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Original article

Association Between Serum Zinc, Vitamin D, and Ferritin Levels and Hair Loss: A Cross-Sectional Study of Patients at Al-Ajilat Central Clinic

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Abstract
One of the common health ailments of today is hair loss, which may be the result of multiple factors, including a person's diet. Therefore, the present research was focused on the assessment of micronutrient deficiencies among Libyan patients suffering from diffuse hair loss. The present research was cross-sectional in nature with a sample consisting of 136 males and 136 females. Serum levels of zinc, vitamin D, and ferritin were measured in study cases (with hair loss) and controls (without hair loss). There was a marked statistically significant difference observed in all three cases of hair loss; the cases were noted to have lower mean levels of zinc (71.48vs94.28µg/dL), ferritin (35.83vs126.56ng/mL), and vitamin D (21.42vs60.59ng/mL). Furthermore, cases of hair loss showed a significant relationship with lower levels of zinc in both males and females (p<0.001). A significantly lower amount of ferritin was more strongly correlated with hair loss in both males and females (p<0.001). A vitamin D deficiency was common in 52.8% of the population sample with hair loss. The current research reflects the significant relationship between hair loss with lower levels of zinc and vitamin D, and ferritin. Furthermore, this study proposes that it would be worthwhile to evaluate the relationship of hair loss with micronutrient deficiencies.
Keywords: *Zinc Deficiency, Vitamin D, Ferritin Level, Hair Loss, Libyan Patients.*

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Introduction

Hair loss represents a prevalent clinical concern frequently encountered in dermatological practice, affecting individuals of all ages and both sexes [1]. The condition carries significant psychosocial consequences, frequently resulting in diminished self-esteem for both men and women [2,3]. The psychological impact is particularly profound for women, as sociocultural norms often equate hair with femininity, beauty, and vitality [4]. The etiology of alopecia is multifactorial, encompassing genetic predispositions and a diverse range of non-genetic factors. These include nutritional deficiencies (specifically of vitamins and minerals), dermatological and systemic diseases, hormonal imbalances, pharmacological side effects, psychological stress, physiological stressors such as childbirth, and medical interventions like chemotherapy [5]. Accurate etiological identification is therefore a critical component of effective diagnosis and management.

Hair analysis serves as a valuable, non-invasive method for detecting deficiencies of essential nutrients [6]. Zinc deficiency, for instance, constitutes a major global health issue with direct implications for hair health [7]. In pediatric populations, zinc deficiency is associated with impaired growth, malnutrition, and other clinical manifestations, which are reversible with supplementation. A study by [8] revealed that 88% of malnourished children exhibited low hair zinc concentrations. Similarly, a large-scale study in Japan involving over 28,000 participants reported zinc deficiency prevalences of 36.5-47.3% in infants and 19.7% in elderly individuals [9]. Further supporting this, [10] found a 9.1% prevalence of zinc deficiency, with higher rates observed among younger children and those from lower socioeconomic backgrounds. Research on Palestinian university students also identified associations between both low and high serum zinc levels and extensive patterned scalp alopecia, though no correlation was found with other health conditions or dietary scores [11].

Iron deficiency is another established factor linked to diffuse hair loss, often manifesting as telogen effluvium [12,13]. The interplay between micronutrients is highlighted by [14], who reported that among 560 zinc-deficient patients, concurrent iron deficiency (60.1% vs. 50%) and iron deficiency anemia (20.2% vs. 12.7%) were significantly more prevalent than in non-deficient individuals.

Emerging evidence suggests a potential association between vitamin D deficiency and various nonscarring alopecias [15]. Vitamin D plays a critical role in cellular proliferation and differentiation, and its deficiency has been implicated in diffuse hair loss [2,16]. Research by [17] indicated that low serum vitamin D levels were linked to significant hair loss in women aged 35-45. Reduced serum 25-hydroxyvitamin D levels have been documented in patients with alopecia areata, telogen effluvium, and female pattern hair loss, with vitamin D replacement therapy demonstrating efficacy in promoting hair regrowth in cases of nonscarring alopecia [14]. These findings underscore vitamin D's crucial role in maintaining follicular health. Beyond its function in hair cycling, vitamin D and its receptor are integral to a wide range of physiological processes,

including calcium and skin homeostasis, as well as the modulation of innate and adaptive immune responses within the skin [18,19].
While a battery of laboratory tests can aid in determining the specific cause of hair loss on a case-by-case basis, the preceding literature substantiates a direct correlation between deficiencies in vitamin D, zinc, and iron (as reflected by ferritin levels) and alopecia. Nonetheless, the precise pathophysiological roles of these micronutrients remain incompletely elucidated due to a paucity of comprehensive research. Consequently, this study aims to investigate the relationship between serum levels of zinc, vitamin D, and ferritin and the presentation of hair loss, and to compare these parameters across different age and gender groups among patients attending the Al-Ajilat Central Clinic.

