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Pediatric calcaneal osteomyelitis: an analysis of literature-reported 128 cases

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Abstract

Background Calcaneal osteomyelitis (CO) poses a formidable challenge in treatment due to the distinct anatomical structure and functional properties of the calcaneus. The present study endeavors to furnish a thorough and comprehensive understanding of the clinical manifestations, therapeutic strategies, and therapeutic outcomes pertaining to pediatric calcaneal osteomyelitis (PCO) by conducting a meticulous synthesis and analysis of cases reported in the literature.

Methods A systematic search of the PubMed, Embase, and Cochrane Library databases was conducted to identify English-language studies analyzing PCO between 2000 and 2021. The quality of the included studies was assessed using the National Institutes of Health (NIH) assessment scale. Effective data were extracted and analyzed.

Results A total of 42 studies, encompassing 128 patients, fulfilled the established inclusion criteria. The gender distribution revealed a male-to-female ratio of 2:1 (81 boys and 40 girls). The median age at the time of diagnosis was 8 years, while the median duration of symptoms was 0.6 month. Trauma emerged as the primary etiology (41 cases, 54%), and limited activity was the most prevalent symptom (68 cases). The positive rate for pathogen culture was 75.4% (49/65), with *Staphylococcus aureus* being the most commonly isolated pathogen (28 cases, 57.1%). Surgical intervention was performed in 51% (64/126) of the patients, with debridement serving as the primary surgical strategy. The rate of infection recurrence was 6.8% (8/118), and the risk of below-knee amputation was 0.8% (1/124).

Conclusions PCO occurred more frequently in male patients, with trauma being the primary underlying cause and *Staphylococcus aureus* being the most prevalent bacterial pathogen isolated. Over half of the patients underwent surgical intervention. Nonetheless, it is imperative that treatment strategies undergo further refinement, as approximately 7% of patients experienced infection recurrence.

Keywords Pediatric osteomyelitis, Calcaneal osteomyelitis, Bone infection, Literature review, Synthesis analysis

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Introduction

Pediatric osteomyelitis represents a category of bone infection which typically targets elongated bones, such as the femur, tibia, and humerus [1]. Nonetheless, the occurrence of calcaneal osteomyelitis (CO) is infrequent, which poses significant challenges in its diagnosis and treatment, primarily due to the intricate anatomical structure and unique functional role of the calcaneus. It is anticipated that there may be a delay in diagnosis due to the subtlety of symptoms, which may not be as prominent as those observed in long bone osteomyelitis [2–4]. Furthermore, the process of differential diagnosis for heel pain in children is extensive and time-consuming, potentially leading to further delays in establishing a definitive diagnosis [5]. Treatment delays in pediatric patients have the potential to result in adverse outcomes, such as the disruption of growth processes, which can ultimately give rise to chronic osteomyelitis, as well as the potential for the spread of infection to adjacent joints [6, 7]. CO represents 3–11% of all chronic osteomyelitis [8–10], and it can occur from hematologic spread or from direct inoculation, usually from an overlying open wound or foreign body penetration, which is often caused by implantation of bacteria into the calcaneus epiphysis following systemic bacteremia [11]. It can also arise in cases of post-traumatic conditions, with a prior history of injury or orthopaedic surgery [12].

Despite numerous attempts to manage pediatric calcaneal osteomyelitis (PCO), it continues to pose significant challenges in treatment. Current therapeutic approaches encompass the administration of antibiotics, meticulous local wound care, surgical excision of the infected bone in the heel region, and the coverage of soft tissue defects [13]. The calcaneus bone exhibits distinctive anatomical and functional characteristics that present substantial difficulties in the course of treatment. When an individual is in a standing position, this bone is situated at the base of the body and is enveloped by soft tissue that demonstrates suboptimal blood flow [14]. In the management of CO, a range of surgical techniques are employed, which encompass irrigation and debridement, surgical drainage, and calcanectomy. Under exceptional circumstances, the possibility of limb amputation is also considered as a potential approach [13, 15, 16]. The purpose of these techniques is to eradicate infection and maintain the functionality of the limb. Nevertheless, the efficacy of treatment for PCO remains suboptimal. A comprehensive retrospective analysis spanning a decade revealed that 17% of pediatric patients experienced a recurrence of infection [17]. The majority of readmissions were attributed to complications arising from the administration of antibiotics or the utilization of peripherally inserted central catheter (PICC) lines. The investigation documented three instances of PICC line-related issues that necessitated their removal, as well as eight occurrences of adverse reactions to antibiotics. Nevertheless, it is important to acknowledge that since the study was conducted retrospectively, there may have been inherent biases influencing the results. Consequently, a more contemporary and comprehensive synthesis analysis is deemed essential to gain a deeper understanding of the disorder.

