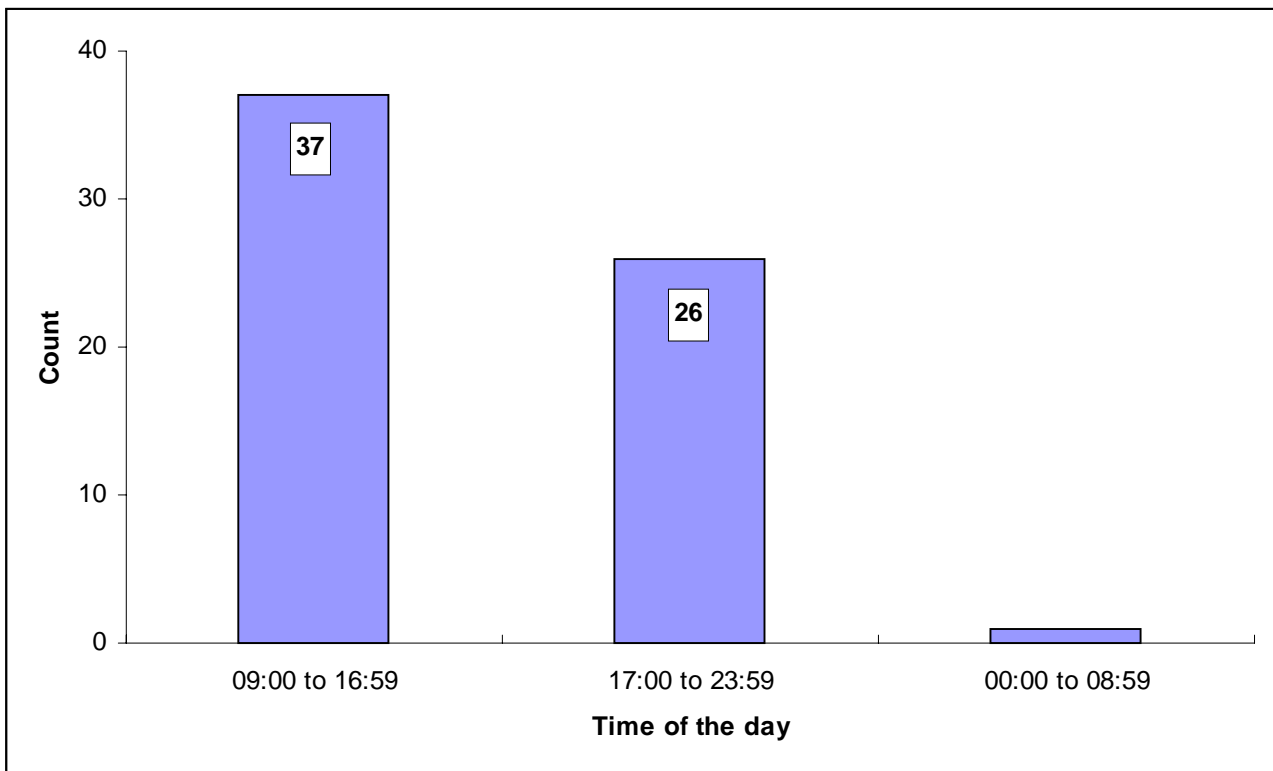


Figure 4. Distribution of cases according to the time of presentation.

