European Review for Medical and Pharmacological Sciences 2023; 27: 2881-2887

# Evaluation of nail psoriasis with ultrasound enhanced blood flow imaging (eflow) and Power Doppler (PD)

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**Abstract. – OBJECTIVE: The aim of this study was to assess the discriminative utility of nail features detected by B-mode (BM), enhanced flow (eflow) and power Doppler (PD) in patients with psoriasis or nail psoriasis (NP) and healthy controls.**

**PATIENTS AND METHODS: Ultrasound appearance of nails was investigated in 5 patients with NP, 8 patients with psoriasis and 7 healthy controls. In total, 195 nails were examined.**

**RESULTS: The thickness of the nail bed (TNB), the thickness of the nail plate (TNP) and the thickness of the nail matrix (TNM) did not differentiate between NP and psoriasis in longitudinal and cross-section of nails. Resistance index (RI) in nails was higher in patients with NP than in patients with psoriasis, and significantly higher in patients with psoriasis than in healthy controls. TNP between patients with psoriasis and healthy controls was statistically insignificant in longitudinal section of nails, but higher than that in the cross-section of nails. TNM was higher in patients with psoriasis than in healthy controls. The ultrasound features of NP in longitudinal and cross-section of nails, nail bed (NB) eflow and PD signal were statistically significant among patients with NP or psoriasis and healthy controls. In patients with NP, there was a correlation between the ultrasound features of NP in longitudinal and cross-section of nails and nail psoriasis severity index (NAPSI).**

**CONCLUSIONS: Our study displayed the usefulness of ultrasound nail examinations in psoriatic nails, not only assessing ultrasonic features of nails and proving correlation between ultrasonic features of nails and NAPSI, but also comparing the accuracy of new technology of blood flow signal in nails.**

*Key Words:*
Nail ultrasound, Nail psoriasis, Eflow, Power doppler.

## Introduction

Psoriasis is a chronic immune-mediated inflammatory disease affecting up to 2% of the general population[1]. Most psoriasis is found to have cutaneous involvement, and disease progression may lead to nail and joint disease. Nail psoriasis (NP) has been demonstrated as a clinical determinant of psoriatic arthritis, and up to 90% psoriatic patients have nail involvement in their lifetime[2]. Psoriatic nail changes are significantly associated with nail and joint disease, which, therefore, have drawn the attention of clinicians[3-5]. Currently, an assessment of psoriatic changes in nails in clinical practice is based on a traditional examination and clinical manifestations. Nail psoriasis severity index (NAPSI) and modified Nail psoriasis severity index (mNAPSI) are frequently used assessment indices which, however, are time-consuming and have strong subjectivity, error diagnosis and unmeasurable thickness of the nail bed (TNB) and nail matrix (TNM). Therefore, ultrasonic imaging has an irreplaceable advantage in psoriatic nail examination with the features of being frequently used, noninvasive, inexpensive and measurable quantity. Recently, several studies[6-12] reported B-mode (BM), Color Doppler signals and power Doppler (PD) signals of nails by ultrasonography; however, enhanced blood flow imaging (eflow) as a new ultrasound (US) technique was not used to assess and quantify microblood flow signal. Our study provides a further understanding of psoriatic nail by ultrasonography.

The aims of our cross-sectional study were to identify NP group, psoriasis group and healthy control group with BM, eflow and Power Doppler by scanning the nails; to compare diagnostic accuracy of microblood flow signal between eflow and PD signals in psoriatic nails; and to assess the correlation between ultrasonic appearance of nails and NAPSI.

## Patients and Methods

A total of 14 patients who were treated at our hospital were enrolled in our study, including

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5 patients with psoriatic nails (45 nails, one patient only provided his right hand) and 8 patients with non-NP (80 nails). Inclusion criteria were as follows: (1) psoriasis and NP diagnosed by an experienced dermatologist; (2) a history of psoriasis, and clinical manifestations such as nail depression, nail peeling, nail thickening, and changes in nail appearance; (3) skin erythema, a reddish translucent membrane after scraping off the scales on the surface, and spot bleeding after removing the membrane. Exclusion criteria were as follows: (1) engagement of heavy manual work; (2) a history of any other form of nail disease; (3) a recent history of nail trauma; (4) other skin diseases. Moreover, 7 healthy controls (70 nails) without disease of skin and nails were selected as the control group. An US examination of nails was conducted in all the patients and people in the control group. The US examination was conducted by an ultrasound doctor experienced in US examinations of the skeletal and muscular system for approximately 20 years. Changes in nail manifestation were examined with HITACHI ALOKA (Tokyo, Japan) (a linear head L55 with frequency ranging from 5 to 13 MHZ).