Despite the increasing number of studies including systematic reviews [18–20] analyzing different aspects of CO, to the best of our understanding, there remains a lack of a comprehensive review that analyzes PCO in detail, which potentially revealing differences from adult calcaneal osteomyelitis (ACO). Consequently, we embarked on this study with the objective of summarizing the clinical characteristics, treatment modalities, and efficacy of PCO through a synthesis analysis of literature-reported cases.

Materials and methods

Literature search and study registration

This study adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [21] checklist to ensure transparent reporting rigor. Two separate authors carried out a rigorous literature search within the PubMed, Embase, and Cochrane Library databases, with the objective of identifying English-language studies that encompassed clinical characteristics, therapeutic interventions, and efficacy of PCO published between the years 2000 and 2021. The search strategy employed the following terms: "("osteomyelitis" OR "osteitis" OR "bone infection" OR "osteoarticular infection") AND ("calcaneal" OR "calcaneus" OR "heel")", with a specific focus on pediatric patients as the subject population. This study protocol has been registered in the PROSPERO database with the registration number CRD42022301091.

Inclusion and exclusion criteria

In the context of this study, our focus was solely on investigations pertaining to PCO. Therefore, we conducted a rigorous screening process that encompassed randomized controlled trials and observational studies, specifically cohort studies, case-control studies, case reports/series, as well as select article formats such as letters, correspondences, short communications, and meeting abstracts. However, these were only included if they provided data on PCO that could be utilized for pooled analysis. Studies that did not report on PCO or lacked data suitable for synthesis analysis were excluded from our review. Furthermore, we made efforts to contact the authors of the studies whenever feasible, in order to obtain additional information.

Study identification, data extraction, and assessment of the study quality

Four authors, acting independently, meticulously screened the titles, abstracts, and full texts of the studies to ensure that only those fulfilling the predetermined inclusion criteria were included in the analysis. Additionally, they painstakingly extracted pertinent data from all the studies that met the eligibility requirements. To assess the quality of these studies, these authors employed the rigorous National Institutes of Health (NIH) assessment scale, a specialized tool designed exclusively for evaluating case series and case reports [22]. Each reviewer independently assigned ratings to each study, and the final score for each category was subsequently calculated. In the event of any discrepancies, they were resolved through thorough discussion, and where necessary, the opinions of the corresponding authors were taken into account to arrive at a final decision.

Statistical analysis

The statistical analysis was conducted using GraphPad Prism (version 9). Initially, the normality of continuous variables was assessed through the Kolmogorov-Smirnov test. For normally distributed data, the results were presented as mean with standard deviation, whereas for abnormally distributed data, the median with interquartile range was utilized. The student's t-test was applied to compare differences between two groups for normally distributed data, and the Mann-Whitney test was employed for abnormally distributed data. Dichotomous variables were expressed as percentages, including events and totals. The chi-square test was used to compare rate differences between or among various groups. A *P*-value less than 0.05 was deemed statistically significant.

Results

Study identification and clinical characteristics

After identifying 1109 potentially relevant English publications, we removed duplicates, screened titles, evaluated abstracts or even the full texts, and finally included 42 studies [3, 4, 17, 23–61] including 128 patients (Fig. 1).

Table 1 displays the clinical characteristics of PCO from the included studies.

Study quality assessment

Based on the NIH scale, the assessment of studies indicated that 8 were categorized as good, 31 as fair, and 3 as poor (Table S1). Given that the majority of the studies included were case reports, four key aspects were deemed inapplicable: (1) reporting of consecutive cases, (2) comparability of the subjects involved, (3) consistent implementation of outcome measures across all participants, and (4) well-described statistical methods employed. As a result, the quality of these studies was constrained.

