Water content and other aspects of brittle versus normal fingernails

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Background: Previous authors have claimed that dehydration of the nail plate causes brittle nails. Some experts claim that normal nails contain 18% water, and brittle nails contain less than 16%.

Objective: We sought to test the hypothesis that brittle nails contain 2% less water than normal nails. We also examined the relationship between a number of health and behavioral variables and brittle nails.

Methods: In all, 102 participants with either brittle or normal nails had two nails clipped and then analyzed for water content by a blinded investigator in the laboratory. Participants filled out a detailed questionnaire designed to reveal information about health and behavior.

Results: The mean water content for normal nails was 11.90% and for brittle nails was 12.48%. There was no statistically significant difference between the two groups. The odds of having brittle nails was 3.23 times greater among participants who received a professional manicure (95% confidence interval 1.21, 8.59). The frequency of professional manicures was associated with the likelihood of having brittle nails. Frequency of hand moisturizer use was significantly associated with nail brittleness (95% confidence interval 1.35, 32.10). Family history was significantly associated with the likelihood of having brittle nails (95% confidence interval 1.65, 21.11).

Limitations: Analyzing nails from living participants is limiting because samples can only be collected from the distal unattached nail plate. A small subanalysis was performed and showed that the nails were losing water between the time of clipping and laboratory analysis. Therefore, our water percentage results may not be representative of in vivo nail plate water contents.

Conclusions: There was no significant difference in water content of brittle compared with normal nails. (J Am Acad Dermatol 2007;57:31-6.)

Many authors assert that brittle nails result from dehydration of the nail plate.[1-3] Some experts specifically claim that normal nails contain 18% water, and brittle nails contain less than 16%.[2,4] However, in our review of the literature, there were sparse data to support these claims. We, therefore, proposed to test the hypothesis that brittle nails contain 2% less water than normal nails. We also investigated the relationship between a number of health and behavioral variables and brittle nails.

Studies have shown the incidence of brittle nails in the European and North American population is approximately 20%,[5,6] with women affected approximately twice as often as men.[5,7] The diagnostic criteria in the literature for brittle nails are not well defined. We used the definition elaborated by Kechijian,[8] who describes brittle nails as having two pathologic alterations: (1) excessive onychorrhexis (longitudinal ridging) that results in distal splitting; and/or (2) onychoschizia (horizontal layering).[8] Figs 1 and 2 show onychorrhexis in comparison with excessive onychorrhexis, respectively.

Brittle nails may be mainly a cosmetic issue but when dystrophy is severe, nail function may become impaired. To prevent and treat brittle nails, a better understanding of the pathogenic process is essential.

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Fig 1. Onychorrhexis.

Fig 2. Excessive onychorrhexis.

METHODS

Our institutional review board approved this study. Patients visiting our department of dermatology were asked whether they would like to participate in a nail study. Patients at least 18 years of age were examined for clinical evidence of either normal or brittle fingernails. Brittle nails were defined using the previously mentioned definition. To be included in the sample, participants with brittle nails were required to have at least two nails, one from each hand, identified as brittle by an investigator. Volunteers qualified as having normal nails if they had 10 clinically normal nails. Volunteers with obvious clinical nail disorders other than idiopathic brittle nails were excluded, as were individuals who had treated their brittle nails within 28 days of the study screen day, and volunteers with nails that were too short to cut. Persons wearing nail enamel at the time of screening, and those individuals who had washed or soaked their hands within 1 hour of the nail clipping were also excluded. Table I shows the characteristics of the study population.

Eligible volunteers filled out a questionnaire that was designed to provide information about their health and behavior including: chronic medical conditions, medication and vitamin intake, nail hygiene/manicure habits, demographic data, occupational exposures, and self-diagnosis of personal or family history of brittle nails. Photographs of the volunteer's nails were taken and measurements of the length of the whole nail plate and the length of the distal unattached nail plate were obtained. Two nails, one from each hand, were then clipped from each patient. Nail clippings were then stored in a labeled container and analyzed in the laboratory by a blinded investigator within an average of 24 hours. Because the time lapse between nail clipping and laboratory analysis may have affected our results, a subanalysis was designed to assess whether the nail clippings were losing water in the time period between being clipped and analyzed.