Micro-vascular blood flow of fingernails was detected by eflow and PD signals. To enhance the sound penetration into nails, liquid gel was applied to every nail and a pad filled with an ultrasonic gel was used when the images were taken.

In longitudinal section of nails, the thickness of the nail plate (TNP) was measured from the dorsal to the ventral plate at the maximum distance between both plates. TNB was measured at the maximum distance from the ventral plate to the cortex of the distal phalanx. TNM was measured at the proximal end of the nail bed (NB). The methods of TNP and TNB assessment for cross-section of nails were the same as that for longitudinal section of nails. In longitudinal and cross-section of nails, microblood flow signal of NB was evaluated by eflow and PD, and in longitudinal section of nails, resistance index (RI) of NB was measured by eflow.

In longitudinal and cross-section of nails, the following ultrasonography of nail plate (NP) was assessed on BM: grade 1, the dorsal plates and the ventral plates show ultrasonic structure clearly; grade 2, the ventral plates lose the sharpness and show irregularities; grade 3, the NP is wavy; grade 4, the normal ultrasonic appearance of the trilaminar NP is lost, and two plates merge into each other.

In terms of longitudinal and cross-section of nails, we assessed the blood flow signal of NB by eflow and PD: grade 1, blood flow signal in <20% of the area; grade 2, blood flow signal in 20-40% of the area; grade 3, blood flow signal in 40-60% of the area; grade 4, blood flow signal in >60% of the area.

The dermatological condition was assessed by the same dermatologist for all patients, which consisted of evaluating nail involvement in the hands according to the NAPSI (0-8 at nail level) and skin involvement according to the Psoriasis Area and Severity Index (PASI) (0-72). Patients and controls waited for 10-15 min in a room at about 23°C before US scanning. Throughout the scanning, we standardized the BM, eflow and PD settings. Patients sat at the inspection table, with hands placed on the inspecting stand in a relaxing state.

### Statistical Analysis

Statistical analysis was performed using the IBM-SPSS 26.0 package (IBM Corp., Armonk, NY, USA), with $p<0.05$ considered statistically significant. Quantitative variables were summarized as mean, standard deviation (SD) and median, depending on their normal or nonnormal distribution. Ordinal and nominal variables were summarized as frequencies and percentages. Comparisons between groups were analyzed with the ANOVA, Kruskal-Wallis' or Mann-Whitney test. Correlations between clinical and US variables were tested with the Spearman's coefficient. The diagnostic values of two ultrasound techniques were assessed by ROC curves.

## Results

### Demographics and Clinical Features (Table I)

The gender was not significantly different between groups, as evidenced by 2 (40%) men and 3 (60%) women in the NP group, 4 (50%) men and 4 (50%) women in the psoriasis group, 3 (43%) men and 4 (57%) women in the healthy control group ($p=0.934>0.05$). The median age was 51 (range 24-74) years for the NP group, 36 (range, 20-50) years for the psoriasis group, 36 (range 24-74) years for the healthy control group. The age was significantly higher in the NP group than in the psoriasis group ($p<0.05$) and healthy control group ($p<0.05$). The mean±SD (range) duration

**Table I.** Demographics and clinical features.

| | NP nails | Psoriasis nails | Control group nails | *p*-value |
|---|---|---|---|---|
| Gender (number: men/women) | 2/3 | 4/4 | 3/4 | 0.934 |
| Age (years) | 54.49 ± 17.84 | 37.44 ± 7.97 | – | < 0.001 |
| | 54.49 ± 17.84 | – | 48.95 ± 17.68 | < 0.001 |
| | – | 37.44 ± 7.97 | 48.95 ± 17.68 | 0.613 |
| Duration of disease (years) | 36.37 ± 15.75 | 12.30 ± 5.25 | – | < 0.001 |
| PASI | 21.39 ± 7.99 | 15.07 ± 10.49 | – | < 0.001 |

of nail psoriasis was 36.37±15.75 (range, 2-51) years for the NP group, and 12.3±5.25 (range 1-20) years for the psoriasis group ($p<0.05$). The mean±SD of PASI was 21.39±7.99 in the NP group, and 15.07±10.49 in the psoriasis group ($p<0.05$). The mean±SD of NAPSI was 5.40±0.60 in the NP group.