Clinical characteristics of the included PCO patients

Sex ratio and age at diagnosis

Out of the patients included, there were 81 boys and 40 girls, with a sex ratio 2:1 indicating a preference for boys. The median age at diagnosis was 8 (4-10.6) years for overall patients, with no significant difference between boys [9, (4–11) years] and girls [7 (5–11) years] ($P=0.75$).

Symptom duration, body side distribution and etiology

The duration of symptoms before receiving medical intervention was a median of 0.6 (0.3–2.3) month. Among the cases, 29 had an infection on the right calcaneum, while 16 had it on the left. The primary causes of infection were trauma (41 cases) and hematogenous (27 cases). There were 6 cases caused by nervous system problem, 2 cases caused by immunosuppression (Table 1).

Clinical symptoms, pathogen culture and serological levels of inflammatory biomarkers

Distribution of the reported clinical symptoms were limited activity (68 cases), swelling (53 cases), fever (32 cases), pain (26 cases), redness/erythema (19 cases), ulcers (6 cases), fistula/sinus discharge or purulent secretion (15 cases) and edema (10 cases).

The positive rate of pathogen culture was 75.4% (49/65), with *Staphylococcus aureus* (28 cases), *Mycobacterium species* (10 cases), and *Pseudomonas aeuriginosa* (4 cases) as the top three for monomicrobial infection. The median serological levels of inflammatory biomarkers for overall patients were as follows: white blood cell count (WBC) was [9.92 (6.79–14.7)] $\times 10^9$/L, erythrocyte sedimentation rate (ESR) was [36 (19–68)] mm/1 h, and C-reactive protein (CRP) was [24.1 (5.1–64.5)] mg/L (S Table 2).

Treatment strategy and clinical efficacy

Among all the patients included, the treatment strategies adopted were categorized into conservative treatment and surgical treatment. The infection recurrence rate was 6.8% (8/118) among all patients. A total of 62 cases were treated conservatively and all recurred well without infection recurrence. Surgical treatment or other invasive operations were performed in a total of 64 cases, with an overall recurrence rate of 10.4% (5/48). Among the surgical treatment strategies, focus debridement emerged as the most prevalently employed method. Specifically, 39 cases received focus debridement, 9 cases necessitated debridement accompanied by local implantation of antibiotics, and 4 cases underwent debridement with flap coverage. Aside from debridement, 2 cases underwent total calcanectomy, and even 1 case had below-knee

