Plantar Puncture Wounds in Children: Analysis of 80 Hospitalized Patients and Late Sequelae

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Abstract

Background: Puncture wounds in the feet of children present a clinical dilemma.

Objectives: To evaluate our approach, we reviewed the charts and all available images of 80 children admitted to our institution because of plantar punctures from 1988 to 1999.

Methods: The charts of 80 children were reviewed retrospectively.

Results: Three groups of patients were found: 59 with superficial cellulitis, 11 with retained foreign bodies, and 10 with osteomyelitis and/or septic arthritis. There was a significant presentation delay in patients from the second and third groups. Most common organisms were *Staphylococcus aureus* or Group A *Streptococcus*. Of the 80 children, 34 were treated surgically and 46 were treated with antibiotic therapy alone. All patients with osteomyelitis and septic arthritis were re-examined; at follow-up, all but one were asymptomatic apart from residual radiologic sequelae in four.

Conclusions: Patients with an established infection 24–36 hours after a plantar puncture should be admitted to hospital for parenteral antibiotic therapy. Delayed presentation is a significant marker for deep-seated infection. Further infection or relapse after initial improvement suggests the presence of osteomyelitis or a retained foreign body. A bone scan is advisable in all patients with suspected osteomyelitis: a positive bone scan necessitates aggressive early debridement combined with appropriate antibiotics; while negative bone scan, X-ray and exploration suggest that the infection is due to a foreign body, which can be detected by computed tomography.

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Puncture wounds in the feet of children are relatively common; about 0.81% of visits to the pediatric emergency room are related to puncture wounds [1]. Nails predominate as the offending agent in up to 98% of cases, but other objects, such as wood, metal or glass, have also been described [1,2]. The incidence of infection varies from 0.6 to 14.8% [1,2]. Infectious complications include mainly cellulitis and soft tissue abscesses, but more serious deep infections, such as osteomyelitis and septic arthritis, may occur in 0.6–1.8% of patients [1]. The significance of *Pseudomonas aeruginosa* as the etiologic agent in such infections has been stressed [3,4], especially when the puncture wound occurred through a sneaker [5]. The role of a retained foreign body, such as a nidus, as the cause of infection cannot be overestimated.

Most children who present in the first 24 hours after the puncture do well, with a relatively low incidence of complications. Patients who present beyond 24–72 hours after the injury frequently have an established wound infection and need to be treated differently [4]. In this study we evaluate our approach to the management of plantar punctures of hospitalized children during the past 12 years and investigate the possible sequelae of puncture wounds.

Materials and Methods

We reviewed the charts and all available images of 80 patients admitted to the Department of Pediatrics and the Pediatric Orthopedics Unit from 1988 to 1999 because of established foot infection following a plantar puncture. The criterion for inclusion included a history of plantar puncture of the foot by stepping on a nail, glass, needle or wood. The patient's age, duration of symptoms before presentation, location of injury, the offending object, temperature on the day of presentation, white blood count and sedimentation rate, microbiologic culture findings, length of hospital stay, antibiotic treatment, isotopic scan results when available, and X-ray findings were recorded. All the patients who were treated for osteomyelitis and septic arthritis were invited for follow-up re-examination.

Results

The charts of the 80 children reviewed revealed that 47 were boys and 33 were girls, aged from 15 months to 15 years (mean age 7 years). The causative injury objects were metal nails in 64 children, glass in 8, needles in 3, other metal particles in 2, plastic pieces in 2, and wood in one. Oral antibiotic therapy (amoxicillin+cavulanate, cefalexine, cloxacillin) was administered to 34 children before hospitalization. None was admitted on the day of injury. Delay between the puncture and presentation to the emergency room ranged from 1 day to 6 weeks (mean 4.1 days).

The indication for admission was evidence for established infection. On admission all patients complained of pain. The most common clinical signs were local or diffuse swelling, erythema, tenderness, and difficulty or inability to bear weight.

X-ray examinations were performed in all patients. Blood tests included complete blood count and ESR. Three groups of patients were identified: a) 59 patients with either superficial cellulitis or soft tissue abscess, b) 11 patients with retained foreign bodies, and c) 10 patients with osteomyelitis and/or septic arthritis.