### Comparisons of TNP, TNB, TNM and NB Blood Flow RI Between the NP Group and Psoriasis Group

In the NP group, psoriasis group and healthy control group, TNP, TNB, TNM and RI were compared in pairs, whereas NP ultrasonic performance, NB eflow grade and PD signal grade were compared in three groups. Mann-Whitney test showed that differences between the NP group and the psoriasis group, between the nail psoriasis group and the healthy control group, were statistically significant ($p<0.05$).

Table II displays the comparisons of TNP, TNB, TNM and RI between the NP group and the psoriasis group. In longitudinal and cross-section of nails, TNP, TNB and TNM were not significantly different in the NP group and the psoriasis group. The RI of NB eflow signal was significantly higher in the NP group than in the psoriasis group.

Table III displays the comparisons of TNP, TNB, TNM and RI between the NP group and the healthy control group. In longitudinal and cross-section of nails, TNP and TNB were significantly higher in the NP group than in the healthy control group, and TNM was significantly higher in the healthy control group than in the NP group. The RI did not show significant differences between the NP group and the healthy control group.

Table IV displays the comparisons of TNP, TNB, TNM and RI between the psoriasis group and the healthy control group. In cross-section of nails, TNB was significantly higher in the psoriasis group than in the healthy control group. TNP (in longitudinal and cross-section)

**Table II.** Comparisons of TNP, TNB, TNM and NB blood flow RI between the NP group and psoriasis group.

| Ultrasonic manifestation (mean ± SD) | | NP group | Psoriasis group | *p*-value |
|---|---|---|---|---|
| TNP | In longitudinal section (cm) | 0.0776 ± 0.0166 | 0.7650 ± 0.0156 | 0.492 |
| | In cross-section (cm) | 0.0746 ± 0.0132 | 0.0755 ± 0.0167 | 0.892 |
| TNB | In longitudinal section (cm) | 0.1683 ± 0.0419 | 0.1513 ± 0.0315 | 0.077 |
| | In cross-section (cm) | 0.1446 ± 0.0343 | 0.1350 ± 0.0323 | 0.115 |
| TNM (cm) | | 0.1769 ± 0.0478 | 0.1834 ± 0.0335 | 0.097 |
| NB eflow RI | | 0.5532 ± 0.0941 | 0.5364 ± 0.0926 | 0.024 |

**Table III.** Comparisons of TNP, TNB, TNM and RI between the NP group and the healthy control group.

| Ultrasonic manifestation (mean ± SD) | | NP group | Healthy control group | *p*-value |
|---|---|---|---|---|
| TNP | In longitudinal section (cm) | 0.0776 ± 0.0166 | 0.0679 ± 0.0119 | 0.001 |
| | In cross-section (cm) | 0.0746 ± 0.0132 | 0.0632 ± 0.0910 | < 0.001 |
| TNB | In longitudinal section (cm) | 0.1683 ± 0.0419 | 0.1610 ± 0.0464 | 0.027 |
| | In cross-section (cm) | 0.1446 ± 0.0343 | 0.1317 ± 0.0376 | 0.020 |
| TNM (cm) | | 0.1769 ± 0.0478 | 0.1936 ± 0.0415 | 0.002 |
| NB eflow RI | | 0.5532 ± 0.0941 | 0.4641 ± 0.2109 | 0.935 |

**Table IV.** Comparisons of TNP, TNB, TNM and RI between the psoriasis group and the healthy control group.

| Ultrasonic manifestation (mean ± SD) | | Psoriasis group | Healthy control group | *p*-value |
|---|---|---|---|---|
| TNP | In longitudinal section (cm) | 0.7650 ± 0.0156 | 0.0679 ± 0.0119 | 0.344 |
| | In cross-section (cm) | 0.0755 ± 0.0167 | 0.0632 ± 0.0910 | < 0.001 |
| TNB | In longitudinal section (cm) | 0.1513 ± 0.0315 | 0.1610 ± 0.0464 | 0.771 |
| | In cross-section (cm) | 0.1350 ± 0.0323 | 0.1317 ± 0.0376 | 0.244 |
| TNM (cm) | | 0.1834 ± 0.0335 | 0.1936 ± 0.0415 | 0.027 |
| NB eflow RI | | 0.5364 ± 0.0926 | 0.4641 ± 0.2109 | 0.006 |

and TNB (in longitudinal section) did not show significant differences between the psoriasis group and the healthy control group. TNM was significantly higher in the healthy control group than in the psoriasis group, and RI was significantly higher in the psoriasis group than in the healthy control group.

