

Article

Subungual Exostoses as an Infrequent Cause of Pain and Nail Plate Deformities of the First Toe: A Retrospective Cohort Study

Carmen Valverde-Gestoso ^{1,*}, Rafael Llombart-Blanco ¹, Javier Antoñanzas-Pérez ², Nerea Mateo-Guarch ¹
and Matías Alfonso Olmos-García ¹

¹ Department of Orthopedic Surgery, Clínica Universidad de Navarra, Avenida Pio XII 36, 31008 Pamplona, Spain; rllombartb@unav.es (R.L.-B.); nmateoguar@unav.es (N.M.-G.); malfonsool@unav.es (M.A.O.-G.)

² Department of Dermatology, Clínica Universidad de Navarra, 31008 Pamplona, Spain; jantonanzas@unav.es

* Correspondence: cvalges@gmail.com

Abstract

Background: Toenail deformities are a frequent reason for medical consultation. The etiology is not always well understood, particularly in cases without trauma, where abnormal nail growth conditions have been excluded, and microbiological cultures yield negative results. Thus, identifying the underlying cause of toenail anomalies can be challenging. Patients often do empirical treatments—i.e., antifungals—for extended periods without achieving remission. Subungual exostoses, on the other hand, are an important consideration in the differential diagnosis of subungual pain, particularly in the first toe. Although exostoses have been well documented in the literature, studies specifically examining their role in nail deformity and discomfort are lacking. **Methods:** A retrospective analysis was conducted on 173 feet of patients with weightbearing lateral radiographs. These radiographs were classified into two groups based on the presence or absence of subungual exostoses, and we collected patient history data focusing on the presence or absence of pain localized beneath the nail and associated nail abnormalities. **Results:** Subungual exostoses were observed in 52% of the sample, whereas nail disorders were identified in 18.5%. Notably, among patients with nail disorders, 78% (25 patients) also presented with subungual exostoses. Subungual pain was reported in 25 patients (14.5%), of whom 76% had subungual exostoses. Conversely, the prevalence of subungual exostoses was lower in patients without nail abnormalities (46%) or subungual pain (48%). Statistically significant associations were found between nail abnormalities and the presence of exostoses and subungual pain and exostoses, as well as pain and nail deformities ($p < 0.05$). **Conclusions:** Both pain and nail abnormalities may be considered to have a high positive predictive value for the presence of subungual exostoses.



Academic Editor: Warren S. Joseph

Received: 22 November 2024

Revised: 25 February 2025

Accepted: 25 March 2025

Published: 28 September 2026

Copyright: © 2026 by the authors.

Published by MDPI on behalf of the

American Podiatric Medical

Association. Licensee MDPI, Basel,

Switzerland. This article is an open

access article distributed under the

terms and conditions of the [Creative](#)

[Commons Attribution \(CC BY\)](#) license.

Keywords: exostoses; subungual pain; nail deformities

1. Introduction

During embryogenesis, the distal phalanx and the hallux nail develop in a coordinated manner, enabling the nail to adopt a configuration that protects the underlying phalanx. The nail matrix, which is responsible for producing the nail plate, is anchored to the dorsal surface of the distal phalanx. This anatomical arrangement is crucial, as the structure of the distal phalanx directly influences the shape and growth of the nail plate [1].

The prevalence of subungual exostoses remains largely unknown and may vary depending on geographic region and age group. It is estimated to affect approximately 1%

of the population, with 80% of cases occurring in the first ray of the foot. The condition is most commonly observed in individuals during the second and third decades of life, often associated with factors such as tight footwear or physical activity. Some studies suggest that subungual exostosis accounts for approximately 30% of all surgical procedures involving the nail apparatus.

Subungual exostoses were first described by Dupuytren in 1847 [2,3]. It is an isolated bony prominence that predominantly occurs on the distal phalanx of the big toe, with a range of clinical and radiological manifestations [4]. This outgrowth of normal bone tissue, occasionally covered by a thin cartilaginous cap, can cause a volume increase beneath the nail, leading to potential conflicts [5]. The pathogenesis of subungual exostoses remains a topic of debate, with chronic infections, trauma, tumors, and hereditary abnormalities contributing to uncertainty regarding its reactive versus benign neoplastic etiology [6,7].

Regarding trauma as a potential pathogenic factor, various theories have been proposed. Some authors, such as De Palma et al. [8], could not establish a causal relationship between microtrauma and the development of exostoses, despite most of their cases involving athletes. Conversely, Multhopp-Stephens [3] and Wu [9] et al. suggested that these exostoses often arise after trauma and are particularly common in young individuals.

