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Research Article

Investigation of Nailfold Capillary Structures Using Digital Dermatoscopy in Rheumatological Diseases

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ABSTRACT

Objective: Evaluating the microvascular structure in rheumatological diseases provides important information for understanding the pathogenesis and clinical management of these diseases. Nail capillaroscopy is a reliable method that allows non-invasive examination of these changes. This study aimed to evaluate nail capillary findings in rheumatological diseases using digital dermoscopy and to compare capillary patterns in different disease groups.

Methods: The study included 200 patients diagnosed with rheumatological diseases and 50 healthy volunteers. The nail bed capillaries of all participants were evaluated using a digital dermatoscope. Capillary examination assessed the presence of edema, tortuous, elongated, dilated, and brush-like capillaries, microhemorrhages, and avascular areas. Statistical analyses were performed using appropriate parametric and non-parametric tests, and a P value < 0.05 was considered statistically significant.

Results: The frequency of capillary abnormalities was significantly higher in the patient group than in the control group. The most frequently observed findings were edema and tortuous, elongated capillaries. Capillary patterns differed by disease group, with more specific findings particularly prominent in patients with systemic sclerosis.

Conclusion: Nail capillaroscopy is an effective, easily applicable, and non-invasive method for evaluating microvascular changes in rheumatological diseases. Capillary patterns observed in different disease groups can provide clinically valuable information for diagnosis and disease monitoring.

Keywords: Capillaroscopy, nail capillaroscopy, rheumatological diseases, digital dermatoscopy, microvascular changes, systemic sclerosis.

INTRODUCTION

Rheumatological diseases constitute a group of chronic, multisystemic disorders affecting connective tissue and vascular structures. In these diseases, microvascular involvement plays a crucial role in pathogenesis and may directly influence clinical outcomes. In particular, microcirculatory alterations in autoimmune connective tissue diseases can be detected early and may provide valuable information for diagnosis and prognosis.[1,2]

Nailfold capillaroscopy is a non-invasive, easily applicable, and reproducible method that allows *in vivo* evaluation of the microcirculation.[2, 3]. It enables detailed assessment of capillary morphology and identification of disease-specific patterns. The "scleroderma pattern," particularly observed in systemic sclerosis (SSc), is one of the most characteristic examples demonstrating the diagnostic value of capillaroscopy.[1] However, varying degrees of capillary abnormalities may also be observed in other rheumatological diseases such as systemic lupus erythematosus (SLE), rheumatoid arthritis (RA), and ankylosing spondylitis (AS).[4]

Recent technological advancements, particularly digital dermoscopy, have increased the accessibility and standardization of capillary evaluation.[3,5,6] These developments have facilitated the assessment of microvascular changes in larger patient populations and contributed to the expansion of

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clinical data in this field. However, studies that directly compare capillary findings across different rheumatological disease groups remain limited.

The aim of this study was to evaluate nailfold capillary findings in patients with rheumatological diseases using digital dermoscopy and to compare capillary patterns among different disease groups.

Capillaroscopy

Nailfold capillaroscopy is a valuable method for evaluating microcirculation and blood supply *in vivo* (Figure 1). It is a non-invasive, cost-effective, and easily repeatable technique. The capillaries in the nail bed consist of arterial and venous limbs connected by an apical loop, which runs parallel to the skin surface, allowing direct visualization.[2] Normal nailfold capillaries are regularly arranged, hairpin-shaped, and homogeneously distributed.[7] (Figure 2).