In the subanalysis, 10 participants with brittle nails and 8 participants with normal nails volunteered to have two nails clipped for examination. After being clipped, each nail was then clipped in half and one portion was analyzed within 1 hour of the clipping, and the other nail segment was analyzed at 24 hours. Because age was a significant predictor of water content in our larger analysis, all means in the subanalysis were age adjusted.

In the laboratory, nail clippings were first weighed using a fine balance (Sartorius Corp, Bohemia, NY) and predehydration weight was recorded. Samples were analyzed within 30 hours of collection (mean analysis time 24 hours). The samples were then heated in a vacuum oven (Precision Scientific Group, Chicago, Ill) at 100°C for 24 hours. The samples were subsequently removed from the oven and placed in an airtight jar equipped with silica to ensure dehumidification of the jar. The samples cooled in this airtight jar for 2 hours and were then weighed again. The difference in weight between prehydration and postdehydration divided by the predehydration weight was used to express the water content as a percentage.

Statistical analysis

Statistical analyses were performed using software (SAS Institute Inc, Cary, NC). Chi-square tests were used to compare proportions of patients with brittle and normal nails among categories of several variables. Logistic regression models were used to compute odds ratio and 95% confidence interval (CI) to compare characteristics of brittle versus normal nails. Age was found to confound the association between brittle/normal nail status and the independent variable of interest and so all odds ratios were age adjusted. Because 87 of the 102 patients had two nails sampled, mixed model analysis of variance, a statistical method that accommodates correlated data, was used to compare mean percent water values among categories of several variables. As a result of nail sample losses, 15 of the 102 nails were not included in the final analysis.

RESULTS

Water percentage

The mean water content percentage for normal nails was 11.90% (SD ± 1.88; range 7.69-22.22), and for brittle nails was 12.48% (SD ± 2.64; range 6.25-24.0). There was no statistically significant difference between the two groups.

There was no difference in the water content between participants with onychorrhexis and onychoschizia.

The results of our subanalysis showed that at 1 hour the mean water content for brittle nails was 13.96% (95% CI 12.44, 15.49), whereas normal nails contained 11.25% (95% CI 10.25, 12.26). When the other half of the sample segments were analyzed at hour 24, the brittle nails had a mean water percentage of 10.32% (95% CI 8.98, 11.65) and the mean water content for normal nails was 10.69% (95% CI 8.98, 12.40). Water loss occurred between the time the nails were clipped and analyzed. The brittle nails appeared to lose more water during this time period than the normal nails.

The percentage of water in the nail plate was found to significantly decrease with age (P = .0343). When all variables were age-adjusted, there were no statistically significant relationships between the water percentage of the nail plate and the following variables: sex, race, presence of a chronic medical condition, vitamin supplementation, professional manicuring habits, use of nail enamel remover, length of nail plate, length of the distal unattached nail plate, digit number, chemical exposures, current smoking status, use of fingernails to open containers, use of hands for typing, moisturizer use, hand soaking, frequency of hand washing, and climate during last 3 months.

An analysis of variance was performed on water content percentage and intrapatient and interpatient variance components were estimated. Among the 102 participants, the interpatient SD was 0.70% and the intrapatient SD was 1.99%. Thus, water percentage results varied more within a single participant than between participants.

Table I. Patient characteristics

	Brittle	Normal	Total
Sex			
Male	4	21	25
Female	23	54	77
Age, y			
≤ 29	7	20	27
29-43	6	20	15
43-52	1	9	10
>52	13	26	39
Race			
Caucasian	17	46	63
Black	2	8	10
Hispanic	6	7	13
Asian	1	12	13
Other	1	2	3
Nail smaples			
No. of nails, men	8	37	45
No. of nails, women	42	102	144
Onychorrhexis (nonexcessive)	0	36	36
Onychoschizia only	19	0	19
Excessive onychorrhexis	31	0	31
Neither onychorrhexis nor onychoschizia	0	103	103