Puncture wounds were localized in 23 patients (29%) in the area between the metatarsophalangeal joints to the ends of the toes, from the MTP joints to the heel in 44 (55%), and overlying the heel

ESR = erythrocyte sedimentation rate
MTP = metatarsophalangeal

in 13 (16%). The mean duration of symptoms before admission was 4.1 days, but a clinically significant difference was found between the three groups: 2.1 days (range 1–4 days) in group 1, 6.3 days (range 1–28) in group 2, and 7.7 days (range 2–30) in group 3.

A foreign body was demonstrated in 7 of 11 patients (64%) by plain X-ray. In one patient, destruction of calcaneus was demonstrated on admission X-ray 14 days after the puncture. X-rays were normal on presentation in the remaining 72 patients. Later radiologic findings of bone changes were found in five children with osteomyelitis (time range 10–34 days). Bone scan with Tc-99 was performed on 28 patients with suspected osteomyelitis and was positive in all patients in group 3.

For all three groups, the mean total WBC count was 11.8/ml^3, ESR was 35.5 mm/hour, and temperature was 37.8°C. Hospital stay was shorter in group 1 (range 1–6 days, mean 3.3 days) than in group 2 (range 1–13 days, mean 5.1), and longest in group 3 (range 9–47 days, mean 21).

Blood cultures were drawn from all patients and all were sterile. Cultures taken from the site of infection were positive in 27 patients. A single causative bacterial agent was identified in 21 samples, while mixed flora was present in 6 [Table 1]. Initial treatment in all patients was parenteral semi-synthetic penicillin (dicloxacillin or cefazolin) for 2–5 days.

Surgical intervention was performed in those whose plain film clearly showed a foreign body and in those with soft tissue abscesses. The 34 patients who had surgical intervention included all the patients of groups 2 and 3, and 13 patients of group 1 with superficial abscesses. In all 11 patients in group 2 the foreign bodies were removed, but more than one operation was performed in 3 patients in this group because a missed foreign body was revealed only after a CT scan was performed. Incision and drainage were performed in 15 patients with abscesses and septic arthritis; curettage of cartilage and bone, and excision of all devitalized soft tissues was necessary in 7 children with osteomyelitis.

Antibiotic treatment alone resulted in cure of infection in 46 patients. Clinical improvement was initially noticed in four children with osteomyelitis caused by *Pseudomonas aeruginosa* and in three children with unrecognized foreign bodies. Despite initial improvement, all these patients later had a relapse of symptoms and exacerbation. In the first group of patients, the results of treatment – parenteral anti-staphylococcal antibiotics followed by oral antibiotics for 3–5 days – were most predictable.

All patients were seen in follow-up at 7–10 days and 1 month after discharge. Cure was achieved in all patients. The 13 patients who presented with superficial soft tissue abscesses were treated by incision and drainage, pus cultures were taken and appropriate parenteral antibiotics administered. This policy also resulted in the cure of all patients.

In the second group, consisting of 11 patients with retained foreign bodies, unrecognized foreign bodies were found after exploration in 3 patients due to the recurrence of symptoms after initial improvement with antibiotic treatment. Intraoperatively, a plastic piece was found in two patients with a clear-cut history of nail puncture. In the third patient a piece of wood was found. A total of six operative procedures were performed in these three patients.

Table 1. Culture table

Organisms	No. of patients	Group 2 diagnosis
Staphylococcus aureus	14	All groups
Staph. aureus + *Pseudomonas aeruginosa*	3	Osteomyelitis
Pseudomonas aeruginosa	3	Osteomyelitis
Staph. aureus + streptococci	3	Group 1, superficial abscess
Streptococcus hemolyticus	1	Superficial abscess
Serratia	1	Osteomyelitis
Klebsiella	1	Foreign body
Propionobacteria	1	Superficial abscess

Not surprisingly, the most problematic patients were the eight with osteomyelitis and the two with septic arthritis [Table 2]. The calcaneus was involved in five patients, the second metatarsal in two and the proximal phalanx of the big toe in one. Septic arthritis was localized in the MTP joints in two of these patients.

P. aeruginosa was isolated in three patients, *and Staphylococcus aureus* plus *P. aeruginosa* were isolated together in another three patients. *Staph. aureus* was detected as the only causative organism in three patients and *Serratia marcenses* in one. In one patient, cultures were negative despite a typical clinical course of osteomyelitis, a positive Tc-99 scan and the radiologic appearance of calcaneal bone destruction on X-ray.