Methods

Study Design, Setting, and Period

A cross-sectional study was conducted at the Al-Ajilat Central Clinic in the western region of Tripoli, Libya, from June to September 2024.

Study Participants

The study enrolled 272 participants (136 females, 50%; 136 males, 50%) who presented to the dermatology department with a complaint of hair loss. Patients of all ages exhibiting any type of alopecia were included. Exclusion criteria encompassed a diagnosis of chronic liver disorders or the use of medications known to influence bone metabolism or hepatic function.

Biochemical Analysis

Venous blood samples were collected from all participants to determine serum levels of zinc, vitamin D, and ferritin. Ferritin concentration was evaluated using a Cobras Integra hematological blood analyzer from EDTA-anticoagulated samples. Plasma zinc levels were measured via spectrophotometry (pm4040). Serum 25-hydroxycholecalciferol (Vitamin D) concentration was assessed using a competitive enzyme-linked immunosorbent assay (ELISA). All laboratory investigations were performed on-site at the Al-Ajilat Central Clinic.

Statistical Analysis

Data were analyzed using descriptive and inferential statistics. The sample distribution by gender and age was summarized using frequencies and percentages. Independent samples t-tests were employed to compare mean levels of Zinc, Ferritin, and Vitamin D between the case (hair loss) and control groups, as well as between males and females. The Chi-square test was used to examine associations between categorical classifications of micronutrient levels and hair loss. Differences in micronutrient levels across age groups were analyzed using a one-way ANOVA with post hoc comparisons. A p-value of less than 0.05 was considered statistically significant for all tests. Analyses were performed using SPSS (Version 27).

Results

Demographic Characteristics of the Study Population

The final analytical sample consisted of 272 participants, demonstrating a balanced gender distribution with 136 males (50%) and 136 females (50%) (Table 1). Age stratification revealed a predominantly young to middle-aged cohort, with 48.5% (n=132) under 30 years, 43.8% (n=119) aged 30-49 years, and 7.7% (n=21) aged 50 years or older (Table 2).

Table 1. Sample distribution based on gender.

Gender	Count	%
Male	136	50
Female	136	50

Table 2. Sample distribution based on age.

Age	**Count**	**%**
< 30	132	48.5
30 – 49 years	119	43.8
≥ 50	21	7.7

Comparative Analysis of Serum Micronutrient Profiles

Independent samples t-tests revealed significant disparities in serum micronutrient concentrations between cases (n=180) and controls (n=92). As summarized in Table 3, cases exhibited markedly lower mean values across all measured parameters: zinc (71.48 ± 16.76 vs. 94.28 ± 13.33 µg/dL, t = -12.198, $p < 0.001$), ferritin (35.83 ± 41.67 vs. 126.56 ± 96.42 ng/mL, t = -8.624, $p < 0.001$), and 25-hydroxyvitamin D (21.42 ± 13.78 vs. 60.59 ± 21.11 ng/mL, t = -16.127, $p < 0.001$).

Table 3. Comparison of Zinc, Ferritin, and Vitamin D Levels Between Experimental and Control Groups.

Variable	Group	Count	Mean	Std	T value	P value
Zinc	Case	180	71.48	16.760	-12.198	< 0.001
	Control	92	94.28	13.333		
Ferritin	Case	180	35.83	41.668	-8.624	< 0.001
	Control	92	126.56	96.424		
Vitamin D	Case	180	21.42	13.777	-16.127	< 0.001
	Control	92	60.59	21.114		

Stratified analysis by age cohorts maintained these significant differences (Table 4). Across all age categories (<30, 30-49, and ≥50 years), case participants demonstrated consistently diminished micronutrient levels compared to age-matched controls (all comparisons $p < 0.05$).

Table 4. Comparison between cases and controls in terms of Zinc, Ferritin, and vitamin D across different age groups.