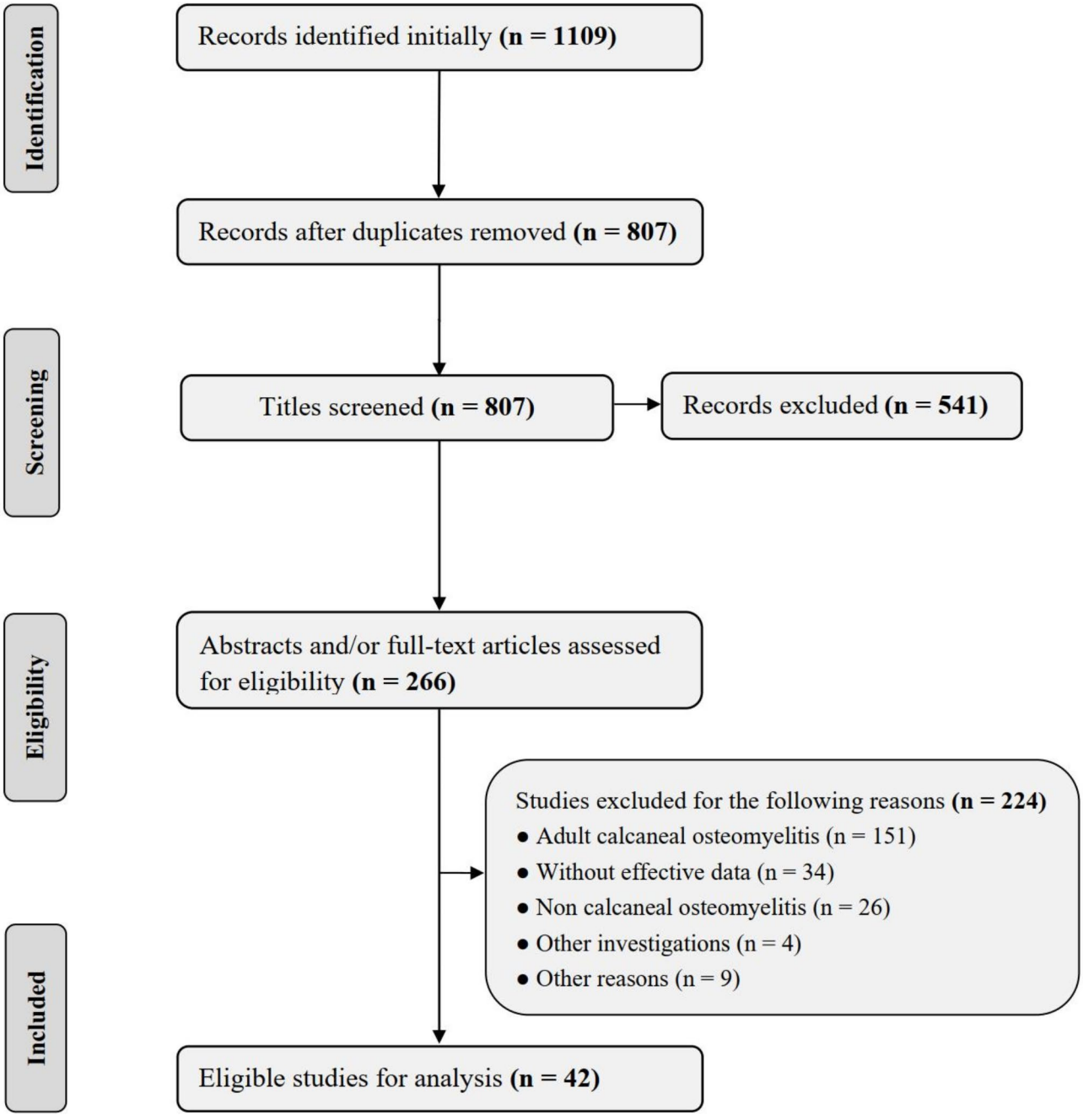

Fig. 1 Flow chart of the eligibility selection

amputation, and an additional 9 cases received other forms of invasive surgical interventions (S Table 2).

Discussion

The current study has undertaken a synthesis analysis of 128 patients, sourced from 42 publications, in order to thoroughly examine the clinical features, therapeutic approaches, and treatment outcomes associated with PCO. Our findings underscore the predominance of PCO in male patients, particularly those experiencing infections stemming from trauma and hematogenous dissemination. The most prevalent symptoms reported were restricted mobility and localized swelling, with *Staphylococcus aureus* emerging as the most frequently identified microbial agent. Despite the fact that over half of the patient cohort underwent surgical intervention, the infection relapse risk was approximate 7%.

Our findings reveal that the incidence of PCO is twice as high in boys compared to girls, aligning with previous research analyzing chronic osteomyelitis. In

Table 1 Clinical characteristics of pediatric calcaneal osteomyelitis of the included studies