Although pain is one of the main symptoms leading patients to seek medical attention, it remains unclear whether dorsal exostosis is merely an incidental finding on simple radiographs or is directly associated with subungual symptoms due to exostosis being able to exert pressure on surrounding soft tissues, potentially causing chronic inflammation [10,11].

To address this controversy, García et al. [12] proposed a clinical classification of subungual exostoses. However, despite their clinical significance, evidence regarding their management remains limited. Furthermore, no definitive causal relationship has been established between subungual exostoses and nail deformities or the painful symptoms experienced by some patients.

Differentiating subungual exostoses from conditions such as osteochondroma, enchondroma, onychopapilloma, and glomus tumor involves a combination of clinical evaluation, imaging studies, and histopathological examination. As previously mentioned, subungual exostosis is a benign bony outgrowth originating from the distal phalanx beneath the nail, often associated with pain and nail deformities.

In contrast, osteochondromas are also benign bone tumors that consist of both bone and cartilage. However, osteochondromas are often asymptomatic unless they cause pain by impinging on adjacent structures. A key distinguishing feature is the cartilaginous cap that covers the bony growth, visible on X-ray. This feature differentiates osteochondromas from subungual exostosis, which is exclusively osseous. Additionally, osteochondromas typically affect the long bones, particularly around the knee or shoulder, rather than the distal phalanx.

Enchondromas, on the other hand, are benign cartilage tumors usually located within the bone, often in the phalanges. Unlike subungual exostoses, enchondromas do not typically project outward beneath the nail. Enchondromas may also have a central cartilage component, which can be identified on MRI or CT scans, further distinguishing them from the purely bony nature of subungual exostoses.

Finally, soft-tissue tumors such as onychopapillomas and glomus tumors do not present the bony growth characteristic of subungual exostoses. Onychopapillomas are often associated with superficial, epithelial growths beneath the nail, whereas glomus tumors are vascular in nature and typically present with tenderness, particularly in response to cold exposure. Both of these soft-tissue tumors lack the ossified component seen in subungual exostoses.

Although subungual exostoses may be an incidental finding when performing weight-bearing X-rays of the feet for other indications, their presence becomes particularly significant in cases where they are associated with pain or nail abnormalities, as their treatment is crucial for pain disappearance and nail abnormalities correction.

This article aims to explore the connection between subungual exostoses, pain, and nail abnormalities, and emphasizes the importance of precise diagnosis and appropriate therapeutic approaches to improve clinical outcomes for affected patients.

2. Material and Methods

We designed a retrospective cohort study including 173 feet from patients who were admitted at our outpatient clinic, Clinica Universidad de Navarra, Pamplona (Spain), a tertiary hospital between May 2014 and June 2024. This study was approved by the Research Ethics Committee of the hospital (Approval No. 2020.106 Thesis).

Medical records provided detailed information on the presence or absence of nail abnormalities (defined as changes in the color, thickness, or integrity of the nail plate) or pain (defined as an unpleasant sensation in the nail, whether at rest or under pressure), and all patients enrolled had weight-bearing foot radiographs available for evaluation.

Exclusion criteria included any history of foot fractures, previous foot surgeries, or highly advanced hallux valgus where toe rotation could obscure the presence of exostoses on lateral radiographs. Demographic variables such as age, sex, and laterality (right or left foot) of the radiographed foot were collected (Table 1).

Table 1. Demographic data.

Sex	Women	98 (56.6%)
	Men	75 (43.4%)
Age	Arithmetic average	49.8 years old
	Range	[4–83]
Laterality	Right	93 (53.8%)
	Left	80 (46.2%)

On lateral X-rays, we assessed the presence or absence of subungual exostoses of the first toe as described in the literature [13] (Figure 1).