The third group of patients had a mean temperature at presentation of 37.9°C. The mean ESR was 46.5 mm/hour and mean WBC 11.1/ml^3. The initial history and clinical signs in all the groups were very similar. Surgery combined with antibiotic treatment according to culture results were the mainstay of treatment in the third group. In patients with septic arthritis, arthrotomy, irrigation and microbiologic sampling were performed. In patients with osteomyelitis, curettage of lesions without skin closure, or simple biopsy of the lesion with irrigation was performed. In all these patients the surgical approach was through the plantar aspect of the foot with excision of the skin around the puncture site when needed. There were no complications with delayed skin closure, and no problems with scarring at the plantar region were noted at the last follow-up. In addition to surgery, all patients with osteomyelitis were treated with parenteral antibiotics for 10–14 days after the operation, until clinical improvement, decrease in ESR, and wound clearance were achieved.

All patients in the third group were re-examined at least 1 year after discharge (range 12 months to 4 years). All the patients returned to follow-up and were re-examined at the time this study was conducted. All but one were asymptomatic, despite residual radiologic sequelae in four. In one patient with calcaneus osteomyelitis, severe destruction of the calcaneus occurred 9 years after his injury; this patient still suffered from pain and limitation during sporting activities but not at rest.

WBC = white blood cell

Table 2. Description of the group 3 patients

No.	Diagnosis	Age (yrs)	Duration (days)	Region	Temp. (°C)	ESR (mm/hr)	WBC	Hosp. days	Culture	Surgery	X-ray positive	Tc scan	Compli-cations	Follow-up (yrs)
1	Osteomyelitis	10	14	Calcaneus	37.8	80	12.2	14	*Pseudomonas*	Curretage	+	+	–	6
2	Osteomyelitis	3	3	Second metatarsal	37.5	38	11.7	27	*Staph. aureus*	Biopsy	+	+	–	12
3	Osteomyelitis	10	5	Calcaneus	37.1	55	10.8	27	No culture	Curretage	–	+		5
4	Osteomyelitis	1.3	1	Second metatarsal	38.2	50	15.1	13	*Serratia*	Biopsy	–	+	–	5
5	Osteomyelitis	3	30	Calcaneus	37.1	54	10.1	9	*Staph. aureus*	Curretage	–	+	–	5
6	Osteomyelitis	10	8	Proximal phalanx, big toe	39	39	11.0	21	*Pseudomonas*	Biopsy	+	+	Two admissions due to operative delay	4
7	Osteomyelitis	15	9	Calcaneus	38	18	4.3	47	*Pseudomonas*	Curretage	+	+	Severe bone destruction	9
8	Osteomyelitis	11.5	3	Calcaneus	38	26	7.9	12	*Pseudomonas + Staph. aureus*	Curretage	+		–	10
9	Sept. arthritis	11	2	Metatarsal-phalangeal joint	39	60	11.2	28	*Pseudomonas + Staph. coag.*	Incision + drainage	–	+	–	12
10	Sept. arthritis	2.5	2	Metatarsal-phalangeal joint	37.8	45	16.7	12	*Staph. aureus*	Incision + drainage	–	+	–	10

Discussion

Many aspects of the management of puncture wounds in children have been discussed in the pediatric literature [1–9], but controversies still exist regarding the proper management of this relatively common injury and its complications [2]. The true incidence of infection is unknown, the role of immediate prophylactic antibiotics is questionable, and the optimal duration of antibiotic treatment for osteomyelitis, proper imaging, and the role and timing of surgery all remain undefined.

In our study we found that the time of presentation is an important prognostic factor, in agreement with the largest reported study to date [1]. Houston et al. [10] reported that only 51 of 2,303 patients (2.2%) developed wound infection, and only one of these 51 (2%) developed osteomyelitis. Many of the patients who present later than 24–36 hours from the time of the injury already have an established infection. Fitzgerald [1] found wound infection in 64 of 113 patients (57%) with late presentation. We found a greater delay in group 2 and especially group 3 as compared with group 1.

Algorithms for management and wound classification have been published [2,5,6]. For patients who seek medical aid on the day of injury, we believe that management should include prophylactic tetanus, cleansing of the puncture site, and X-ray or sonography of the foot if a foreign body is suspected. Most of the patients who present after 24–36 hours with signs of local or diffuse infection need hospitalization for parenteral antibiotic treatment and/or surgery. From our review we learned that patients who presented later than a week after the injury suffered from retained foreign body or osteomyelitis. The later the symptoms develop the more deep the infection.