Brittle nails compared with normal nails

Table II shows odds ratios relating several variables of interest to brittle nail status. Characteristics of statistical significance in our analysis were professional manicuring habits, frequency of hand moisturizer use, and family history of brittle nails. The odds of having brittle nails were 3.23 times greater among participants who received a professional manicure (95% CI 1.21, 8.59). The frequency of professional manicures was associated with the likelihood of having brittle nails. The odds of nail brittleness were 2.21 times greater among participants who used nail polish remover (95% CI 0.84,5.84). The frequency of use of nail polish remover was also associated with the incidence of brittle nails. Specifically, the odds of having brittle nails was 4.71 times greater among participants who used nail polish remover twice a week (95% CI 0.56, 39.65), 3.36 times greater among participants who used remover weekly or every other week (95% CI 0.89, 12.70), and only 1.49 times greater among infrequent users of nail polish remover defined as less than once every 6 months (95% CI 0.37, 5.98). Hand moisturizer was significantly associated with nail brittleness. The odds being 6.57 times greater among participants who frequently used hand moisturizer defined as at least 7 times per day (95% CI 1.35, 32.10). Family history was significantly associated with the likelihood of having brittle nails. The odds being 5.9 times greater among participants who

Table II. Odds ratios relating several variables of interest to brittle nail status

	Age-adjusted odds ratio	95% Confidence interval
Professional manicure		
Yes	3.23	1.21, 8.59
No*	1.00	. . .
Frequency of manicures		
1×/2 wk	5.16	1.32, 20.19
1×/mo	4.33	1.04, 18.03
<Every month	4.07	0.76, 21.93
<Every 6 mo	1.43	0.33, 6.30
Never*	1.00	. . .
Use of nail polish remover		
2×/wk	4.71	0.56, 39.65
1×/2 wk	3.36	0.89, 12.70
1×/mo	1.42	0.36, 5.63
<Every month	3.72	0.65, 21.25
<Every 6 mo	1.49	0.37, 5.98
Never*	1.00	. . .
Frequent use of hand moisturizer		
Yes	6.57	1.35, 32.10
No*	1.00	. . .
Family history of brittle nails		
Yes	5.90	1.65, 21.11
No*	1.00	. . .
Sex		
Female	2.43	0.73, 8.05
Male*	1.00	. . .

*Reference category.

reported a family history of brittle nails (95% CI 1.65, 21.11). The odds of having brittle nails were 2.43 times greater among women (95% CI 0.73, 8.05).

There were no significant differences between brittle and normal nails for the following variables: age, race, self-described health status (on a scale from excellent to poor), presence of a chronic medical condition, vitamin supplementation, length of the distal unattached nail plate, digit number, current smoking status, use of fingernails to open containers, use of hands for typing, frequency of hand soaking and hand washing, chemical exposures, and climate during last 3 months.

A separate analysis was performed to determine whether one of the variables, age or menopausal status, was more predictive of brittle nails than the other variable. Because menopausal status was completely confounded by age (ie, premenopausal women were between 19 and 61 years of age with only one woman older than 51 years and postmenopausal women were between 52 and 79 years of age), an age-adjusted odds ratio comparing postmenopausal and premenopausal women would not be valid. To address this question, the analysis was expanded to look at the odds ratios of women to men within the younger and older age groups. If menopausal status had no effect and only age was a predictor, one would expect the resulting odds ratios to be similar in the two age groups. On the other hand, a difference in odds ratios (of women to men) would suggest that the premenopausal and postmenopausal women were different relative to the comparably aged men, indicating that menopausal status had predictive ability above and beyond age alone. The odds ratio comparing premenopausal women with men younger than 61 years was 1.83 (95% CI 0.45, 7.39) and that comparing postmenopausal women with men older than 61 years was 3.24 (95% CI 0.33, 31.54). The difference between the two odds ratios was not statistically significant (P = .7592).

DISCUSSION

In contrast to several claims that brittle nails contain less than 16% water and normal nails contain 18% water, in this investigation there was no significant difference in water content between brittle and normal fingernail plates. The mean water content of the nail plates in this analysis (12.05%) was within the range of the water content of normal nails reported in the literature (7%-18%).[2-4,6-10] In this investigation, although the difference was not statistically significant, brittle nails had higher nail plate water content than normal nails. Water percentage results varied more within a single participant than between participants. It may be possible that nail plate water content is variable within a single nail plate.

These results do not suggest that brittle nails contain more water than normal nails but rather that given the findings in this study it is possible that nail plate water content is random and that there is no relationship between nail plate water content and nail brittleness. When we consider the physiology of the nail plate, it becomes easier to conceptualize nail plate water content as an ephemeral phenomenon. Nail plates are extremely absorptive and in a constant state of influx and efflux of water. The flux of water across the nail plate has been demonstrated to be 10 times that of the epidermis and up to 1000 times more permeable to water than the stratum corneum.[9] Given the intrinsically transient nature of the water content of the nail plate, it seems more plausible that the water content is both random and constantly changing. Therefore, as demonstrated in this study, water content is not related to nail brittleness.