Study (First author, publication year and country)	Total number of cases	Age at diagnosis (years)	Sex	Side involved	Origin of infection	Symptom duration
Yu et al. (2021) China	1	1.17	Boy	Right	Not reported	10 days
Hoshina et al. (2021) Japan	1	5	Boy	Left	Not reported	8 days
Chan et al. (2021) China	1	4	Girl	Right	Other cause	1 month
Hiraoka et al. (2021) Japan	1	4	Boy	Right	Hematogenous	3 days
Bikoroti et al. (2021) Rwanda	1	9	Girl	Left	Not reported	4 months
Peng et al. (2021) China	3	5, 6 and 7	Boy (1) Girls (2)	Not reported	Trauma (3)	1.25, 2 and 1 months
Nadau et al. (2020) France	7	1.8, 5.9, 11.1, 1.7, 9.1, 12, 9.4	Not reported	Not reported	Hematogenous (7)	5, 10, 1, 9, 4, 2, 0 days
Qin et al. (2020) China	1	10	Boy	Left	Trauma	Not reported
Jain et al. (2020) India	1	12	Boy	Left	Nervous system problem	72 months
Jiang et al. (2020) China	4	10, 10, 12, 3	Boys (4)	Left (3 cases) Right (1 case)	Hematogenous (1) Trauma (3)	Not reported
Ingersoll et al. (2019) United States	1	1	Boy	Right	Hematogenous	10 days
Chan et al. (2018) China	1	4	Girl	Right	Immunosuppression	Not reported
Insalaco et al. (2017) United States	1	1	Boy	Right	Hematogenous	Not reported
Tural Kara et al. (2016) Turkey	1	7 days	Girl	Right	Trauma	3 days
Kuntz et al. (2016) Germany	1	6	Boy	Right	Not reported	1 month
D'Amelio et al. (2016) Spain	1	6	Boy	Right	Not reported	Not reported
Pääkkönen et al. (2015) Finland	11	10 (mean age)	Boys (8) Girls (3)	Not reported	Hematogenous (11)	Not reported
Mallia et al. (2015) UK	1	9	Boy	Left	Not reported	10 days
Khan et al. (2015) Canada	1	2	Boy	Right	Not reported	14 days
El-Sobky et al. (2015) Egypt	1	14	Boy	Right	Not reported	72 months
Suresh et al. (2014) Oman	1	9	Boy	Right	Trauma	21 days
Mustapić et al. (2014) Croatia	1	9	Boy	Left	Not reported	1 month
Mallia et al. (2014) UK	1	9	Boy	Not reported	Not reported	8 days
Alcafache et al. (2014) Portugal	1	2	Boy	Left	Hematogenous	15 days
Bergmann et al. (2014) Germany	1	8	Boy	Right	Hematogenous	4 months
Abdulla et al. (2014) UK	1	12	Boy	Left	Hematogenous	21 days
Rafiqi et al. (2013) Morocco	2	13, 6	Girls (2)	Right (1) Not reported (1)	Not reported	3, 5 months
Hoops et al. (2013) USA	1	12	Boy	Right	Trauma	7 days
Daneshjou et al. (2012) Iran	4	12, 13, 8, 7	Boy (1) Girls (3)	Right (4)	Nervous system problem (4)	Not reported
Fathinul et al. (2010) Malaysia	1	13	Boy	Right	Trauma	Not reported
Chen et al. (2010) United States	1	9	Boy	Left	Not reported	14 days
Leigh et al. (2010) New Zealand	60	6.67 (mean age)	Boys (40) Girls (20)	Not reported	Trauma (24) Not reported (36)	6.8 days (mean)
Pepper et al. (2010) United States	1	10	Girl	Right	Trauma	21 days
Michelarakis et al. (2009) Greece	1	4	Boy	Left	Not reported	1 month
Khan (2007) India	1	8	Boy	Left	Not reported	6 months
Lee et al. (2007) United States	1	12	Girl	Right	Hematogenous	7 days
Yüksel et al. (2007) Turkey	1	17 days	Girl	Left	Trauma	10 days
Vidyadhara et al. (2006) Indian	1	14	Boy	Right	Trauma	5 months
Kesiktas et al. (2006) Turkey	1	10	Boy	Left	Nervous system problem	Not reported
Baktiroglu et al. (2005) Turkey	1	6	Girl	Right	Hematogenous	15 days
Clark et al. (2003) United States	1	3	Boy	Right	Not reported	42 days
Antonio et al. (2003) Italy	3	13, 6, 8	Boy (1) Girls (2)	Right (3)	Trauma (3)	3, 3, 1 months