Table V shows the comparisons of the ultrasound features of NP, NB eflow and PD signal among the NP group, psoriasis group and the healthy control group. In longitudinal and cross-section of nails, the area of eflow signal, PD signal and ultrasound features of NP were significantly different among the NP group, the psoriasis group, and the healthy control group ($p$<0.05).

### Relationship Between Clinical NAPSI Scores and US findings

In the NP group, to correlate NAPSI, NB blood flow signal classifications and NP ultrasonic classifications were analyzed by Spearman correlation coefficient.

In longitudinal and cross-section, NAPSI showed no significant correlation with NB eflow signal and PD signal ($p$:0.539; $p$:0.736; $p$:0.415; $p$:0.674; $p$>0.05), whereas in longitudinal and cross-section, NAPSI showed a significant correlation with NP ultrasonic classifications. Spearman correlation coefficients were 0.551 and 0.413 respectively ($p$<0.05).

### Comparisons of the Diagnostic Value Between the Eflow Signal and PD Signal in the NP Group and Psoriasis Group (Table VI)

The diagnostic values of eflow signal and PD signal were analyzed using area under ROC curve (AUC) (AUC<0.5, no diagnostic value; AUC: 0.5-0.7, low diagnostic value; AUC: 0.7-0.9, moderate diagnostic value; AUC>0.9, excellent diagnostic value). Table VI showed that the diagnostic value of eflow signal and PD signal were merely significant in longitudinal section of nails. In the NP group, the accuracy of two blood flow diagnostic technology was not obvious (AUC of longitudinal eflow signal and longitudinal PD signal was 0.661 and 0.620, respectively).

## Discussion

Although several case-control studies[6,7,13,14] comparing US characteristics of psoriatic nails have been published in different groups, to our knowledge, our study is the first to provide the new NP group, in which nails in patients with NP, those with psoriasis and healthy controls were assessed with new ultrasonic technology. Meanwhile, we also measured the TNP and TNB in longitudinal and cross-section for the first time and improved the accuracy and credibility of measurement parameters. Similar to

**Table V.** The comparisons of the ultrasound features of NP, NB eflow and PD signal among the NP group, psoriasis group and the healthy control group.

| Ultrasonic manifestation [median (range)] | | NP group | Psoriasis group | Healthy control group | *p*-value |
|---|---|---|---|---|---|
| Ultrasound features of NP | In longitudinal section | 2 (1-4) | 1 (1-4) | 1 (1-4) | < 0.001 |
| | In cross-section | 2 (1-4) | 2 (1-4) | 1 (1-4) | < 0.001 |
| Eflow signal | In longitudinal section | 2 (1-4) | 1 (1-4) | 2 (1-4) | 0.001 |
| | In cross-section | 1 (1-4) | 1 (1-4) | 1 (1-4) | 0.008 |
| PD signal | In longitudinal section | 2 (1-4) | 1 (1-4) | 2 (1-4) | 0.010 |
| | In cross-section | 1 (1-4) | 1 (1-4) | 1 (1-4) | 0.031 |

**Table VI.** Comparisons of eflow signal and PD signal (AUC).

| AUC | | NP group | Psoriasis group |
|---|---|---|---|
| Eflow signal | In longitudinal section | 0.661 | 0.370 |
| | In cross-section | 0.498 | 0.391 |
| PD signal | In longitudinal section | 0.620 | 0.391 |
| | In cross-section | 0.486 | 0.404 |