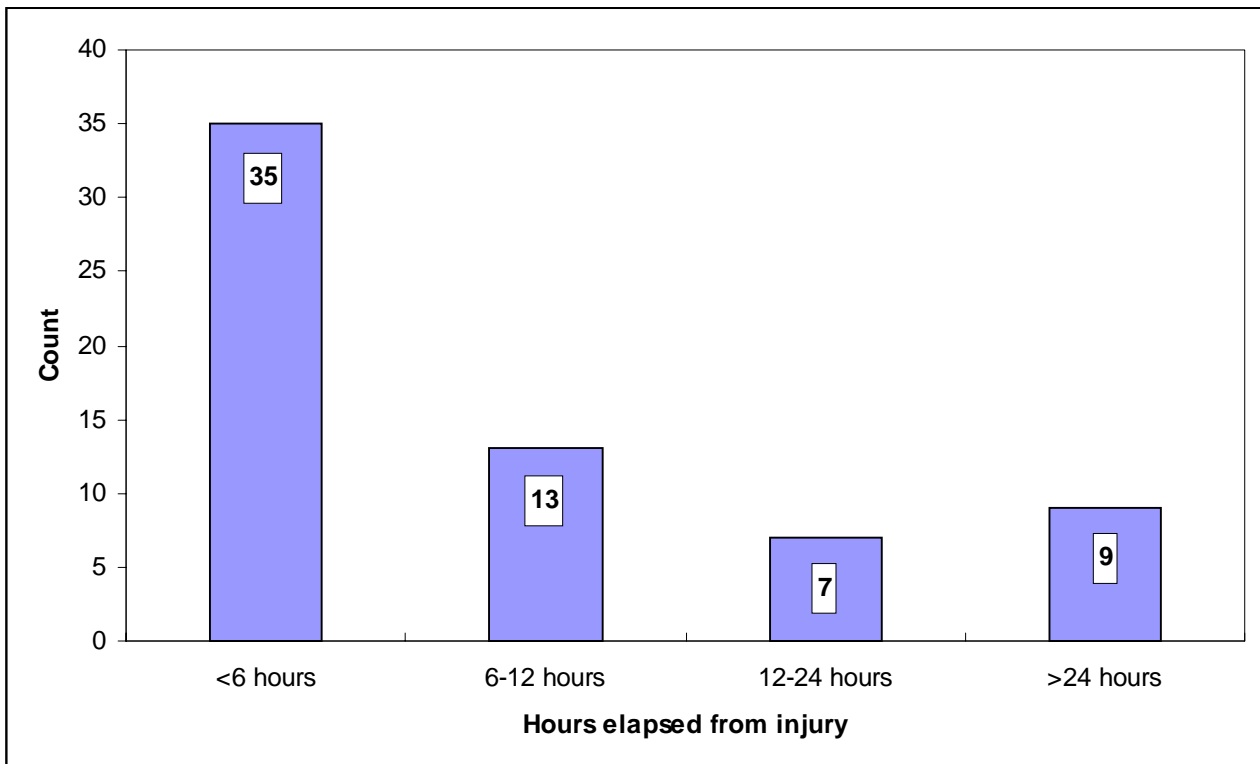


Figure 5. Time lag in presentation to emergency department.

consumers. Only one patient (1.6%) had diabetes mellitus.

Twelve patients (18.8%) had X-ray done after initial assessment and foreign bodies were detected in three patients. One patient strongly requested the investigation but no radio-opaque foreign body was found.

Fifty six patients (87.5%) could not provide detailed history of whether they have received a complete course of tetanus vaccination and were therefore commenced on a new course. Only 6 patients (9.4%) had full course of ATT within 10 years. One patient had not completed the full course of ATT and one other refused injection. None was given tetanus immunoglobulin. All patients received wound dressing in our department. Three patients (4.7%) received intramuscular analgesics before wound treatment. Removal of foreign body was performed in three patients and two were successful in the emergency department. The third required removal of foreign body by orthopaedic surgeon.

All but one patient were discharged with follow-up after treatment. That remaining patient was admitted because of failure to remove the broken glass in the foot. He was admitted to orthopaedic department and was discharged uneventfully after successful removal of foreign body and debridement. Only 14 (22%) patients returned for follow-up. There were no complications of abscess or osteomyelitis in these patients.

Discussion

Plantar puncture injury

Plantar puncture injury is one of the commonest foot injuries seen in the emergency department. It accounted for 0.8% of emergency department visits in the States in 1970's.¹ The apparent trivial appearance does not preclude any significant complications. In fact, the complication rate was reported to be as high as 12%.² Osteomyelitis, cellulitis, soft tissue abscess and pyarthrosis were known to be associated with plantar puncture injury.³⁻⁵ Pseudomonas osteomyelitis resulting from plantar puncture injury was also notorious.¹ The management of the injury was controversial and

included aggressive debridement of a cone of tissue at the puncture site to conservative treatment with wound cleansing only.^{2,4}

Characteristics of injury in our series

Forefoot and hindfoot injuries comprised more than 70% of cases in our series as they were the weight bearing part of the foot. Only 25% of cases injured the midfoot as it constituted the footbridge and was usually away from injury. Pain was the major symptom after the injury. Symptoms that might suggest infection (redness and discharge) were not common, which was compatible with the low infection rate in our study.

Forty nine cases involved nails and this was consistent with the fact that most of the cases occurred in construction sites. Most nails were less than 50 mm. About half of these patients estimated the depth of penetration to be less than 10 mm. It was understandable that construction sites were the commonest sites where the injury occurred and this potential occupational risk was increased by the large number of workers who only wore sports shoes or other non-protective footwear. Education on occupational protection is an the important measure to decrease these accidents.