Capillaroscopic examination has been used for over two decades in the evaluation of autoimmune connective tissue diseases.[2] Many connective tissue diseases, such as SSc, dermatomyositis, and mixed connective tissue disease, exhibit characteristic capillary abnormalities.[5,6] Among rheumatological diseases, SSc exhibits the most specific capillary pattern. Microcirculatory impairment is a central feature of the disease process in SSc.[1]

The most common capillaroscopic findings in SSc include giant capillaries, microhemorrhages, and avascular areas.[7,8] In addition, tortuous (Figure 3), elongated, and dilated capillaries may also be observed in diseases such as dermatomyositis, mixed connective tissue disease, and SLE.[5,6,9]

Capillaroscopy is a convenient technique that can provide reliable information about disease severity and differentiate primary from secondary Raynaud's phenomenon (RP) in patients. It has also been reported that it can be a useful device in evaluating follow-up in RF associated with coronary heart disease (CHD).[10,11]

Procedure

Morphological evaluation of cutaneous capillaries is usually performed at the nail bed because the main axis of the capillaries is parallel to the skin surface (in other areas the capillaries are perpendicular) and the nail bed is easily accessible for sampling. All patients should wait in the test room for at least 15 minutes before evaluation. The ideal room temperature for the procedure is 20-22 °C. Traumatized fingers are not evaluated. The nail bed capillaries of the fourth and fifth fingers of the non-dominant hand are the most suitable sites for evaluation because the skin of these fingers is more transparent than that of other fingers. Before performing nail bed videocapillaroscopy, immersion oil is applied to the nail bed, and the capillaries are evaluated at 100x or 200x magnification with minimal pressure.

Early capillary changes seen in autoimmune connective tissue diseases include large and prominent capillaries,



Figure 1. Due to the cumbersome equipment required for photographic documentation, in vivo nail bed capillaroscopy has not yet been integrated into clinical practice as a standard bedside routine in rheumatology and dermatology clinics. Recent studies have suggested that the hand dermatoscope can be used as a capillary-scopic device for this purpose.

MAIN POINTS

- Digital dermoscopy detected significantly more nailfold capillary abnormalities in patients with rheumatological diseases than in healthy controls.
- Distinct capillary patterns were identified among different rheumatological diseases, particularly in systemic sclerosis
- Nailfold capillaroscopy is a practical, non-invasive, and accessible method for evaluating microvascular involvement.
- Capillaroscopic findings may support the diagnosis and clinical follow-up of patients with rheumatological diseases.

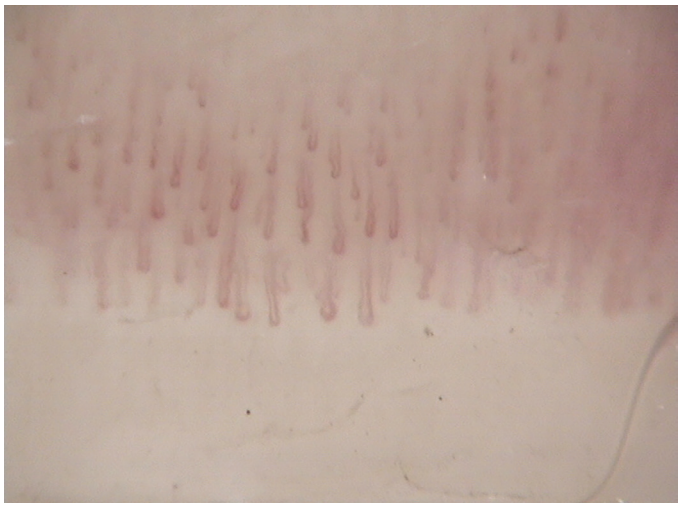


Figure 2. Many instruments have been used in the evaluation and characterization of nail bed capillary morphologies. The most commonly used capillary microscope consists of an optical microscope connected to a camera and a light source with external cooling. 30X and 50X magnification is usually sufficient to evaluate the morphological structure of the nail bed capillary plexus. Monitor-connected video capillaroscopes can provide 100X, 200X magnification, enabling storage and display with the help of a specific program.



Figure 3. Torsional capillaries. Patients with increased torsion in the descending and ascending limbs of capillary loops were classified as having torsional capillaries.

microhemorrhages, capillary loss, edema (Figure 4), branched-brush capillaries (angiogenesis) (Figure 5), irregularities in the vascular sequence, capillary loss and/or avascular areas(Figure 6), and irregularities in the vascular periphery.[12]

MATERIAL AND METHODS

Ethical approval for this study was obtained from the Atatürk University Faculty of Medicine Ethics Committee (approval date: 03.12.2015, decision number: 25). The study was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants prior to inclusion in the study.

