

Updates on Current Situation of Cutaneous Sporotrichosis: A Narrative Review

Jing Shi¹, Wei Zhang², Xiao Liu¹, Mingcheng Li³

¹Department of Dermatology, Jilin Central Hospital, Jilin, 132011, People's Republic of China; ²Department of Clinical Laboratory, Jilin Central Hospital, Jilin, 132011, People's Republic of China; ³Department of Clinical Microbiology, School of Laboratory Medicine, Beihua University, Jilin, Jilin, 132013, People's Republic of China

Correspondence: Mingcheng Li, School of Laboratory Medicine, Beihua University, No. 3999 East Road of Binjiang, Jilin, Jilin, 132013, People's Republic of China, Tel +86432-64608115, Email limingcheng@beihua.edu.cn; Xiao Liu, Email yunxia_161@qq.com

Abstract: Sporotrichosis, a cutaneous or subcutaneous infection caused by the dimorphic fungus *Sporothrix* species, is widely distributed in China, with a notably higher incidence during colder seasons in northeastern Jilin Province. Recent advancements in *Sporothrix* taxonomy have significantly improved our understanding of diagnosis, epidemiology, and treatment strategies. In this review, we described the updated overview of recent progress of sporotrichosis, including etiology, epidemiology, clinical manifestations, diagnostic approaches, and treatment strategies, to provide a comprehensive description of preventive measures and control strategies aimed at facilitating future breakthroughs in research. We highlighted the geographical and population distributions specific to Jilin, China. The ongoing research efforts of novel diagnostic technologies, nanodrugs or nanoformulations treatment options are developed to advance knowledge about this sporotrichosis and its agents.

Keywords: sporotrichosis, sporothrix, treatment and prevention measures

Introduction

Sporotrichosis is a fungal infection commonly observed in tropical and subtropical regions. It primarily occurs through exposure to contaminated soil or plant materials, leading to chronic infections of the skin and subcutaneous tissues. In recent years, with the expansion of agricultural, horticultural, and forestry activities, coupled with the impacts of global climate change, the incidence of sporotrichosis has been increasing.^{1,2} The genus *Sporothrix* is comprised of 53 species, and pathogenic species are not evenly distributed worldwide. For an example, *S. schenckii* and *S. globosa* are widely distributed across the globe, contrasting with the mainly restricted presence of *S. brasiliensis* in Brazil and the exclusive reports of *S. luriei* in Africa, Italy, and India. The distribution of *S. globosa* is mainly in Asia, with several cases reported in Europe and South America.³ China ranks among the countries with the highest sporotrichosis incidence globally.⁴ Most cases of human sporotrichosis are concentrated in the northeast region of China, including Jilin and Liaoning Heilongjiang provinces.⁵ This study systematically reviews the major research advancements in sporotrichosis, analyzing its transmission routes, diagnostic methods, treatment strategies, and proposing effective prevention and control measures.^{6,7} Through this review, we aim to provide a comprehensive understanding of the clinical characteristics and public health concerns associated with sporotrichosis and to offer scientific guidance and references for public health departments, clinicians, and high-risk populations to mitigate pathogen infection and transmission.

Overview and Characteristics of Cutaneous Sporotrichosis

Based on the location of lesions and the progression of infection, sporotrichosis can be classified into three forms: cutaneous, mucocutaneous, and extracutaneous infections.⁸ Among these, the cutaneous form is the most prevalent. Depending on distinct cutaneous manifestations, cutaneous sporotrichosis can further be categorized into three types: fixed cutaneous, lymphocutaneous, and disseminated sporotrichosis.^{9,10} Lymphocutaneous sporotrichosis is one of the most common types, characterized by pathological changes spreading along the lymphatic system, forming bead-like

nodules or ulcers. Fixed cutaneous sporotrichosis is confined to the skin surface, presenting as single or multiple nodules, abscesses, or ulcers without lymphatic dissemination. Disseminated sporotrichosis is relatively rare and primarily affects immunocompromised individuals, manifesting with widespread skin lesions and systemic symptoms (as shown in Figure 1a–c).¹¹ Understanding the classification of sporotrichosis is crucial for clinical diagnosis and treatment, as different types may exhibit significant variations in disease progression, treatment response, and prognosis.