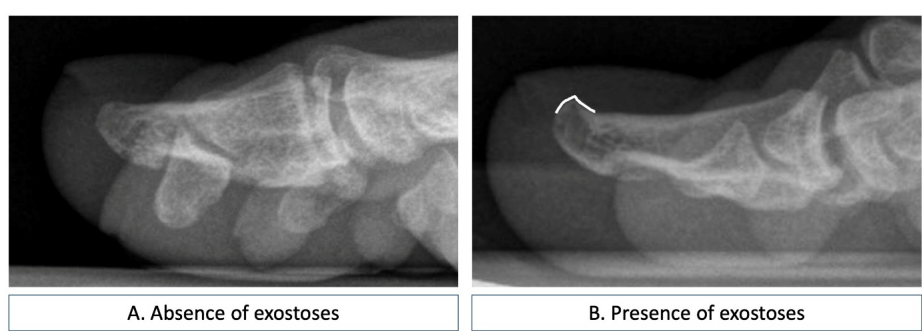


Figure 1. Lateral weight-bearing radiographs. (A): Absence of exostoses. (B): Presence of exostoses.

Statistical analyses were conducted using Stata version 14 (StataCorp LP, 2015; Stata Statistical Software: Release 14, College Station, TX, USA). All statistical tests were two-sided, and *p* values less than 0.05 were considered statistically significant. Data normality was tested using the Kolmogorov–Smirnov and Shapiro–Wilk tests.

This is a retrospective series, which may introduce biases or result in missing data. Additionally, this study’s temporal design prevents the estimation of factors such as whether

the duration of exostoses is associated with increased symptom intensity over time. While weight-bearing X-rays of the feet with both frontal and lateral projections were performed for all patients, other imaging techniques—such as CT or MRI, which have been recommended by other authors for more challenging cases—were not utilized. Finally, although this is a relatively large series, a larger sample size could help to further validate and strengthen the findings of this study.

3. Results

The study sample included 173 feet from patients with a mean age of 49.8 years (SD $\pm$ 15). Among the entire cohort, 56.6% of the feet belonged to women, and 53.8% were right feet (Table 1).

Subungual exostoses were observed in 52% of the total sample. Of the entire series, 32 patients (18.5%) exhibited nail abnormalities in the first toe, while 141 patients (81.5%) had nails with no detectable changes.

Regarding subungual pain, 14.5% (25 patients) reported or exhibited it during physical examination. Notably, not all patients with nail abnormalities experienced pain. The relationship between the presence or absence of subungual exostoses and nail abnormalities is presented in Table 2.

Table 2. Number of feet with and without nail abnormalities based on the presence or absence of subungual exostoses.

	Nail Disorders	Normal Nails	Total
Presence of subungual exostoses	25	65	90
Absence of subungual exostoses	7	76	83
Total	32	141	173

Among patients with nail abnormalities—including pincer nail, subungual hyperkeratosis, and distal onycholysis (Figure 2)—78.1% had subungual exostoses. In contrast, 91.6% of patients without exostoses had normal nails. The distribution of subungual pain based on the presence or absence of subungual exostoses is shown in Table 3.

Table 3. Number of patients with and without subungual pain based on the presence or absence of subungual exostoses.

	Subungual Pain	No Pain	Total
Presence of subungual exostoses	19	71	90
Absence of subungual exostoses	6	77	83
Total	25	148	173

Regarding patients with subungual pain, 76% had subungual exostoses. Conversely, 92.8% of patients without exostoses had nails without abnormalities. The distribution of subungual exostoses was similar among patients lacking nail abnormalities or pain, with 46% in the group without nail abnormalities and 48% in the group without subungual pain.