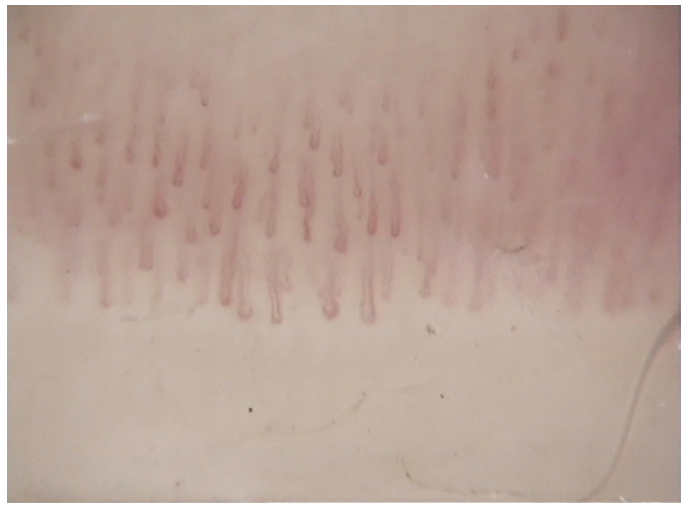


Figure 4. Edema. Edema was considered present if the capillary image appeared cloudy due to damaged vessels or if the dermal papilla appeared empty due to increased synthesis of extracellular matrix proteins.



Figure 5. Ramified/bushy capillaries (angiogenesis). Excessively convoluted and branched capillary arch clusters are characteristic of angiogenesis findings. Patients with ramified capillary clusters consisting of thin and thick capillaries showing significant heterogeneity, which is the main morphological feature of angiogenesis, were classified as having branched/brushed capillaries.

Between July 2015 and December 2015, 268 patients with a history of rheumatic disease were evaluated; these patients had presented to the rheumatology outpatient clinic and were referred to the dermatology outpatient clinic at Atatürk University Faculty of Medicine Research Hospital. Comorbidities, smoking, and the use of vasoconstrictive agents were considered exclusion criteria. 200 patients with a diagnosis of rheumatic disease who did not meet the exclusion criteria and 50 volunteers forming the control group were included in the study. In our study, the patients' file numbers, ages, genders, and rheumatic disease diagnoses were recorded.



Figure 6. Capillary loss and/or avascular areas. Patients with extensive avascular areas (5 mm < 30 loops in the distal row of the nail bed) resulting from widespread capillary loss in the nail bed were classified as avascular.

Patients were acclimatized in the test room at approximately 20-22°C for at least 15 minutes before capillaroscopy. The procedure was not performed on fingers with local trauma. The capillaries of the fourth and fifth nail beds of the non-dominant finger were evaluated first. The capillaroscope (FotoFinder® dermoscope, FotoFinder Systems GmbH, Bad Birnbach, Germany) was applied with very little pressure. The presence of homogeneously dilated, giant, irregularly dilated, brush-like, and tortuous capillaries, microhemorrhages, edema, and avascular areas was investigated and noted.

Normal Pattern

Patients with capillary loss in the nail fold (30 capillaries linearly in 5 mm) and with homogeneous capillary distribution without morphological changes were considered normal.

Statistical Analysis

Statistical analysis was performed using SPSS Statistics 22.0 (IBM Corp., Armonk, NY, USA). Descriptive data were presented as mean ± standard deviation, median (min-max), and frequency (%). The normality of the distribution was assessed using the Kolmogorov-Smirnov test. For comparisons between groups, the Student's t-test or Mann-Whitney U test was used for continuous variables, and the Chi-square test or Fisher's exact test was used for categorical variables. A *P* value < 0.05 was considered statistically significant.

RESULTS

The nail beds of 200 patients with a history of rheumatic disease and of 50 healthy volunteers with no history of disease were evaluated by capillaroscopy.