Lymphocutaneous sporotrichosis is characterized by the formation of bead-like nodules along the lymphatic pathways, which may gradually ulcerate and produce purulent secretions. Fixed cutaneous sporotrichosis is marked by localized nodules or ulcers that do not spread via the lymphatic system, often resulting in thickened, hardened skin areas and the formation of sclerotic patches. Disseminated sporotrichosis predominantly occurs in immunocompromised patients, presenting with widespread skin nodules, ulcers, and systemic symptoms such as fever and fatigue.^{12,13} Due to the similarity of sporotrichosis clinical manifestations to other skin diseases (eg, tuberculous skin diseases, pyoderma), etiological examination, histopathological analysis, and molecular biology techniques are often required for accurate diagnosis. Recognizing and understanding these clinical features is essential for early diagnosis and timely treatment.

Etiology and Transmission Routes of *Sporothrix* Species Infection

Currently, the taxonomy of *Sporothrix* has been significantly refined, with the genus comprising 53 recognized species.¹⁴ These species can be categorized into two major clades: the clinical clade and the environmental clade. The clinical clade includes *S. brasiliensis*, *S. globosa*, *S. luriei*, and *S. schenckii*. Among these, *S. globosa* and *S. schenckii* are globally widespread. In addition, *S. globosa* could be divided into eight clustering groups (I–VIII), with groups I, II and IV being



Figure 1 Clinical manifestations of sporotrichosis in patients with chronic cutaneous and subcutaneous lesions in Jilin Province, China. **(A)** Fixed lesions: solitary or satellite erythematous and papular lesions. **(B)** Lymphocutaneous lesions: ulcerative/papular/tumor-like lesions distributed along the lymphatic vessels. **(C)** Disseminated lesions: ulcerative/granulomatous/crusty lesion with multiple cutaneous lesions.

the most common clusters with the microsatellite length polymorphism (MLP) analysis technique. The environmental clade comprises *S. mexicana*, *S. pallida*, *S. humicola*, *S. phasma* and *S. chilensis*. *S. globosa* is the predominant species causing infections in the northeast region of China, although sporadic cases caused by *S. schenckii* have also been reported.¹⁵ From 2010 to 2019, a total of 6508 sporotrichosis cases have been described in China, which distributed in most provinces of China except Tibet and Hainan, with the highest incidence in northeastern China. A total of 5240 cases were reported in Jilin Province, followed by 542 cases in Heilongjiang Province and 285 cases in Liaoning Province.¹⁶ There were a limited number of epidemiological reports on *Sporothrix* infection in the other Provinces in China. The distribution of sporotrichosis cases in 9 different areas from Jilin Province was presented in Figure 2.¹⁷

The *Sporothrix* was commonly found in the natural environment, especially in rotten plants and wood. All species could be isolated from soil, sludge, cornstalks, reeds, rice, and dead branches. The two main routes of transmission of sporotrichosis were traumatic inoculation via infected plants or animals and inhalation of fungal conidia. In China, traumatic inoculation of plant debris carrying the *Sporothrix* species is the major transmission route of sporotrichosis. In northeast China, contact with decayed corn stalks is the primary source of sporotrichosis infection. Adults may acquire sporotrichosis through direct contact with the pathogen while preparing the cornstalks for biomass fuel for cooking. Therefore, similar to epidemics in Africa, in Asia, the traumatic inoculation of plant debris is also the main transmission route, whereas the another transmission route of *Sporothrix* is through animal scratches, bites, and close contact with animal secretions, particularly cats in Brazilian territory. While cutaneous infections occurred, the fungal conidia may occasionally enter the body via the respiratory or digestive tracts, leading to pulmonary or systemic infections in rare cases.

The pathogenicity and clinical type of human exposure to *Sporothrix* mainly depend on their pathogenic virulence and the host's immune system conditions. Immunocompromised individuals are particularly susceptible to disseminated infections, as *Sporothrix* spp. can spread hematogenously, resulting in severe systemic involvement.^{16,17} Understanding the transmission routes and mechanisms of infection is crucial for implementing effective preventive