X-ray examination

In our experience, the major concern of most of the patients after plantar puncture injury was the presence of foreign body. Frequently they would request x-ray after the initial assessment. We do not believe routine x-ray is necessary. Only one patient insisted on having an X-ray performed despite our discussion and it turned out to be negative. We requested x-ray in 12 (18.8%) patients in whom foreign bodies were clinically suspected and the yield was 25% (3).

Complications

A retrospective survey on infection after plantar puncture injury showed that Staphylococcus aureus and Streptococcus species were the two commonest pathogens involved in adult diabetes patients.⁶ Osteomyelitis caused by Pseudomonas aeruginosa was well known as a complication after plantar puncture injuries.^{3,7-11} It accounted for up to 93% of cases of osteomyelitis.³ It was more common in patients who wore tennis shoes.^{5,6} The management

of *Pseudomonas* infection required surgical debridement and anti-pseudomonas antibiotics.¹² A near fatal case of streptococcal toxic shock syndrome secondary to plantar puncture wound has been reported.¹³ Chronic infection with *Mycobacterium* has also been described in the literature.^{14,15}

Late presentations (after 24 hours) usually dictated a worse prognosis as the risk of infection was increased.⁴ Fitzgerald et al. described infection rate of up to 57% in patients who presented after 24 hours.¹ In our study, about 15% of patients presented at least 24 hours after injury but no significant infection was detected among them. The use of prophylactic antibiotics might play a role here.

Diabetes Mellitus was one of the most important factors associated with osteomyelitis (usually associated with multiple pathogenic organisms) after plantar puncture injury.^{10,16,17} In contrast, *Pseudomonas* osteomyelitis was more prevalent in non-diabetic patients. We did not perform wound swab and culture, which may provide information on the possible associated organisms.

We did not experience any serious infection due to plantar puncture injury in our series. However, quite a number of patients defaulted and we could not confirm their status afterwards. They could seek help from other physicians or even traditional Chinese herbalist.

Wound prognosis prediction

Patzakis et al. reported a higher incidence of infection if the puncture had occurred at the forefoot.⁵ Lavery, et al. also reported higher likelihood of osteomyelitis if the injury occurred in the metatarsal head or toes region.¹⁸ They believed that the high prevalence of infection in forefoot was due to the lack of soft tissue cover and the fact that metatarsals constituted the weight bearing part of the foot which resulted in a greater risk of penetration of bone by the nail. On the contrary, the abundance of soft tissue in the midfoot could act as a soft pad to prevent bony penetration. But their idea was disputed by Schwab and Powers.² In our series, about 56% of patients had injuries in forefoot. We could not perform further correlation analysis, as there was no complication reported in our subjects.

Management of plantar puncture injury

The initial first aid treatment for plantar puncture injury should be simple wound cleansing followed by dressing. However, only about one-quarter of our patients used antiseptic solution to cleanse the wound. About 28% of patients did not attempt any immediate treatment before medical consultation. Less than 10% of patients applied medicinal herbs to the wound. As most of injuries occurred in the workplace, prevention of injury should be targeted at these workers and better education on first aid treatment in the workplace reinforced. The Labour Department should be responsible to maintain the appropriate knowledge of the workers.

Krych and Lavery also described a scoring system for puncture wounds, which they used to guide subsequent management.¹⁹ (Tables 6a & 6b) They advised wound cleansing only if the wound was fresh and not complicated. However, incision and drainage would be mandatory if it was deep and complicated. We have not performed a detailed scoring assessment as suggested by Krych and Lavery. Most of our patients would fall into the groups with low to intermediate scores. Further study is required to verify the applicability of the scoring system for our patients.

Some authors suggested an aggressive approach in the management including irrigation or coring of the puncture wound.²⁰⁻²² Resnick and Fallat proposed a classification based on the depth of penetration.²³ (Table 7) They advised irrigation of the wound with Betadine and sterile water followed by wound edge excision for puncture wound with subcutaneous involvement. Inaba et al. also suggested similar treatment categories according to the severity of the wound.³ The management ranges from wound cleansing for clean and superficial wounds, to surgical debridement for wounds which are high suspiciously of underlying soft tissue infection.

