Objective: To assess the extent to which UV-A and UV-B radiation can penetrate the human fingernail plate.

Design: The Dermalite UV light machine (National Biological, Beachwood, Ohio) was used as the source of UV radiation. The amount of UV-A and UV-B penetrating the nail plate was measured using a radiometer and compared with a control.

Setting: Academic phototherapy clinic.

Patients: Ten cadaver fingernails were obtained from 1 cadaver from the National Disease Research Interchange. Because the objective was to determine transmission through normal fingernails, grossly diseased or deformed nails were not used.

Main Outcome Measures: The percentage of UV light penetration through each fingernail was calculated by dividing the amount of radiation measured when the fingernail was in front of the light by the amount of radiation measured when there was nothing in front of the light (UV with nail divided by UV without nail).

Results: All 10 fingernails completely blocked the UV-B light, reading 0 mW/cm² on the radiometer. The mean penetration of UV-A light through the fingernails was 1.65%, ranging from 0.56% for the right fifth digit to 2.43% for the left second digit.

Conclusions: The nail plate completely blocked UV-B light, and only a minimal amount of UV-A light penetrated the nails. If UV is required to directly penetrate the nail to treat nail bed psoriasis, then these data suggest that therapeutic efficacy may be compromised by the intervening nail plate. This minimal penetration of UV-A light may explain why therapies such as psoralen–UV-A (PUVA) have low efficacy for the treatment of nail psoriasis.

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Psoriasis is a chronic inflammatory skin disease that causes significant morbidity for millions of individuals worldwide, including 6.4 million persons in the United States. Classic skin lesions are erythematous, silvery-white scaly plaques and papules that vary in severity and distribution. The pathogenesis is multifactorial; it is a polygenic, immune-mediated disorder that is often triggered by environmental factors such as infection, trauma, stress, and drugs. Although psoriasis mainly affects the skin and joints, 80% to 90% of patients with psoriasis will have nail psoriasis during their lifetime.

Psoriasis is the most common dermatosis that affects the nail; more than 50% of persons with psoriasis also have nail involvement at any given time. Nail psoriasis is characterized by multiple dystrophies, mainly pitting, oil spots, onycholysis, and subungual hyperkeratosis. Pitting of the nail plate results from psoriatic lesions of the proximal matrix. Psoriatic involvement of the nail bed causes discolorations of the nail, which are referred to as oil spots. Proliferation and deposition of nail bed cells without desquamation produce subungual hyperkeratosis. Subungual debris and nail bed involvement can result in onycholysis.

Nail psoriasis is often challenging to treat. There is a general paucity of clinical research evaluating therapies specifically for nail psoriasis. Treatment options include topical therapies, intralesional injections, systemic therapies, and radiation therapy, including phototherapy. Topical therapies, which include corticosteroids, vitamin D analogues, fluorouracil, anthralin, tazarotene, and calcineurin inhibitors, have limited efficacy because they have poor penetration through the nail plate. Intralesional injections of corticosteroids are painful and tedious; they have adverse effects such as cuticular hemorrhage and require long-term therapy. Systemic treatment with cyclosporine and etretinate has shown some reduction in nail involvement. Etretinate therapy is particularly helpful for pustular forms of nail psoriasis, but its use is limited in females of child-bearing potential owing to its long half-life and teratogenicity.
The use of radiation in the form of superficial phototherapy, Grenz rays, and electron beam therapy has been evaluated in limited studies, with mixed results. Biologic therapy has been investigated in preliminary studies as a promising treatment for nail psoriasis. However, for patients who have nail disease with limited cutaneous involvement, the risks of treatment with biologic agents must be weighed against the potential benefits.

Therapy with UV light is a safe and effective method that is commonly used to treat plaque-type psoriasis. However, UV light therapy has been evaluated for the treatment of nail psoriasis, with disappointing and conflicting results. In 1980, Marx and Scher treated 10 patients with nail psoriasis with oral photochemotherapy. Among the 10 patients, there were 26 cases of nail dystrophies and 18 improved with treatment. Proximal nail-plate and proximal nail-fold disease showed the greatest improvement with psoralen–UV-A (PUVA) therapy. Onycholysis and oil-drop change responded moderately well, and pitted nails failed to respond. The authors measured the amount of UV-A radiation that passes through a single normal fingernail plate to be 15%. Their method of measurement was not explained. Another small study of 5 patients found modest improvement of onycholysis and pitting with the use of psoralen–UV-A.

More recently, Aubin et al evaluated the efficacy of UV-B light delivered via 308-nm monochromatic excimer light for the treatment of a variety of chronic localized dermatoses, including nail psoriasis. In their study, 4 patients with nail psoriasis were treated. None of the patients saw any improvement of their nail involvement.

The use of phototherapy for nail psoriasis raises the question as to whether UV light can penetrate the nail plate to treat lesions in the nail bed. In 1983, Parker and Diffey examined the transmission of optical radiation (300–600 nm) through 13 human cadaver toenails. The study concluded that 22% of UV-A and little UV-B transmitted through the nail plate and reached the nail bed, making the nail plate a "very efficient sunscreen." The authors stated that because of these low transmission rates, nail psoriasis would require a significantly more "tedious" regimen of phototherapy than is required to treat cutaneous psoriasis plaques. Since these results were published, phototherapy has still been used to treat nail psoriasis, with little clinical evidence of success. The objective of this study was to assess the extent to which UV-A and UV-B radiation can penetrate the human fingernail plate.