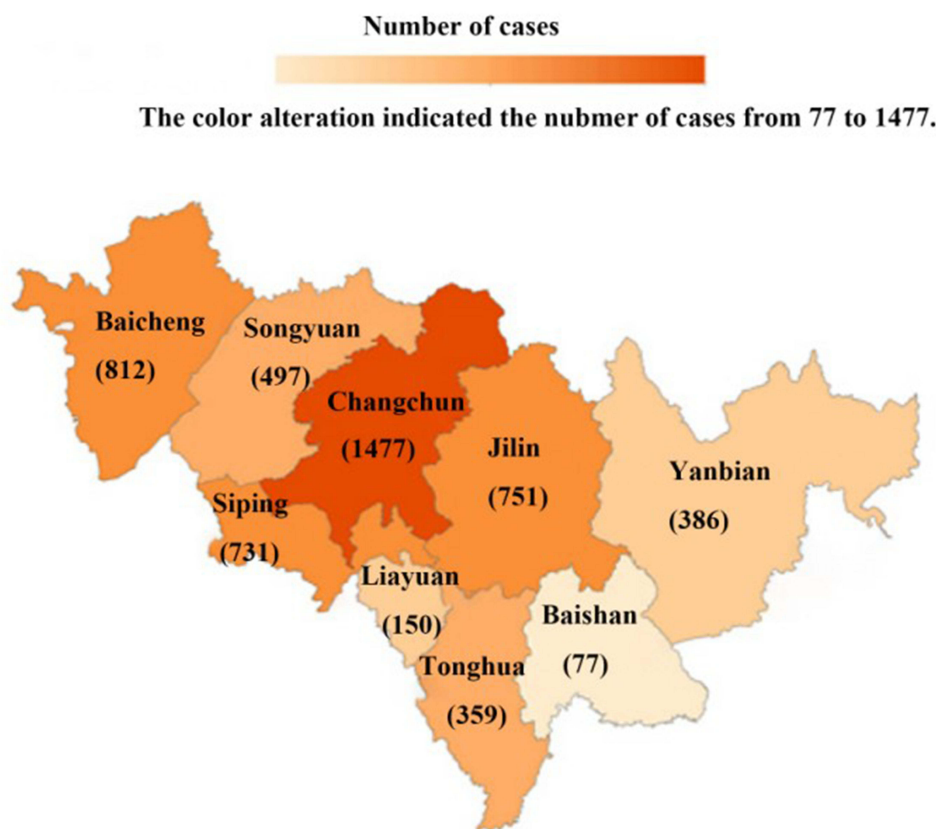


Figure 2 The distribution of sporotrichosis cases in 9 different areas from Jilin Province (2010–2019).

measures and enabling early diagnosis. For high-risk occupational groups, such as farmers, gardeners, and forestry workers, specific protective measures should be enforced.^{6,18} These include wearing puncture-resistant gloves and long-sleeved clothing to minimize skin exposure during outdoor activities. Additionally, protective footwear should be worn to prevent foot injuries and reduce infection risks. After work, hands and exposed skin areas should be thoroughly washed using antibacterial soap and disinfectants, followed by a meticulous examination for any minor wounds. Any identified wounds should be promptly treated with antiseptic agents and properly bandaged to prevent fungal entry through skin breaches.

Environmental and Host factors

The warm and humid climate, coupled with abundant organic material, provides optimal conditions for the growth and dissemination of *Sporothrix* spp. Significant variations in infection incidence across different regions highlight the influence of local climatic factors, agricultural practices, and socioeconomic status. Agricultural, horticultural, and forestry activities often involve frequent exposure to soil with high concentrations of *Sporothrix* spp. thereby increasing the likelihood of human infection.¹⁹ Natural disasters such as floods and hurricanes can lead to the redistribution of *Sporothrix* spp. in soil and water, expanding its geographic range and consequently elevating infection risks.²⁰ Urbanization and industrialization also play significant roles in influencing *Sporothrix* spp. infections. As urban areas expand, individuals may encounter contaminated soil and plant materials more frequently, particularly in newly developed suburban regions or integrated urban-rural zones. Industrial emissions may alter the chemical composition of the soil, affecting the survival and reproduction of *Sporothrix* spp.²¹

Occupational exposure also plays a critical role; farmers, gardeners, forestry workers, and construction workers, who frequently interact with soil and plant materials, are at elevated risk of exposure to *Sporothrix* spp. spores.²² Similarly, individuals engaging in outdoor activities, such as mountain climbers and gardening enthusiasts, face increased infection risks if appropriate protective measures are not taken.²³ Gender and age also play roles in infection epidemiology, with adult males showing a relatively higher infection rate due to their frequent engagement in outdoor work and related professions.²⁴ Knowledge of the regional and population-specific distribution characteristics of sporotrichosis enables public health authorities to develop targeted prevention and control strategies, which is critical for effective health education and enhancing protective awareness among high-risk populations.