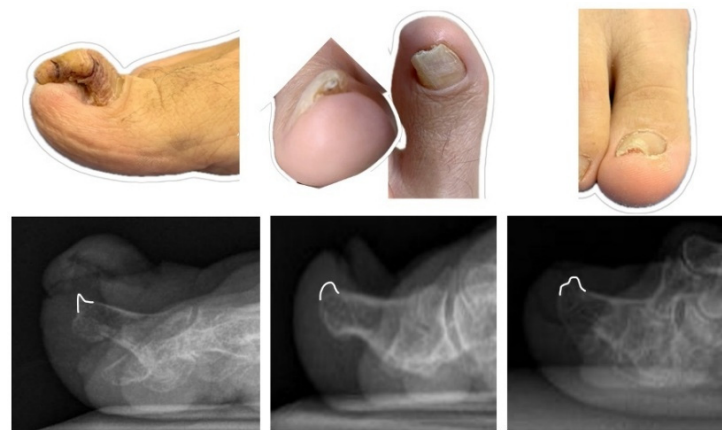
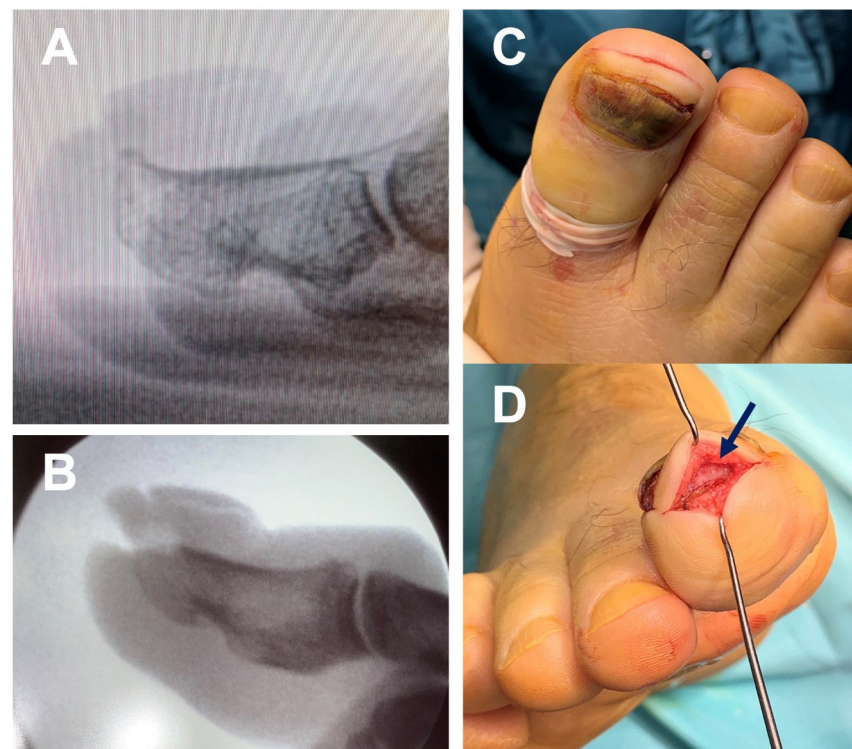
Finally, all patients with subungual pain ($n = 25$) exhibited nail abnormalities, while 95.3% (141 patients) without pain had normal nails (Table 4).

There was a statistically significant association between having nail abnormalities and the presence of dorsal exostoses ($p < 0.05$), between experiencing subungual pain and the presence of dorsal exostoses ($p < 0.05$), and between having pain and nail dystrophy ($p < 0.05$).

Table 4. Number of patients with and without subungual pain based on the presence or absence of nail abnormalities.

	Nail Disorders	Normal Nail	Total
Presence of subungual pain	25	0	25
Absence of subungual pain	7	141	148
Total	32	141	173

Nine patients who underwent open surgical resection [14–16] of the exostoses (Figure 3) experienced progressive resolution of symptoms without associated complications. Pain subsided almost immediately, although nail abnormalities persisted for nearly a year (time required for full nail regeneration), improving its final appearance. No recurrences were observed during the 2-year follow-up period.

**Figure 2.** Examples of three patients with nail abnormalities, showing subungual exostoses on lateral radiographs.**Figure 3.** Example of a surgically treated patient. (A): Preoperative X-ray showing exostoses. (B): Intraoperative X-ray showing exostosis resection. (C): Nail with onychogryphosis and incision under the nail. (D): Approach and the exostoses (arrow).

4. Discussion

Subungual exostoses is a relatively uncommon osseocartilaginous tumor that primarily affects the distal phalanx of the first toe, with its exact pathogenesis remaining unclear [1]. The most common presentation involves a tender, small, painful nodule that typically projects beyond the free edge of the nail. However, these lesions are not always visible and sometimes can only be identified through imaging. Therefore, their presence should be always considered and ruled out in patients presenting with a pathology involving the first toe, even in those with no evident deformities. Moreover, uncommon presentations of subungual exostoses, such as pincer nail dystrophy and onycholysis, may also occur, as observed in this series [17].

Pincer nail is a form of dystrophy characterized by thickening of the nail plate, a reduction in nail width, and an increase in height. This condition is both aesthetically and clinically significant, as the altered nail plate exerts pressure on the surrounding soft tissues, leading to severe pain, increased risk of infections, discomfort, and potential changes in nail color. Mechanical forces play a key role in influencing nail configuration and its progression [18]. Therefore, the presence of subungual exostoses may further exacerbate these forces.

On the other hand, distal onycholysis is characterized by the separation of the nail plate from the underlying nail bed. In toenails, it is often of traumatic origin, typically caused by mechanical stress [19]. As observed in this study, distal onycholysis may also result from damage to the nail plate associated with subungual exostoses [20].