a retrospective analysis conducted by Jiang et al. [8], which encompassed 394 patients with chronic osteomyelitis from Southern China, they observed a male-to-female ratio of 3.5. Analogously, Wang et al. [9] reported a male-to-female ratio of 4.8 among patients suffering from chronic osteomyelitis in Southwest China. The duration of PCO symptoms varies among publications, ranging from 0 to 72 months, despite a median of 0.6 (0.3–2.3) month in the present study. Nadau et al. [51] described clinical manifestations and outcomes of seven PCO patients in detail. Notably, in one instance, a 9.4-year-old individual was diagnosed with the condition, exhibiting an unprecedentedly brief symptom duration of 0 days. This unusually prompt manifestation may be attributed to the characteristic systemic (fever) and localized (abscess) presentations of the infection, as displayed by the patient. In stark contrast, El-Sobky et al. [40] reported a 14-year-old PCO patient experienced a maximum symptom duration of 72 months. Such a wide range of symptom duration implies the high heterogeneity of this disorder. Our findings reveal that the occurrence of PCO is more prevalent on the right side of the body, which could potentially be attributed to the majority of individuals' right-side dominance. Furthermore, the primary factors contributing to the development of PCO are trauma and hematogenous origins. Nevertheless, there have been reports of other less common etiological factors, such as nervous system disorders and immunosuppression. Daneshjou et al. [33] described four pediatric patients with congenital insensitivity to pain and anhydrosis (CIPA) in detail. The primary clinical manifestations observed among these patients was recurrent osteomyelitis of the foot, and despite the presence of deep sores and infections, they do not experience pain. Similarly, Jain et al. [49] reported a 12-year-old boy who were diagnosed of chronic CO with heel ulcers. This condition has arisen due to an injury and subsequent infection, which was exacerbated by a lack of sensation resulting from myelomeningocele.

In order to prevent the onset of chronic CO stemming from neurological disorders, such as CIPA, it is imperative to adopt a comprehensive strategy that effectively manages and minimizes the associated risks. This necessitates the implementation of the following measures: (1) Infection control: It is crucial to maintain a rigorous routine of inspecting and cleaning the feet, with particular emphasis on areas that are susceptible to injury. Early detection and prompt treatment of any wounds or ulcers are essential to prevent their progression and the subsequent development of chronic osteomyelitis. Additionally, the utilization of antibiotics for both preventive and therapeutic purposes is pivotal in halting the spread of infections and mitigating their potential to evolve into chronic conditions [62]. (2) Prevention of self-harm: It is crucial to utilize protective equipment, such as gloves, guards, and suitable footwear, to minimize the risk of patients inadvertently harming themselves. Moreover, it is imperative to ensure that patients who exhibit a propensity for self-harm are adequately safeguarded and supervised during their daily routines. (3) Temperature control: It is essential to regularly monitor the body temperature of individuals to prevent exposure to extreme temperatures. Measures must be taken to avert overheating or hypothermia, and the utilization of cooling or heating devices is paramount to ensure that patients reside within a safe and comfortable temperature range. (4) Education and support services: It is essential to offer comprehensive education to patients and their families in order to facilitate a better understanding of the disease's characteristics and effective management strategies. This includes educating patients on self-examination techniques, enabling them to recognize potential wounds and infections, and emphasizing the importance of seeking prompt medical attention when necessary [63]. It is of utmost significance to offer support to families and caregivers, arming them with the essential knowledge and skills necessary for managing and averting complications. By adopting these preventive strategies, the incidence of chronic CO arising from neurological disorders could be effectively reduced, thereby enhancing the patients' quality of life and extending their lifespan.

This research highlights both the similarities and differences in the clinical manifestations of PCO compared to those observed in individuals with post-traumatic osteomyelitis and chronic osteomyelitis. Among the cohort of PCO patients evaluated, the predominantly reported symptoms encompassed restricted mobility and localized swelling. These manifestations were attributed to the presence of pain and edema adjacent to the soft tissue structures of the heel bone, as well as inadequate perfusion of blood to these tissues. Such factors are intensified by traumatic injuries and hematological abnormalities, thereby enhancing the vulnerability to wound complications. Wang et al. [9] reported analogous discoveries in their research on patients suffering from post-traumatic osteomyelitis, emphasizing that the presence of wound sinus is observed in roughly 75% of such cases. Analogously, chronic osteomyelitis, particularly in the long bones, may manifest as pain, swelling, limited mobility, and the development of wound sinuses—symptoms that closely resemble those observed among the PCO patients [64, 65]. The protracted nature of both conditions poses similar challenges in their management, necessitating extended use of antibiotics and potentially requiring surgical removal of necrotic bone tissue. Nevertheless, in contrast to post-traumatic osteomyelitis and chronic osteomyelitis, PCO can stem from neurological disorders, immunological reactions, and other systemic

complications, apart from trauma. This distinction holds paramount importance in tailoring therapeutic approaches. For instance, while aggressive infection control and surgical procedures may be beneficial for both conditions, the management of PCO might additionally necessitate addressing underlying systemic health concerns in order to enhance patient outcomes.