Effective environmental management and pollution control are crucial for preventing *Sporothrix* spp. infections. Enhancing sanitation practices and enforcing standardized agricultural and horticultural protocols can significantly reduce the spread of *Sporothrix* spp.²⁵ Public health departments should intensify surveillance in high-risk areas and populations to ensure timely detection and control of infections, thereby preventing epidemic outbreaks. Additionally, public education campaigns aimed at improving protective awareness, especially during high-risk activities (eg, wearing gloves and protective clothing), can effectively mitigate infection rates.²⁶

Host susceptibility to *Sporothrix* spp. infection is influenced by various factors, including immune status, nutritional condition, occupation, lifestyle, and genetic predisposition.²⁷ Immunocompromised populations, including HIV-infected individuals, those undergoing immunosuppressive therapy, suffering from diabetes, and the elderly, are more prone to infection.²⁵ Once infected, these individuals are at higher risk of developing severe disease and disseminated infections affecting multiple organ systems. Poor nutritional status can further weaken the body's immune defenses, rendering individuals more susceptible to *Sporothrix* spp. infections. Personal hygiene and wound care are essential preventive strategies.²⁸ Prompt cleaning and treatment of skin wounds, along with avoiding contact with contaminated soil and plant materials, can effectively reduce infection chances. Genetic factors may also contribute to individual susceptibility to *Sporothrix* spp. infections, though further research is needed to fully elucidate their role. Understanding the influence of host factors on *Sporothrix* spp. infections can aid in the development of personalized prevention and treatment strategies. For high-risk groups, regular health check-ups to detect and manage potential immune dysfunction are vital preventive measures. Furthermore, targeted educational programs for high-risk occupational groups can enhance self-protection awareness and effectively reduce infection risks associated with occupational exposure.²⁹

Diagnosis and Treatment of *Sporothrix* Spp. Infection

Microbiological diagnosis is a critical step in the identification of *Sporothrix* spp. infections. Common diagnostic methods include culture and microscopy.²⁹ Diseased tissue or secretions can be cultured on media such as potato dextrose agar or brain heart infusion agar, followed by incubation at 25°C and 37°C to observe the characteristic colony morphology and microscopic features of *Sporothrix* spp. Due to the slow growth of *Sporothrix* spp. cultures typically require 2–4 weeks to yield results (Figure 3). Histopathological diagnosis involves examining pathological lesions for inflammatory reactions and fungal structures within tissues. Typical histopathological features include granulomatous inflammation, giant cells, and the presence of fungal spores.³⁰ Molecular diagnostic techniques, such as PCR (polymerase chain reaction) and qPCR (quantitative polymerase chain reaction), enable rapid and sensitive detection and quantification of *Sporothrix* spp. DNA. These techniques not only enhance diagnostic accuracy but also facilitate treatment evaluation and recurrence monitoring. Recent advancements in gene sequencing technologies, such as next-generation sequencing (NGS), provide new tools for genomic research and clinical diagnosis of *Sporothrix* spp.³¹ In recent years, the MALDI-ToF MS as one of the diagnostic methods also was applied in rapid diagnosis of *Sporothrix* spp. infections and showed new therapeutic perspectives. The databases for MALDI-ToF MS have been constructed and expanded to identify yeast and filamentous fungi. The method was standardized to speciate *Sporothrix* isolates growing in vitro during the yeast phase, which allows the recognition of *S. brasiliensis*, *S. schenckii*, *S. globosa*, *S. luriei*, and members of the *Sporothrix* spp. complex. Furthermore, the speciation results by MALDI-ToF or DNA sequencing methods are consistent.^{32,33} The integrated use of these diagnostic methods improves early detection rates and diagnostic accuracy, thereby supporting timely and effective treatment.