Our findings demonstrate a statistically significant association between the presence of nail abnormalities and subungual exostoses. Furthermore, given the role of compressive forces exerted by the exostoses on the nail matrix in the pathophysiology of nail plate alterations, it is unsurprising that significant relationships were also observed between the presence of exostoses and subungual pain, as well as between pain and nail abnormalities. Nevertheless, the novelty of this study lies in the issue that while subungual exostoses are clearly pathological in this context, they may also represent incidental findings, as they were observed in nearly half of the patients without pain or nail abnormalities. Therefore, although they are not always pathological, this condition should be suspected in patients presenting with nail deformity or subungual pain in the first toe. In addition, in cases where its presence is confirmed, it is likely to have a causal role, and symptoms may resolve following surgical treatment, as described in the patients treated in the context of this study. Conversely, in cases where exostoses are an incidental findings, no treatment is required.

Measurement, precise localization of the tumor and evaluation of its relationship with surrounding structures are essential for guiding subsequent surgical intervention. While weight-bearing radiographs with lateral projections are generally sufficient for diagnosis, ultrasound and, particularly, magnetic resonance imaging (MRI) offer advanced tools for assessing the pathology of the nail apparatus. Regarding treatment, a conservative approach may be appropriate in asymptomatic cases; however, surgery remains the definitive solution when the exostosis is associated with symptoms such as pain or changes in the nail plate. For small subungual exostoses without involvement of the nail bed, a simple excision with direct closure is a viable surgical technique, as it minimizes damage to the nail bed. In contrast, when the tumor leads to destruction of the nail bed, resulting in a significant defect post-excision, reconstructive procedures such as a bed flap or a partial or full-thickness skin graft are necessary to promote healing, prevent postoperative infections, and mitigate the risk of nail deformities.

Surgical treatment is considered the definitive solution for subungual exostoses, with the indication for surgery being primarily based on the presence of symptoms, such as pain. In some asymptomatic cases, however, alteration in the nail plate alone may warrant

consideration for surgical intervention. Incidental exostoses that do not result in anatomical or functional repercussions generally do not require treatment. For smaller exostoses where surgical intervention is not indicated, alternative management strategies such as pain control with analgesics or infiltrations, along with correction of nail plate pathology through the use of antifungal treatments, urea solutions, or salicylic acid, as appropriate, may be considered.

5. Conclusions

Subungual exostoses may be considered in patients showing pain and/or nail abnormalities, especially after ruling out other potential causes. Diagnosis is straightforward and can be easily confirmed with a lateral X-ray of the affected toe.

If exostosis is confirmed, surgical excision is the only effective treatment.

In conclusion, both pain and nail abnormalities may be considered to have a high positive predictive value for the presence of subungual exostoses.

Author Contributions: Conceptualization, M.A.O.-G. and R.L.-B.; methodology, C.V.-G.; software, C.V.-G. and J.A.-P.; validation, C.V.-G., J.A.-P., R.L.-B., N.M.-G. and M.A.O.-G.; formal analysis, J.A.-P. and C.V.-G.; investigation, N.M.-G. and C.V.-G.; resources, N.M.-G.; data curation, C.V.-G.; writing—original draft preparation, J.A.-P.; writing—review and editing, C.V.-G.; visualization, J.A.-P.; supervision, M.A.O.-G. and R.L.-B.; project administration, C.V.-G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Universidad de Navarra (protocol code 2020.106 Thesis, and date of approval 28 September 2021).

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study. Consent for the publication of recognizable patient photographs or other identifiable material was obtained by the authors and this information may be publicly available.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Acknowledgments: The authors sincerely thank the patients whose participation made this study possible.

Conflicts of Interest: All authors involved in this manuscript declare no conflicts of interest including financial interests, activities, relationships and relevant affiliations.