All patients underwent capillaroscopy to assess nail bed edema, convoluted capillaries (Figure 7), elongated capillaries, dilated giant capillaries (Figure 8), microhemorrhages (Figure 9), and avascular areas.

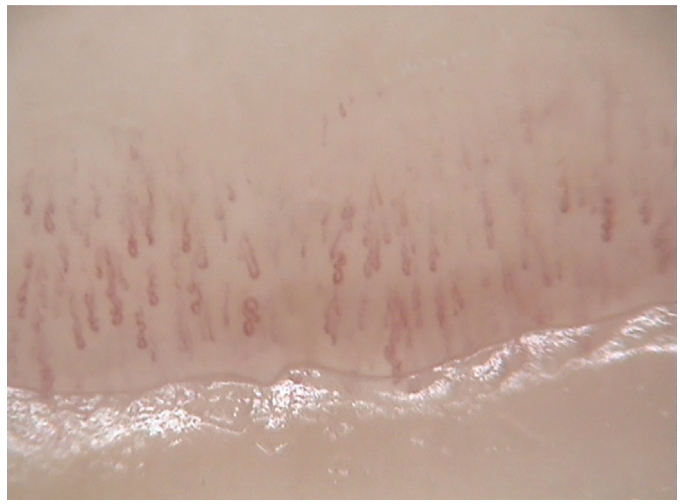


Figure 7. Convoluted capillaries.

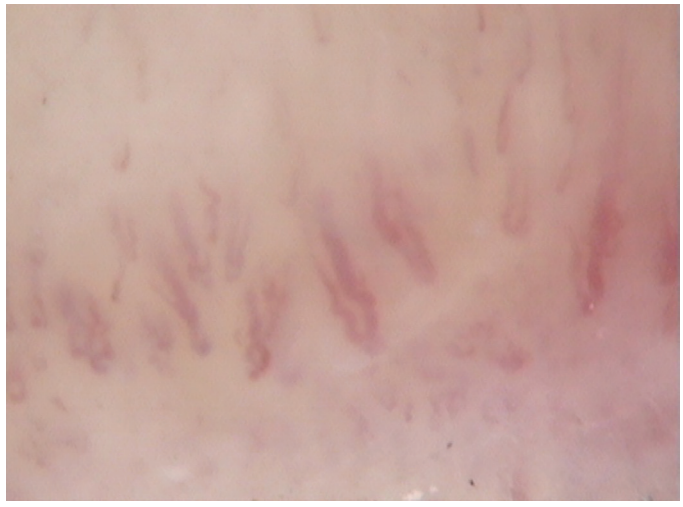


Figure 8. Enlarged capillaries (giant capillaries). Patients with symmetrical giant enlargements (> 50 µm enlargement) in the capillaries were classified as having enlarged capillaries.

In the patient group, 56 participants (28%) were male and 144(72%) were female, with a mean age of 43.01 ± 12.6 years. In the control group, 24 participants (48%) were male and 26 (52%) were female, with a mean age of 29.56 ± 8.8 years (Table 1).

Among the patients included in the study, 50% were diagnosed with RA, 23% with AS, 21% with SLE, and 6% with SSc (Figure 10).

In the capillaroscopic evaluation of patients with SLE (n=42), the most frequently observed abnormalities were tortuous capillaries, followed by edema and bushy (branched) capillaries.

Among patients with RA (n=101), edema was the most common finding, followed by tortuous and elongated capillaries.

In patients with AS (n=46), the most frequent abnormalities were edema, avascular areas, tortuous, elongated capillaries.