The current treatment options for sporotrichosis include systemic antifungal agent therapy, surgical intervention, adjuvant therapies and combination therapy. The systemic antifungal agent therapy strategies for *Sporothrix* spp. infections include potassium iodide, amphotericin B, itraconazole, voriconazole. The clinical selection of antifungal agents must be relied on the antifungal susceptibility testing. Potassium iodide, a traditional oral medication, is administered multiple times daily over a course of three to six months. Although effective, its significant side effects, such as gastrointestinal discomfort and thyroid dysfunction, have led to its gradual replacement by other drugs.³⁴ Amphotericin B, a broad-spectrum antifungal agent delivered intravenously, is primarily used for severe disseminated infections. Despite its efficacy, its nephrotoxicity necessitates close monitoring during administration. Itraconazole and voriconazole, widely used oral antifungal agents in recent years, offer good efficacy with minimal side effects, making them preferred treatments for *Sporothrix* spp. infections.³⁵ Surgical treatment is suitable for cases with localized lesions or inadequate responses to medication, involving the removal of diseased tissue to reduce fungal load and alleviate local symptoms. For lymphocutaneous *Sporothrix* spp. infections, combining surgery with antifungal drugs often yields better

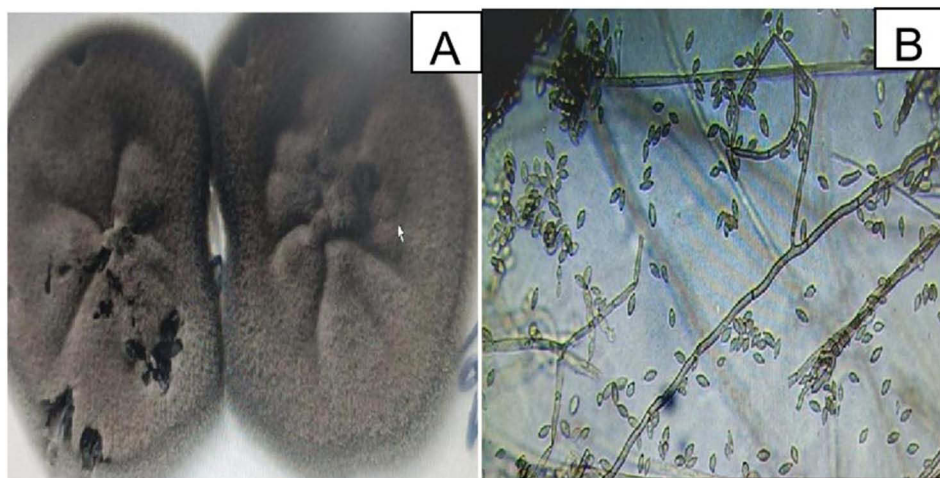


Figure 3 Morphology of colony on the culture media and filamentous under microscopy of *Sporothrix* pp. (A) Colony morphology of isolated *Sporothrix* pp. grown on potato dextrose agar at 25°C following incubation for 2 weeks. (B) The isolated strain was identified using microscopy with lactophenol cotton blue staining.

outcomes. Adjuvant therapies, including symptomatic treatment and immune enhancement, involve the use of anti-inflammatory drugs to relieve local inflammation, nutritional support to improve physical condition, and other supportive measures.³⁶ The progress in the treatment of sporotrichosis mainly includes traditional Chinese medicine (TCM) therapy, non-pharmacological therapy, antimicrobial peptides, vaccines and nanodrugs for potential drug targets on *Sporothrix* spp. based on the bioinformatics analysis.³⁷ TCM may provide potential benefits as adjuvant therapy while treating *Sporothrix* spp. infections. Chinese experts reported that 10 herbal monomers had the best antifungal activity compared with the conventional and well-established antifungal drugs.³⁸ Nanodrugs or nanoformulations-based liposomes, niosomes, nanosponges and solid lipid nanoparticles have been explored for anti-sporotrichosis therapy with highly enhanced activity and reduced toxicity. Seventeen new molecules or repositionable drugs were published in the Cortellis Drug Discovery Intelligence database in the last ten years, highlighting the nanoformulations as a promising and potential alternative targets on *Sporothrix* spp. based on great in vitro and in vivo activities. Future direction involves the construction of novel nanotherapeutic devices and nanorobotics.³⁹ Treatment efficacy is evaluated based on improvements in clinical symptoms, reductions in pathological changes, and laboratory test results. After standard treatment, most patients experience effective disease control, symptom resolution, and low recurrence rates. However, immunocompromised patients may exhibit poorer treatment outcomes, with higher risks of recurrence or disseminated infection, requiring stricter treatment regimens and follow-up. The integrated application of various treatments and personalized treatment plans are key to improving therapeutic outcomes for *Sporothrix* spp. infections.