However, the aggressive approach in management was generally not well accepted by the patients due to increased time of treatment and prolonged discomfort. Schwab and Powers suggested a more conservative management protocol of simple wound cleansing and 24 hours non-weight bearing.² They reported that most patients preferred their recommendation though they still had a

Table 6a. Scoring of puncture wounds proposed by Krych and Lavery.¹⁹

| | Score |
|-------------------------------------------------------------------------------------------------------|--------|
| Classification of wound | |
| Small superficial wound with sharp edge | 1 |
| Ragged, irregular margin with moderate depth | 2 |
| Irregular wound edges with necrotic tissue or foreign body within the wound, and evidence of drainage | 3 |
| Depth of wound | |
| Wounds involving the epidermis and dermis only | 1 |
| Wounds involving through the dermis with no structural involvement | 2 |
| Wounds through the dermis with structural involvement | 3 |
| Presence of concomitant diseases | Plus 1 |
| Age of wound | |
| Less than 6 hours | 1 |
| Greater than 6 hours and less than 24 hours | 2 |
| Greater than 24 hours | 3 |
| Shoe gear | |
| No foot wear | 1 |
| Stocking or shoes, not both | 2 |
| Both stocking and shoes | 3 |
| Radiology | |
| No evidence of bone involvement | 0 |
| Evidence of bone involvement | 9 |

Table 6b. The recommended treatment regimen of plantar puncture wound by Krych and Lavery.¹⁹

| Score | Treatment recommended |
|-----------|---------------------------------------------------------------------------------------------|
| 1 to 4 | Local cleansing Observation |
| 5 to 8 | Local cleansing Incision and drainage Exploration of foreign body Oral antibiotics |
| 9 or more | Incision and drainage Wound lavage Intravenous antibiotics Immobilisation |

complication rate of about 12%. Most of the patients with complications had symptoms which persisted for more than 48 hours, thus scheduled follow-up is recommended to detect those who are likely to develop complications.

Antibiotic was recommended in most circumstances.⁴ Oral ciprofloxacin was considered the prophylactic antibiotic of choice in early presenters as it had activity against both Gram

Table 7. Classification of plantar puncture wounds.²³

| | Classification of plantar puncture wounds |
|-----------|------------------------------------------------------------------------------------|
| Type I | Superficial cutaneous penetration |
| Type II | Subcutaneous or articular joint involvement without signs or symptoms of infection |
| Type IIIA | Established soft tissue infection including pyarthrosis and retained foreign body |
| Type IIIB | Foreign body penetrated into bone |
| Type IV | Osteomyelitis secondary to puncture wound injury |

positive and Gram negative bacteria, especially *Pseudomonas aeruginosa*.²⁴ Intravenous antibiotic was reserved for patient who presented late or wound that was clinically infected. Some authors adopted a more aggressive approach and recommend intravenous cefoperazone for prophylaxis in dirty looking wound.²² In our study, we used Ampicillin and Cloxacillin as the drugs of choice. They cover many Gram positive and negative bacteria including *Staphylococcus aureus*. However *Pseudomonas* is

notoriously resistant to them.²⁵ In our experience most of the local emergency physicians preferred to use the penicillin group as prophylaxis but there has not been any previous study to assess the efficacy of these antibiotics of choice. Further study is required to investigate the efficacy of prophylaxis using the penicillin group of antibiotics in our locality.

Limitation of the study

Our low infection rate could be due to our small sample size and the fact that most of our patients did not have any factors which predispose them to infection. A questionnaire survey conducted in the States found that only about 50% of patients had consulted a physician. The actual wound infection rate after correction for those did not consult a doctor was 6.4% in contrast to the original 11.4%.²⁶ A second drawback was the high default rate on follow-up. Some patients with complications might elect to seek medical attention elsewhere. The follow up response may be increased by a telephone interview which was not done in our survey.

Conclusions

Serious complications due to plantar puncture injury were uncommon in our small group of subjects. Patients who presented with infected puncture wound at initial presentation were not accompanied by major complications subsequently. Plantar puncture injuries were most prevalent at construction sites. Construction site workers should be better educated in the occupational protection and first aid of such injuries.

Acknowledgement

The authors would like to express their sincere gratitude to all the staff in the Accident and Emergency Department, Pamela Youde Nethersole Eastern Hospital for their assistance in data collection.