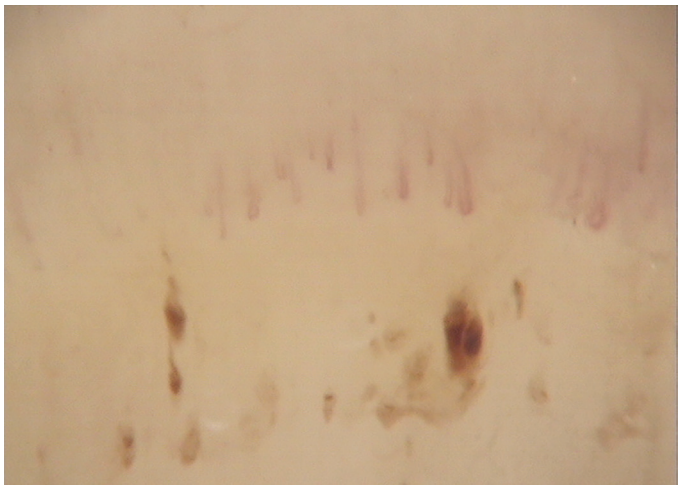


Figure 9. Microhemorrhage. Microhemorrhages may be found around the capillaries, either as pinpoint or linear formations. (More than two punctate hemorrhages or converging hemorrhage areas per finger). Microhemorrhages occur after extravasation of red blood cells following damage to the vessel wall. Patients exhibiting these findings were classified as having microhemorrhages.

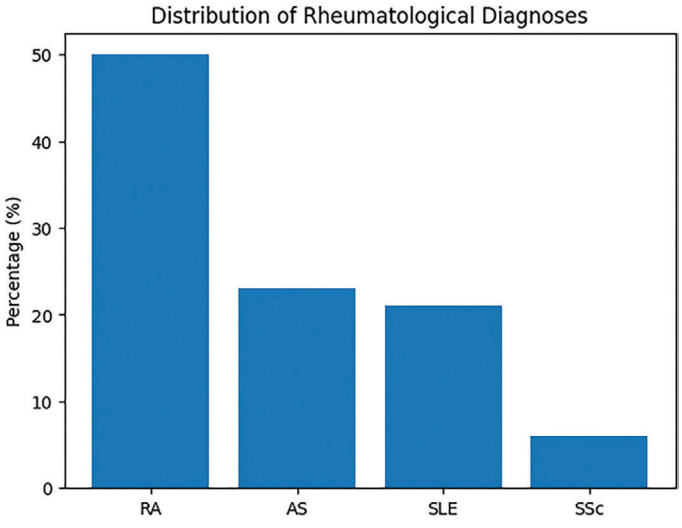


Figure 10. igure 10. Distribution of rheumatological diagnoses among study participants[3]

[3]Data are presented as percentages. RA, rheumatoid arthritis; AS, ankylosing spondylitis; SLE, systemic lupus erythematosus; SSc, systemic sclerosis.

Table 1. Gender Distribution of the Study and Control Groups*

Gender	Patient Group (n=200) n (%)	Control Group (n=50) n (%)
Male	56 (28.0)	24 (48.0)
Female	144 (72.0)	26 (52.0)

*Data are presented as n (%).

In SSc patients (n=11), the predominant finding was dilated capillaries, followed by bushy capillaries (Table 2).

Capillaroscopic evaluation of the nailfold revealed a significantly higher overall frequency of abnormalities, including edema, tortuous, elongated, and bushy capillaries, and microhemorrhages, in the patient group than in the control group (Table 3).

DISCUSSION

Nail bed capillaroscopy is an inexpensive, simple, and non-invasive technique used to evaluate the blood supply and microcirculation of the nail bed.

Many instruments have been used to characterize nail-bed capillary morphology. The most commonly used capillaroscopic device consists of an optical microscope connected to a camera and to a light source with external cooling. 30X and 50X magnification are usually sufficient to evaluate the morphological structure of the nail bed capillary plexus. Monitor-connected video capillaroscopes can provide 100X and 200X magnification, enabling storage and display with the help of a specific program.[2]

Microscopic *in vivo* examination of the nail bed vascular plexus in patients with autoimmune connective tissue diseases has been performed for over 25 years. Many connective tissue diseases (CTDs), such as scleroderma and mixed connective tissue disease (MCTD), frequently exhibit characteristic capillary abnormalities. Among rheumatological diseases, the most important specific capillary pattern is that associated with SSc.