References

1. de Berker, D. Nail anatomy. *Clin. Dermatol.* **2013**, *31*, 509–515. [[CrossRef](#)] [[PubMed](#)]
2. Miller-Breslow, A.; Dorfman, H.D. Dupuytren's (Subungual) Exostosis. *Am. J. Surg. Pathol.* **1988**, *12*, 368–378. [[CrossRef](#)] [[PubMed](#)]
3. Multhopp-Stephens, H.; Walling, A.K. Subungual (Dupuytren's) Exostosis. *J. Pediatr. Orthop.* **1995**, *15*, 582–584. [[CrossRef](#)] [[PubMed](#)]
4. Grisafi, P.J.; Lombardi, C.M.; Sciarrino, A.L.; Rainer, G.F.; Buffone, W.F. Three select subungual pathologies: Subungual exostosis, subungual osteochondroma, and subungual hematoma. *Clin. Podiatr. Med. Surg.* **1989**, *6*, 355–364. [[CrossRef](#)]
5. Chiheb, S.; Slimani, Y.; Karam, R.; Marnissi, F.; Hali, F. Subungual Exostosis: A Case Series of 48 Patients. *Ski. Appendage Disord.* **2021**, *7*, 475–479. [[CrossRef](#)] [[PubMed](#)]
6. DaCamra, M.P.; Gupta, S.K.; Ferri-De-Barros, F. Subungual exostosis of the toes: A systematic review. *Clin. Orthop. Relat. Res.* **2014**, *472*, 1251–1259. [[CrossRef](#)] [[PubMed](#)]
7. Lee, S.K.; Jung, M.S.; Lee, Y.H.; Gong, H.S.; Kim, J.K.; Baek, G.H. Two distinctive subungual pathologies: Subungual exostosis and subungual osteochondroma. *Foot Ankle Int.* **2007**, *28*, 595–601. [[CrossRef](#)] [[PubMed](#)]
8. de Palma, L.; Gigante, A.; Specchia, N. Subungual Exostosis of the Foot. *Foot Ankle Int.* **1996**, *17*, 758–763. [[CrossRef](#)] [[PubMed](#)]
9. Wu, K.K. Subungual exostosis. *J. Foot Ankle Surg.* **1995**, *34*, 96–98. [[CrossRef](#)] [[PubMed](#)]

10. Dika, E.; Lambertini, M.; Misciali, C.; Fanti, P.A.; Contedini, F.; Pinto, V.; Pignatti, M.; Cipriani, F.; Corti, B.; Piraccini, B.M. Nail-plate dystrophy of the fifth toenail: Thinking outside the box. *Clin. Exp. Dermatol.* **2021**, *46*, 584–587. [[CrossRef](#)] [[PubMed](#)]
11. Caprioli, R.; Bilotti, M.A. Surgical nail procedures. *Clin. Podiatr. Med. Surg.* **1989**, *6*, 431–451. [[CrossRef](#)]
12. Carmona, F.J.G.; Huerta, J.P.; Morato, D.F. A proposed subungual exostosis clinical classification and treatment plan. *J. Am. Podiatr. Med. Assoc.* **2009**, *99*, 519–524. [[CrossRef](#)] [[PubMed](#)]
13. Christman, R.A. Radiographic anatomy of the foot and ankle—Part 5: The phalanges. *J. Am. Podiatr. Med. Assoc.* **2015**, *105*, 141–149. [[CrossRef](#)] [[PubMed](#)]
14. Clark, R.E.; Madani, S.; Bettencourt, M.S. Nail surgery. *Dermatol. Clin.* **1998**, *16*, 145–164. [[CrossRef](#)] [[PubMed](#)]
15. Haneke, E. Nail surgery. *Clin. Dermatol.* **2013**, *31*, 516–525. [[CrossRef](#)] [[PubMed](#)]
16. Tritto, M.; Mirkin, G.; Hao, X. Subungual Exostosis on the Right Hallux. *An Illustrative Case Report. J. Am. Podiatr. Med. Assoc.* **2021**, *111*, 20209.
17. Sehgal, V.N.; Chatterjee, K.; Malhotra, S. Twenty-Nail Dystrophy: Revisited. *Skinmed* **2018**, *16*, 119. [[PubMed](#)]
18. Noh, S.H.; Na, G.H.; Kim, E.J.; Park, K. Significance of Surgery to Correct Anatomical Alterations in Pincer Nails. *Ann. Dermatol.* **2019**, *31*, 59–65. [[CrossRef](#)] [[PubMed](#)]
19. Lee, D.K.; Lipner, S.R. Optimal diagnosis and management of common nail disorders. *Ann. Med.* **2022**, *54*, 694–712. [[CrossRef](#)] [[PubMed](#)]
20. Ahn, G.R.; Hong, J.Y.; Li, K.; Park, K.Y. Protruding Hyperkeratotic Tumor Underneath the Big Toe Nail: Answer. *Am. J. Dermatopathol.* **2019**, *41*, 611. [[CrossRef](#)] [[PubMed](#)]

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.