This lack of relationship between nail plate water content and nail brittleness has treatment implications. Many dermatologists prescribe moisturizers for patients with brittle nails. To treat brittle nails we must be able to more effectively conceptualize the pathophysiology of nail brittleness. It was interesting to note that hand moisturizer use was a significant predictor of brittle nails given the number of investigators who claim that brittle nails result from dehydration of the nail plate.[1,2,6,11] In our study, participants who used hand moisturizers frequently, defined as at least 7 times per day, were significantly more likely to have brittle nails. This is an important finding given the multitude of authors who also mention moisturizing as a potential treatment regimen for brittle nails.[2,7,8,12,13] In addition, this finding may suggest that people who have brittle nails also tend to have dry skin, which may also imply that people with brittle nails attempt to self-treat their hands and nails with moisturizers more frequently.

Professional manicures were associated with brittle nails. This finding is consistent with the literature.[7] Our study did not answer the question of whether manicures lead to brittle nails or whether patients with brittle nails are simply more likely to get manicures. It would be interesting to know more about the chemical composition of the nail products. In addition, participants who used nail enamel remover were twice as likely to have brittle nails and the frequency of use correlated with nail brittleness. This is consistent with the literature, which describes nail enamel remover as one of the major causes of brittle nails. It has been theorized that enamel removers dissolve or alter the intercellular adhesive factors within the nail plate.[8] Although some advocate the use of nail enamel to slow the evaporation of water from the nail plate, the removal of nail enamel requires using a nail enamel remover that may lead to brittle nails. In our study, participants did not specify whether they use acetone or nonacetone enamel remover. It is possible that acetone-containing products are more damaging to the nail plate.

The difference between the odds ratio comparing premenopausal women with younger men and that comparing postmenopausal women with older men was not statistically significant. However, this study was not designed or powered to test such a hypothesis. The observation that the odds ratio in the older age group is larger (3.24) than that in the younger age group (1.83) suggests that menopausal status may, in fact, be predictive of brittle nails independent of age and perhaps this hypothesis could be the focus of a larger study in the future.

The diagnostic criteria in the literature for brittle nails are not well defined; however, our definition of brittle nails is consistent with that of Kechijian.[8] The lack of a standard definition complicates the study of brittle nails because of the lack of consistency among researchers and, therefore, limits the comparability of findings. Furthermore, laypeople tend to conceptualize brittle nails differently from physicians. The volunteers in our study were asked whether they had brittle nails. We subsequently compared the accuracy of volunteers' self-diagnoses with our clinical diagnoses. Participants who met the study definition criteria of brittle nails were 30% less likely to accurately self-diagnose themselves compared with participants with normal nails. In other words, the layperson's conceptual definition of brittle nails is not consistent with dermatologic definitions.

There are several limitations to this study. Analyzing nail plates from living volunteers is challenging because nail plate samples can only be collected from the distal unattached nail plate. Therefore, extremely brittle nails that broke before achieving an adequate length for cutting were not available for us to sample. Some might say that our results of water content, therefore, may have been artificially high. However, the average water content was higher in participants with brittle nails than participants with normal nails.

As previously described, we used a universally standard clinical definition of brittle nails, however, some might say that using a clinical term to describe nail brittleness may be limiting in comparison with measuring the actual mechanical properties of the nail.

Our subanalysis was designed to determine the degree to which nail clippings were losing water in the time period between when the samples were clipped and when they were analyzed in the laboratory. As previously stated, our nail plate water contents were higher at 1 hour compared with hour 24, thus demonstrating that water loss occurred while the samples were being stored before analysis.

In future investigations, nail samples should be analyzed as close as possible to the time of the nail clipping to more accurately determine in vivo nail plate water content values. It would be interesting to analyze whole nail plates in future studies to investigate the question of whether water content is variable within a single nail plate.

In conclusion, there was no significant reduction in water content of brittle nails compared with normal nails. Professional manicures and nail enamel remover use were associated with brittle nails. Participants who have brittle nails tend to use hand moisturizers more frequently. Women were more likely to have brittle nails and menopausal status may be a risk factor for brittle nails. A positive family history of brittle nails was predictive of brittle nails.

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