Prevention and Control of *Sporothrix* Spp. Infections

Personal protection is fundamental to preventing *Sporothrix* spp. infections, particularly among high-risk occupations such as farmers, gardeners, forestry workers, and construction workers. Appropriate protective equipment, including gloves, long-sleeved clothing, and footwear, should be worn during work to minimize skin exposure to potentially contaminated soil and plant materials.^{34,40} Regular inspection and prompt treatment of minor wounds are essential to prevent fungal entry through these sites. Outdoor enthusiasts engaging in activities such as gardening or mountain climbing should adopt similar protective measures to avoid direct contact with soil and plants in high-risk environments.^{4,35} Environmental management plays a crucial role in *Sporothrix* spp. infection prevention. Public health departments should strengthen monitoring of organic materials in soil and plants, especially in tropical and subtropical regions, to detect and control pollution sources promptly. In areas with frequent agricultural and horticultural activities, strict health management measures, such as regular disinfection, weed removal, and disposal of decaying plants, should be implemented to reduce fungal breeding and spread.^{36,41} Additionally, governments and relevant institutions should promote urban greening and ecological improvements to mitigate environmental damage caused by natural disasters and reduce fungal infection risks. Public health education is a key component of *Sporothrix* spp. infection prevention. Through publicity and educational campaigns, public awareness of *Sporothrix* spp. infections can be enhanced, strengthening personal protection and self-care abilities.³⁸ Schools, communities, and workplaces should conduct targeted training sessions and lectures to disseminate protective knowledge and skills, particularly among high-risk populations. Medical institutions should also enhance frontline staff training to improve recognition and management of *Sporothrix* spp. infections, ensuring early detection and timely treatment. Comprehensive treatment strategies, including antifungal therapy, surgery, and adjuvant therapies, are essential for managing severe cases, especially in immunocompromised patients.⁴² Medical institutions should strengthen patient follow-up to detect and address recurrent cases promptly. Transmission control is a critical step in *Sporothrix* spp. infection control strategies. Public health departments should establish robust surveillance and reporting systems to collect and analyze infection data, monitor epidemic trends, and implement emergency measures in high-incidence areas, such as large-scale environmental disinfection and enhanced public place health management.⁴⁰ Health monitoring of high-risk occupations and populations, along with regular physical examinations and health education, should be conducted to improve protection awareness and capabilities. Long-term surveillance and research are integral to controlling *Sporothrix* spp. infections. Governments and scientific research institutions should increase investment in *Sporothrix* spp. infection research, focusing on transmission mechanisms, environmental adaptability, and pathogenic factors, while developing new diagnostic techniques and treatment methods.⁴ A long-term surveillance network should be established to continuously monitor the distribution

and changes of *Sporothrix* spp. in the environment, enabling timely detection and warning of potential epidemic risks. Through the comprehensive application of case management, transmission control, and long-term surveillance, the spread of *Sporothrix* spp. infections can be effectively contained, reducing their threat to public health.^{43,44} However, it was worth noting that there were some limitations in our study. As this study mainly focuses on the the research progress of transmission routes, geographical and population distributions, as well as the impact of environmental factors. The most important limitation is that it is a narrative review, and it did not systematically cover all factors concerning cutaneous sporotrichosis and *Sporothrix* spp. infections.

Conclusion

This paper comprehensively summarizes the research progress of cutaneous sporotrichosis and *Sporothrix* spp. infections. The overview of recent progress of etiology, epidemiology, clinical manifestations, diagnostic approaches, and treatment strategies on sporotrichosis was updated. This study provides a scientific basis for clinical practice and serves as a reference for public health departments to develop prevention and control strategies, contributing to improved public health and reduced societal harm from *Sporothrix* spp. infections. The ongoing research efforts of novel diagnostic technologies, development of nanodrugs or nanoformulations treatment are welcome to promote knowledge about this sporotrichosis and its agents in the future.

Data Sharing Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics Approval

The study was approved by the Ethics Committee of our hospital (formal ethical approval number: Protocol Number 2023-23) and all patients or their guardians signed an informed consent form, and they agreed to publish accompanying images.

Consent to Participate

All authors have consented to publication.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests in this work.

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