previous studies[6,13], the TNP and TNP were significantly higher in NP patients than in healthy controls, but the TNP and TNP in NP patients and psoriatic patients did not show significant difference. In psoriatic patients and healthy controls, only the TNP was statistically significant in our study. In cross-section, the accuracy and value of measuring TNP, TNB and TNM need a larger sample size for further study. Several research[6] reported the TNM of psoriatic nails in NP patients was higher than that in healthy controls, but the TNM of the healthy nails in NP patients was not significantly different from that in the healthy controls. Different from previous studies, our study showed the TNM of NP group and psoriatic group was remarkably higher than that in healthy control group, but there was no significant difference in NP group and psoriatic group. We speculated nail matrix presented with subclinical manifestations prior to clinical manifestations of nails; however, whether the TNM could predict the development of psoriatic nails needs further study. Marina et al[15] assessed clinical studies of psoriatic nails with ultrasound and reported that the blood flow signal RI of nail fold of diseased nails was higher than that of healthy nails in psoriatic group, and that the blood flow signal RI of nail fold in psoriatic group was significantly higher than that in healthy control group. Our study set blood flow RI of NB as a research parameter, and the results indicated that there were significant differences in the NP group, psoriatic group, and healthy control group. Generally, RI also was used in measuring the main artery. To measure the RI of tiny blood vessels in psoriatic NB, larger samples experiments are needed for further confirmation. In a number of studies[8,13,16], because grades of ultrasonic findings of NP and blood flow signal grades were evaluated only in longitudinal nails but not in longitudinal and cross nails, the results were not comprehensive with respect to grades of US findings of NP and blood flow signal grades. Naredo et al[13] assessed the blood flow signals in the groups according to the area method, including the first method: grade 0, no or isolated Doppler signal; grade 1, blood flow signal in <50% of the area; grade 2, blood flow signal in ≥50% of the area, as well as the second method: grade 0, no Doppler signal; grade 1, blood flow signal in <25% of the area; grade 2, blood flow signal in 25-50% of the area; grade 3, blood flow signal in >50% of the area. Two methods of blood flow signal classification were not statistically significant between research group and control group. Aydin et al8 assessed the blood flow signal occupying more than 50% of the NB area, which was significantly lower in the psoriasis group than in the healthy control group. Due to blood transfer causing high NB pressure, their study speculated nail blood supply decreased in patients with psoriasis. Our study further perfected the group standard and lowered the grade of blood flow signal down to 20%, showing that in terms of not only longitudinal but also cross-section nails, the grades of NP ultrasonography, NB eflow signal and NB PD signal all had significant difference among the NP group, psoriatic group and healthy control group. Currently, there has been no consensus on standards of assessing the blood flow signal of psoriatic NB. Therefore, the grades of ultrasonography and blood flow signal need further study, and more precise and authoritative approaches need to be explored. Krajewska-Włodarczyk et al[6] studied correlating mNAPSI, clinical nail manifestations and TNP, TNB, TNM. The NP, NB, and matrix thickness increased with mNAPSI, and the thickness in patients with onycholysis and hyperkeratosis-type changes was significantly greater when only pitting-type changes occurred. Asil et al[11] found the correlations of elastic strain rate of nails, TNP, TNB and NAPSI. To our knowledge, our study was the first to explore the association of NAPSI with the grades of blood flow signal and NP ultrasonography and used the two new ultrasonic techniques to assess blood flow signal. The study concluded that no significant difference was found in the diagnostic accuracy

of eflow signal and PD signal in psoriatic NB, and that the ultrasonic diagnostic technique to identify tiny blood flow signal still needs further improvement.

### Limitations

Several potential limitations of this study must be mentioned. The low number of patients included and only one ultrasound doctor measuring the nail parameters may lead to incorrect or biased conclusions. Furthermore, age, duration of disease and PASI were heterogeneous in the research group and healthy control group. It was not considered whether the use of drugs for psoriatic skin diseases had an effect on psoriatic nail diseases, which may have biased the results.

## Conclusions

Measuring TNP, TNB, TNM and RI, coupled with classifying ultrasonography of nails, and applying eflow and PD signal to measure blood flow signal can be conducive to diagnosis of psoriatic nail disease. NAPSI is closely associated with the NP of two-dimensional ultrasonography classifications, therefore, the nail ultrasonography can be used to assess the severity of psoriatic nails.

### Conflict of Interest

The Authors declare that they have no conflict of interests.

### Acknowledgements

Thanks to all participants in our study.

### Ethics Approval

The study was approved by the Medical Ethics Committee of the Fourth Hospital of Hebei Medical University (2022KY033).

### Informed Consent

All participants signed informed consent.

### Funding

None.

### Authors' Contribution

All authors have contributed significantly to this publication. Wei Chen: Substantial contributions to conception and design of the study, acquisition of data, or analysis and interpretation of data as well as validation and final approval of the version of the article to be published. Yakang Zhang: Drafting of the article or making critical revisions related to relevant intellectual content of the manuscript. Wenjie Li: Critical revision of the article.

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### Availability of Data and Materials

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

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