Although the factors triggering vasculopathy, the initial stage of SSc, are not clearly known, it is thought that cytomegalovirus (CMV), whose epitopes resemble endothelial cell surface molecules, anti-endothelial cell antibodies, or free oxygen radicals cause endothelial cell damage, leading to apoptosis in endothelial cells.[13,14] A low number or impaired function of endothelial progenitor cells is also considered a cause of vasculogenesis disorders.[15] Capillary examination can demonstrate microvascular damage in almost all patients. Microcirculation is the main center of the pathological process in SSc.[1] The most frequent changes in SSc are dilated capillaries[7], hemorrhage[8], and avascular areas. Torsional, elongated, and dilated capillaries can also be found in DM, MKDH, and SLE.[5,6,9]

In our study, the nail beds of 11 SSc patients were examined capillaroscopically; dilated capillaries were observed in 6 patients and brush-like capillaries in 3 patients. Edema was observed in 1 patient, and avascular areas were observed in 2 patients. Contrary to the literature, microhemorrhages were not detected in any of the patients.

Dilated, giant capillaries, hemorrhage areas, and avascular areas seen in SSc are much rarer in SLE.[3,6] According to some researchers, capillaroscopic findings are mostly non-specific. The specific nail-bed changes most frequently described in SLE patients include capillary tortuosity or convolution, increased capillary length or diameter, transformation of loops into bizarre forms, and prominence of the subpapillary plexus.

Table 2. Comparison of Capillaroscopic Findings Among Diagnostic Groups[1]

Disease	n	Normal n (%)	Edema n (%)	Tortuous capillaries n (%)	Elongated capillaries n (%)	Dilated capillaries n (%)	Bushy capillaries n (%)	Microhemorrhage n (%)	Avascular areas n (%)
SLE	42	9 (21.4)	6 (14.3)	11 (26.2)	2 (4.8)	3 (7.1)	6 (14.3)	3 (7.1)	2 (4.8)
RA	101	29 (28.7)	32 (31.7)	21 (20.8)	10 (9.9)	3 (3.0)	1 (1.0)	4 (4.0)	1 (1.0)
AS	46	7 (15.2)	21 (45.7)	3 (6.5)	3 (6.5)	0 (0)	1 (2.2)	1 (2.2)	10 (21.7)
SSc	11	0 (0)	1 (9.1)	0 (0)	0 (0)	6 (54.5)	3 (27.3)	0 (0)	1 (9.1)

[1]Data are presented as n(%).

Table 3. Comparison of Capillaroscopic Findings Between Patient and Control Groups[2]

Finding	Patient Group (n=200) Present n (%)	Control Group (n=50) Present n (%)	*P* value
Normal	44 (22.0)	41 (82.0)	**<0.001**
Edema	63 (31.5)	3 (6.0)	**<0.001**
Tortuous capillaries	52 (26.0)	5 (10.0)	**0.02**
Elongated capillaries	15 (7.5)	0 (0)	**0.04**
Dilated (giant) capillaries	12 (6.0)	1 (2.0)	0.47
Bushy capillaries	18 (9.0)	0 (0)	**0.03**
Microhemorrhages	16 (8.0)	0 (0)	**0.04**
Avascular areas	18 (9.0)	1 (2.0)	0.13

[2]Data are presented as n (%). Statistical comparisons were performed using the Chi-square or Fisher's exact test.

In some studies, these SLE-specific changes have been termed the SLE-type capillary pattern (SLE pattern).[3] The SLE pattern is essentially formed by an increase in capillary convolution.[16]

In our study, the most frequently observed pathologies in the capillaroscopic evaluation of 42 patients with SLE were, in order, convoluted capillaries (n=11), edema (n=6), and brush capillaries (n=6). Pathologies were detected in 33 patients, and all types of these pathologies were observed in the nail bed capillaries of SLE patients. In our study, consistent with the literature, convoluted and brush capillaries were the most frequently detected.