### METHODS

Ten cadaver fingernails were obtained from 1 cadaver from the National Disease Research Interchange. The study was waived from institutional review board review. The objective was to determine transmission through normal fingernails, so grossly diseased or deformed nails were not used. The nails were removed whole, complete with the nail bed, which was separated by blunt dissection. The nails were cleaned with alcohol at the dorsal surface, and any loose epithelium was removed. The nails were labeled, and their thickness was measured at the center of each respective nail plate using a caliper. Fingernails were used because, to our knowledge, UV transmission has never been studied through fingernails.

The Dermalite UV light machine (National Biological, Beachwood, Ohio) was used as the UV light source. It was set to emit either UV-A or UV-B light. To standardize the light source, 1 of the 15 halide bulbs was chosen as the UV light source for all 10 nails. The bulb used in the experiment was cleaned before initiation of the study to remove any particles that could alter an even transmission of light. All other bulbs were turned off for the duration of the experiment.

A cardboard barrier was used to block the UV light except for a 4-mm pinhole. Before the pinhole was made, a control experiment was performed to confirm that the cardboard barrier without the pinhole was blocking all potential extraneous UV light. The radiometer confirmed that no light was penetrating the cardboard barrier.

Using a radiometer (IL700A Research Radiometer; International Light Inc, Newburyport, Massachusetts), the amount of UV-A light filtering through the hole was measured before the nail was placed against the cardboard barrier. All 10 nails were individually attached to the barrier in front of the 4-mm hole and taped to the cardboard peripherally with duct tape. All cadaver nails were placed at the same distance from the light source, and the UV radiometer was placed at a uniform distance behind the nail plate. The amount of both UV-A and UV-B light penetrating the nail plate was measured using the radiometer. The percentage of UV light penetration through each fingernail was calculated using the following formulas:

\[
\text{% of UV Light Blocked} = \frac{(\text{UV Penetration Without Nail} - \text{UV Penetration With Nail})}{\text{UV Penetration Without Nail}} \times 100
\]

\[
\text{% of UV Light Penetrating} = 100 - \% \text{of UV Light Blocked}
\]

### RESULTS

The mean thickness of the 10 fingernails was 0.230 mm, with a range of 0.025 to 1.000 mm. All 10 fingernails completely blocked the UV-B light, reading 0 mW/cm² on the radiometer. The mean penetration of UV-A light through the fingernails was 1.65%, ranging from 0.56% for the right fifth digit to 2.43% for the left second digit. The individual readings are summarized in the Table.

### COMMENT

Ultraviolet phototherapy is used to treat nail psoriasis, with mixed success, and limited studies have demonstrated contradictory results regarding its efficacy. The results of this experiment showed much lower UV light penetration of the nail plate than previous studies. The nail plate completely blocked UV-B light, and only a minimal amount of UV-A light penetrated the nails. The minimal penetration of UV-A light may explain why therapies such as psoralen–UV-A have low efficacy for the treatment of nail psoriasis. Because psoriatic nails are often grossly deformed or diseased, it is possible that they allow more penetration of UV light through the nail plate.

Our observations in this study confirm Parker and Diffey’s statement that "the nail plate acts as a very efficient sunscreen." The implications of this finding are great for treating nail psoriasis as well as for understanding the pathophysiologic mechanism of subungual melanoma and other lesions of the nail bed. Although UV exposure may be a risk factor for the development of certain cutane-
ous melanomas, it has been unclear whether UV light is able to penetrate the nail plate and therefore contribute to the pathogenesis of nail apparatus melanoma.11,12 Subungual melanoma causes significant morbidity, often requiring patients to undergo amputation of the affected digit. As with cutaneous melanoma, 5-year survival rates are associated with stage of disease but can be as low as 40% in stage II subungual disease, and melanoma of the nail is frequently diagnosed at late stages.13 An evaluation of the pathogenesis of nail melanoma is beyond the scope of this article but is a ripe area for future research.

Our study design was limited by the fact that only 1 cadaver’s fingernails were tested. Future studies should test multiple individuals’ nails to determine if there is any variation in UV light penetration. Also, this experiment looked at grossly normal nail plates.

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Author Contributions: Dr Stern had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Stern and Lebwohl. Acquisition of data: Stern and Quijije. Analysis and interpretation of data: Stern and Creasey. Drafting of the manuscript: Stern, Creasey, and Quijije. Critical revision of the manuscript for important intellectual content: Stern and Lebwohl. Obtained funding: Stern. Administrative, technical, or material support: Stern, Creasey, Quijije, and Lebwohl. Study supervision: Stern.

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Additional Contributions: The National Disease Research Interchange provided the cadaver nails for this study.

Table. Summary of Study Results

<table>
<thead>
<tr>
<th>Nail No.</th>
<th>Nail Thickness, mm</th>
<th>UV-B Penetration, mW/cm² Without Nail</th>
<th>With Nail</th>
<th>UV-A Penetration, mW/cm² Without Nail</th>
<th>With Nail</th>
<th>% UV-A Blockage</th>
<th>% UV-A Penetration</th>
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<tr>
<td>1L</td>
<td>1.000</td>
<td>0.38</td>
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<td>7.80</td>
<td>0.09</td>
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<td>0.36</td>
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<tr>
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<tr>
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<tr>
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<td>0</td>
<td>8.39</td>
<td>0.07</td>
<td>99.17</td>
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<tr>
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<td>0.34</td>
<td>0</td>
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<td>0.07</td>
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<tr>
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<td>99.44</td>
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<tr>
<td>Mean</td>
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<td>0.35</td>
<td>0</td>
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<td>0.11</td>
<td>98.39</td>
<td>1.65</td>
</tr>
</tbody>
</table>

Abbreviations: L, left; R, right.