In terms of pathogen identification, the positive rate of sample culture for PCO patients was found to be 75.4%, higher than the 71% reported by Jiang et al. [8] and the 64% reported by Wang et al. [9] regarding the chronic osteomyelitis patients. It is crucial to emphasize that the positivity rate of traditional culture for osteomyelitis patients is subject to various influencing factors, including recent administration of antibiotics and surgical interventions, the specific sampling site, the culture conditions employed, and the quantity of samples submitted for culturing [66]. Furthermore, the underlying cause of chronic osteomyelitis has the potential to influence the outcomes of microbiological cultures. It is imperative to conduct a more exhaustive analysis to ascertain whether analogous factors exert an influence on culture results in PCO patients. Notably, *Staphylococcus aureus* remained to the the most prevalent pathogen in PCO patients, comprising 57.1% of all cases. It is intriguing to observe that *Mycobacterium* species and *Pseudomonas aeruginosa* were also frequently encountered, with 10 and 4 instances respectively, highlighting the intricate nature of the disease and pointing towards a distinctive bacterial profile. These observations emphasize the necessity for a holistic approach in identifying pathogens among PCO patients. Accurate and prompt pathogen detection can serve as a cornerstone for targeted antibiotic treatment, thereby enhancing patient outcomes and mitigating the risk of persistent infection. The diverse array of pathogens further underscores the significance of integrating advanced diagnostic methodologies with traditional culture practices to encompass a comprehensive range of potential infectious agents.

In terms of treatment, we have observed that surgical therapy constituted 51% of the total treatment modalities administered to patients with PCO. However, despite this, the infection recurrence rate was about 7%. It is widely acknowledged that the recurrence of infection is contingent upon various factors, encompassing etiology, the extent and severity of infection, the type of pathogen involved, and its virulence. Furthermore, the chosen treatment strategy holds significant weight as a determinant factor [8, 9, 58, 67]. The results of the synthesis indicate that conservative therapy demonstrated a superior efficacy in terms of infection recurrence, whereas surgical intervention was associated with a notably higher recurrence rate. However, this finding does not imply that conservative treatment is appropriate for all PCO patients, since those necessitating surgical intervention frequently present with more advanced situations. Moreover, the limited sample size could also influence the results. Debridement emerged as the most prevalent surgical technique, with two cases received total calcanectomy. Jain et al. [49] reported a 12-year-old boy with heel ulcers and chronic CO. The patient underwent total calcanectomy with local vancomycin-impregnated calcium sulfate implantation, followed by four weeks of intravenous antibiotics. At the 18-month follow-up, the patient maintained full functionality with the orthosis and experienced no complications. The other case, reported by El-Sobky et al. [40], was a 14-year-old male patient who was diagnosed with fungal osteomyelitis affecting the calcaneum. The patient underwent total calcanectomy followed by 8 weeks of oral itraconazole, showing significant improvement. Furthermore, amputation might be considered as a possible solution for individuals suffering from severe deformities or recurrent infections, yet both of these procedures are highly invasive and require careful weighing of the pros and cons. Daneshjou et al. [33] reported a 13-year-old girl with CIPA syndrome who underwent foot amputation due to severe deformity and failed antibiotic treatments. Unfortunately, cellulitis developed three weeks post-surgery, spreading to the knee. These cases highlight the complexity of managing PCO. While conservative treatments may reduce recurrence, surgical interventions like total calcanectomy, combined with rigorous postoperative care, are effective for more advanced cases. Amputation stands as a final measure for cases of severe and recurrent infections. Further research is imperative to refine treatment strategies, taking into account the severity and the unique needs of each patient. Tailored, comprehensive care can enhance outcomes for individuals suffering from PCO and comparable conditions.