Depth of penetration is another important factor. According to the literature, nails that penetrate deeper than the plantar fascia are more likely to cause serious complications [8,9]. Unfortunately, it is usually impossible to accurately estimate the true depth, especially in very young children. Patzakis et al. [8] divided the plantar surface of the foot into three zones: zone 1 – from the metatarsal neck to the end of the toes, zone 2 – from the distal end of the calcaneus to the neck of the metatarsals, and zone 3 – overlying the calcaneus. Because zone 1 has relatively minimal soft tissue coverage as compared to the other zones, these authors believe that early hospital admission should be considered for all patients with deep puncture wounds in this area, and for patients with bone penetration in zones 2 or 3 at the time of injury. Although this algorithm seems to be logical, it is not clear how to estimate the depth of penetration in young children. From a practical point of view, we believe that it is easier to divide the anatomic location of the puncture as follows: zone 1 – from the end of the toes to the MTP joints, zone 2 – from the distal end of the calcaneus to the MTP joints, and zone 3 – under the calcaneus area. Most of our patients had their injury in zone 2 (44/80), although only two were complicated by osteomyelitis. Of 13 patients in zone 3, 5 had osteomyelitis; and from 23 patients with injury localized to zone 1, only one had osteomyelitis of the phalanx and 2 had septic arthritis in the MTP joints. Since we were unable to differentiate between the three layers, we cannot support the approach of Patzakis et al. [8].

Initial symptoms are very similar in the first few days for most patients: redness and swelling around the puncture site, mild pain, normal or low grade temperature, mild or moderately elevated ESR,

normal X-ray usually, and difficulties with weight bearing. Infections that occur in the first few days after the injury are usually caused by *Staphylococcus aureus* or Group A *Streptococcus* [1,11,12]. Initial antibiotic treatment must be appropriate for these organisms, and our approach is to give parenteral cloxacillin for 2–5 days in the presence of cellulitis until clinical improvement occurs, followed by a few more days of oral treatment. This policy resulted in the cure of all patients with cellulitis. When there is no improvement or when relapse occurs, osteomyelitis, septic arthritis, or an undetected foreign body must be suspected.

Since initial X-ray changes appear only after 10–14 days, bone scan is preferred as an early modality to identify bone and joint involvement. Bone scan may be positive as early as 24 hours after the onset of symptoms and will be suggestive of osteomyelitis before changes are seen on plain X-ray films [13,14]. In the presence of a positive scan indicating bone or joint involvement, aggressive surgical debridement of all devitalized tissues must be performed and a combination of anti-*Pseudomonas* and anti-staphylococcal antibiotics initiated. Antibiotic treatment should be continued based on culture results. Suggested duration of antibiotic therapy varies in the literature from 4 weeks of parenteral therapy to 10–14 days, and even a 7 day course [2,15,16]. Most of our patients were treated for 10–14 days, including those with osteoarticular involvement. No relapse after cessation of antibiotics was noted.

For patients with no improvement, we recommend a CT scan to locate a missed retained foreign body. On CT scan, plastic pieces or wood, granuloma around a foreign body, and collections of pus can better be demonstrated. This approach was helpful in three children from group 2 in whom no cause of infection was found, despite multiple explorations.

Conclusion

Based on our experience, patients who have an established infection 24–36 hours following a plantar puncture should be admitted to hospital for parenteral antibiotic therapy. Delayed presentation is predictive for deep-seated infection or retained foreign body. If there is further infection or relapse after initial improvement, one must consider osteomyelitis or a retained foreign body. In all patients with suspected osteomyelitis, a bone scan must be considered. When a bone scan is positive, aggressive early debridement combined with appropriate antibiotics is warranted. When a bone scan, X-ray and exploration are negative, the cause of infection is usually a roentgenonegative foreign body and, in this situation, CT scan can help to determine the source of the problem.

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A hundred times have I thought New York is a catastrophe ... it is a beautiful catastrophe

Le Corbusier (1897-1965), Swiss-born French architect and one of the most influential of his profession in the 20th century. He was a pioneer of the International Style, characterized by the use of steel and reinforced concrete, open-plan interiors and geometric forms.