Rheumatism, or rheumatic disease, is a term used to describe more than 200 chronic diseases that affect the joints and/or connective tissues and cause pain. Although rheumatic diseases generally begin in the joints, with joint pain as the most common complaint, many exhibit multisystem involvement.

RA is the most common rheumatic disease. Currently, the cause of RA remains unknown, and the lack of a pathognomonic diagnostic method means that diagnosis can only be made through a combination of laboratory, clinical, and imaging methods, thus requiring additional diagnostic techniques.[17]

Although there are insufficient studies evaluating whether nail capillaroscopy in RA patients can aid diagnosis, data in the literature are contradictory. In a study by Redisch et al.[18] involving 31 RA patients, they found elongation of capillaries, increased folds, and prominent subpapillary plexuses. However, none of the RA patients in this study showed a scleroderma pattern.[18]

Our study included 101 patients diagnosed with RA, of whom pathology was detected in the nail bed capillaries of 72 patients. The most common pathologies were edema (n=32), tortuous capillaries (n=21), and elongated capillaries (n=10). In 3 of our patients, an SSc pattern was detected even though no diagnosis of SSc had been made.

AS is a chronic, multisystemic rheumatic disease that primarily affects the sacroiliac joints and spine.18 AS is a spondyloarthropathy. Spondyloarthropathies are related to each other genetically human leukocyte antigen and through a shared pathology (enthesitis). Although there is no specific diagnostic method for AS, diagnosis is based on a combination of inflammatory low back pain and radiological evidence of enthesitis or arthritis.

There are insufficient studies on nail bed capillaroscopy in patients with AS. Wendling et al.,[19] in their study with 32 AS patients, reported that there was more edema and microangiopathy at the nail bed compared to the control group.

Our study included 46 AS patients, and pathology was detected in the nail bed capillaries of 39 of them. The most frequently detected pathologies were edema, avascular areas, tortuous capillaries, and elongated capillaries. No SSc pattern was detected in any of our AS patients.

Study Limitation

This study has several limitations. First, it was conducted at a single center; therefore, the patient population, referral patterns, and clinical characteristics may not fully represent those of other centers, potentially limiting the generalizability of the findings. Second, although the overall sample size was sufficient for the main comparisons, the number of patients in some disease subgroups, particularly systemic sclerosis,

was relatively limited. This may have reduced the statistical power for subgroup analyses and should be considered when interpreting disease-specific capillary findings. Third, interobserver variability was not assessed, which may have affected the evaluation of capillary abnormalities. In addition, capillary findings were evaluated using digital dermoscopy rather than conventional nailfold videocapillaroscopy, which may limit direct comparability with studies using standard nailfold videocapillaroscopy. Finally, the cross-sectional design of the study does not allow assessment of causal relationships, temporal changes, disease progression, or treatment-related changes in capillary structures.

CONCLUSION

Nail bed capillaroscopy can aid in diagnosing the disease, and abnormalities detected by BPC can reflect the extent of microvascular involvement in SLE, thereby informing treatment strategies in cases of systemic organ failure. In one study, severe or moderate pathological changes in nail bed capillaries were also detected in SLE patients with internal organ involvement.[3]

It has been reported that nail bed capillaroscopy can be used in patients with RA when findings suggestive of microangiopathy are detected, to classify the disease into subgroups and/or to monitor for overlap syndrome with other connective tissue diseases.

Ethics

Ethics Committee Approval: Ethical approval for this study was obtained from the Atatürk University Faculty of Medicine Clinical Research Ethics Committee (approval date: 03.12.2015, decision number: 25).

Informed Consent: Informed consent was obtained from all participants prior to inclusion in the study.

Footnotes

Author Contributions:

Concept Design – H.K.S., Ş.Ö.; Data Collection or Processing –H.K.S.; Analysis or Interpretation – H.K.S.; Literature Review – H.K.S., Ş.Ö.; Writing, Reviewing and Editing – H.K.S., Ş.Ö.

Declaration of Interests: The authors declare no conflict of interest regarding the publication of this paper.

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