The etiology and treatment strategies for PCO and ACO exhibit certain differences. Initially, considering that children's bones are in a phase of active growth and development, they have a more abundant periosteum and intraosseous blood supply. As a result, there is a heightened risk of blood-borne infections. This phenomenon also accounts for the observation that children's initial infection symptoms may not be as pronounced as those observed in adults, frequently resulting in a delayed diagnosis [17, 68]. From a therapeutic perspective, conservative treatments like antibiotics are more frequently utilized and generally effective in children due to their incompletely developed skeletal structure. In contrast, surgical intervention is more commonly necessary to excise necrotic tissue and manage infections in adult patients [69, 70]. Furthermore, osteomyelitis in children can cause damage to the epiphyseal plate, potentially impacting bone growth and resulting in limb deformities

that are typically absent in adults [71]. Consequently, the management of PCO should consider not only infection control but also its enduring impacts on bone development. In summary, while PCO and ACO exhibit some shared characteristics, such as the potential for localized pain and swelling, they are fundamentally different in their etiologies and therapeutic approaches. These distinctions necessitate that clinicians tailor their management strategies to these unique patient groups to guarantee the best possible outcomes and prognoses.

Although a thorough analysis has been undertaken in this study, it is imperative to acknowledge several limitations, and consequently, future research endeavors should be directed towards addressing these identified gaps. First, the study is constrained by a limited sample size, encompassing a total of 128 cases. Notably, one study contributed 60 samples, whereas the majority of the other studies consisted solely of single-case reports. This disparity poses a substantial risk of bias and undermines the generalizability of the findings. Furthermore, the reliance on a narrow range of samples from individual studies may not adequately mirror the broader spectrum of PCO patients, thereby compromising the representativeness of the results. Secondly, the absence of standardized reporting guidelines poses another limitation to this study, as it results in a lack of essential information, such as sex and the specific treatment approach. Likewise, despite summarizing a plethora of cases and diverse treatment strategies, the study falls short in presenting a clear-cut and comprehensive treatment protocol tailored specifically for PCO patients. The lack of a unified approach creates difficulties in reaching definitive conclusions regarding the most efficacious treatment strategies. For instance, although debridement emerges as a prevalent surgical technique, there exists significant variation in the specific techniques and methodologies employed, contributing to the inconsistency observed in treatment outcomes. Third, this study encompasses a comprehensive review of literature spanning two decades, during which time there have been notable advancements in treatment protocols and medical technologies. This temporal variation may potentially impact the efficacy of treatments as reported across various time periods. To ensure a more precise portrayal of treatment efficacy, it is imperative to conduct future stratified analyses that take into account these dynamic factors.

Conclusions

In conclusion, the exhaustive analysis conducted on 128 patients in the current study has revealed that the incidence of PCO is significantly elevated among males, primarily stemming from trauma. *Staphylococcus aureus* has emerged as the most prevalent causative microorganism. More than half of the patients underwent surgical intervention. However, approximately 7% of the patients experienced recurrence of infection, which necessitates heightened vigilance and attention.

Abbreviations

CO	Calcaneal Osteomyelitis
PICC	Peripherally inserted central catheter
PCO	Pediatric Calcaneal Osteomyelitis
ACO	Adult Calcaneal Osteomyelitis
NIH	National Institutes of Health
CIPA	Congenital Insensitivity to Pain and Anhydrosis

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12879-024-09887-9.

Supplementary Material 1

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None.

Author contributions

N.J. and B.Y. conceived and designed the study. Z.X.L., H.F.Z., P.C., and N.J. screened studies for inclusion. I.A.D., Z.X.L., P.C., and H.F.Z. extracted effective data of the included studies. I.A.D., P.C., V.T.M. and M.U. evaluated the study quality; I.A.D. and M.Q. performed statistical analysis; H.F.Z., N.J., and B.Y. acquired funding support. I.A.D., Z.X.L. and N.J. wrote the manuscript. N.J. and B.Y. supervised the study. All authors reviewed and revised the manuscript. All authors read and approved the final manuscript.

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Data availability

The data that support the findings of this study are available from the corresponding authors, B.Y. and N.J., upon reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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