References

1. Fitzgerald RH, Cowan DE. Puncture wounds of the

- foot. *Orthop Clin North Am* 1975;6(4):965-72.
2. Schwab RA, Powers RD. Conservative therapy of plantar puncture wounds. *J Emerg Med* 1995;13(3):291-5.
 3. Inaba AS, Zukin DD, Perro M. An update on the evaluation and management of plantar puncture wounds and pseudomonas osteomyelitis. *Pediatr Emerg Care* 1992;8(1):38-44.
 4. Chisholm CD, Schlessler JF. Plantar puncture wounds: Controversies and treatment recommendations. *Ann Emerg Med* 1989;18(12):1352-7.
 5. Patzakis MJ, Wilkins J, Brien WW, et al. Wound sites as a predictor of complications following deep nail punctures to the foot. *West J Med* 1989;150(5):545-7.
 6. Lavery LA, Harkless LB, Felder-Johnson K, et al. Bacterial pathogens in infected puncture wounds in adults with diabetes. *J Foot Ankle Surg* 1994;33(1):91-7.
 7. Das De S, McAllister TA. Pseudomonas osteomyelitis following puncture wounds of the foot in children. *Injury* 1981;12(4):334-9.
 8. Siebert WT, Dewan S, Williams TW Jr. Case report. Pseudomonas puncture wound osteomyelitis in adults. *Am J Med Sci* 1982;283(2):83-8.
 9. Jacobs RF, McCarthy RE, Elser JM. Pseudomonas osteochondritis complicating puncture wounds of the foot in children: A 10-year evaluation. *J Infect Dis* 1989;160(4):657-61.
 10. Jarvis JG, Skipper J. Pseudomonas osteochondritis complicating puncture wounds in children. *J Pediatric Orthop* 1994;14(6):755-9.
 11. Saha P, Parrish CA, McMillan JA. Pseudomonas osteomyelitis after a plantar puncture wound through a rubber sandal. *Pediatr Infect Dis J* 1996;15(8):710-1.
 12. Jacobs RF, Adelman L, Sack CM, et al. Management of Pseudomonas osteochondritis complicating puncture wounds of the foot. *Pediatrics* 1982;69(2):432-5.
 13. Miller JH, Nath RL, Stoughton J, et al. Streptococcal toxic shock syndrome from a puncture wound to the foot. *J Foot Ankle Surg* 1996;35(6):578-84.
 14. Meredith FT, Sexton DJ. Mycobacterium abscessus osteomyelitis following a plantar puncture wound. *Clin Infect Dis* 1996;23(3):651-3.
 15. Subbarao EK, Tarpay MM, Marks MI. Soft-tissue infections caused by Mycobacterium fortuitum complex following penetrating injury. *Am J Dis Child* 1987;141(9):1018-20.
 16. Laughlin RT, Reeve F, Wright DG, et al. Calcaneal osteomyelitis caused by nail puncture wounds. *Foot Ankle Int* 1997;18(9):575-7.
 17. Lavery LA, Walker SC, Harkless LB, et al. Infected puncture wounds in diabetic and non-diabetic adults. *Diabetes Care* 1995;18(12):1588-91.
 18. Lavery LA, Harkless LB, Ashry HR, et al. Infected puncture wounds in adult with diabetes: Risk factors

- for osteomyelitis. *J Foot Ankle Surg* 1994;33(6):561-6.
19. Krych SM, Lavery LA. Puncture wounds and foreign body reactions. *Clin Podiatr Med Surg* 1990;7(4):725-31.
 20. Verdile VP, Freed HA, Gerald J. Puncture wounds to the foot. *J Emerg Med* 1989;7(2):193-9.
 21. Reinherz RP, Hong DT, Tisa LM, et al. Management of puncture wounds in the foot. *J Foot Surg* 1985;24(4):288-92.
 22. Edlich RF, Rodeheaver GT, Horowitz JH, et al. Emergency department management of puncture wounds and needlestick exposure. *Emerg Med Clin North Am* 1986;4(3):581-93.
 23. Resnick CD, Fallat LM. Puncture wounds: therapeutic considerations and a new classification. *J Foot Surg* 1990;29(2):147-53.
 24. Raz R, Miron D. Oral ciprofloxacin for treatment of infection following nail puncture wounds of the foot. *Clin Infect Dis* 1995;21(1):194-5.
 25. British Medication Association & the Royal Pharmaceutical Society of Great Britain. *British National Formulary*. Number 35 (March 1998). London: The Pharmaceutical Press, 1998.
 26. Weber EJ. Plantar puncture wounds: a survey to determine the incidence of infection. *J Accid Emerg Med* 1996;13(4):274-7.