Variables	Age	Group	N	Mean	Std	T value	P-value
Zinc	< 30	Case	94	70.30	16.485	-8.072	< 0.001
		Control	38	95.35	15.249		
	30-49	Case	72	74.13	17.276	-7.463	< 0.001
		Control	47	94.06	11.853		
	≤ 50	Case	14	65.79	14.498	-3.754	0.001
		Control	7	89.91	12.460		
Ferritin	< 30	Case	94	36.19	38.228	-5.030	< 0.001
		Control	38	120.10	99.929		
	30-49	Case	72	31.47	32.248	-7.026	0.003
		Control	47	120.34	82.706		
	≥ 50	Case	14	55.84	85.055	-2.567	0.032
		Control	7	203.44	139.744		
Vit D	< 30	Case	94	19.36	9.526	-13.046	< 0.001
		Control	38	64.58	20.489		
	30-49	Case	72	24.44	18.002	-8.542	0.008
		Control	47	55.35	20.095		
	≥ 50	Case	14	19.72	10.478	-5.884	< 0.001
		Control	7	74.19	23.347		

Parallel analysis stratified by gender confirmed these findings, with both male and female cases showing significantly reduced concentrations of all three biomarkers relative to their control counterparts (all p-values < 0.001) (Table 5).

Table 5. Comparison between cases and controls in terms of Zinc, Ferritin, and Vitamin D across gender.

Variables	Gender	Group	N	Mean	Std	T value	P-value
Zinc	Male	Case	90	74.79	17.728	-7.298	< 0.001
		Control	46	96.03	15.131		
	Female	Case	90	68.17	15.117	-9.659	< 0.001
		Control	46	92.52	11.145		
Ferritin	Male	Case	90	37.58	50.180	-7.945	< 0.001
		Control	46	175.57	112.194		
	Female	Case	90	34.07	31.107	-6.954	< 0.001
		Control	46	77.56	36.124		
Vit D	Male	Case	90	22.86	17.364	-10.625	< 0.001
		Control	46	62.96	22.386		
	Female	Case	90	19.98	8.721	-12.541	< 0.001
		Control	46	58.23	19.722		

Categorical associations between micronutrient status and alopecia

Dichotomization of micronutrient levels revealed substantial associations with alopecia status. As presented in Table 6, zinc insufficiency (<80 µg/dL) was prevalent in 70% of cases, with a statistically robust association (x^2 = 28.800, $p < 0.001$).

Table 6. Association between Zinc level and hair loss.

Zinc Level	Count	%	Chi square	P value
Less than 80 (Low)	126	70.0	28.800	< 0.001
80-120 (Normal)	54	30.0		

Gender-specific analysis of ferritin status demonstrated a particularly strong association in female participants (x^2 = 96.200, $p < 0.001$), where 98.9% of cases exhibited either deficient (<13 ng/mL) or low-normal (13-150 ng/mL) ferritin concentrations (Table 7). The association, while present, was less pronounced in male cases (x^2 = 2.844, p = 0.092).

Table 7. Association between ferritin level and hair loss by gender.

Gender	Ferritin Level	Count	%	Chi square	P value
Male	Less than 30 (Low)	53	58.9	2.844	0.092
	30-400 (Normal)	37	41.1		
	More than 400 (High)	-	-		
	Total	90	100.0		
Female	Less than 13 (Low)	16	17.8	96.200	< 0.001
	13-150 (Normal)	73	81.1		
	More than 150 (High)	1	1.1		
	Total	90	100.0		

Vitamin D status showed the most pronounced association with alopecia (Table 8). Notably, 83.9% of case participants presented with either deficient (<20 ng/mL) or insufficient (20-30 ng/mL) vitamin D levels, with a highly significant chi-square value (x^2 = 106.533, $p < 0.001$).

Table 8. Association between Vitamin D level and hair loss.

Vitamin D Level	Count	%	Chi square	P value
Less than 20 (Deficient)	95	52.8	106.533	< 0.001
20-30 (Insufficient)	56	31.1		
30-80 (Adequate and healthy)	27	15.0		
More than 80 (Associated with toxic side effects)	2	1.1		

Subgroup analysis of micronutrient variations within the case cohort

Comparative analysis within the case group revealed a statistically significant gender difference in zinc concentrations, with male participants exhibiting higher mean levels than females (74.79 ± 17.73 vs. 68.17 ± 15.12 µg/dL, t = 2.697, p = 0.008) (Table 9). No significant gender-based differences were observed for ferritin (p = 0.573) or vitamin D (p = 0.163) levels.

Table 9. Comparison between males and females with hair loss across different variables.

Variable	Gender	N	Mean	Std	T value	P-value
Zinc	Male	90	74.79	17.728	2.697	0.008
	Female	90	68.17	15.117		
Ferritin	Male	90	37.58	50.180	0.565	0.573
	Female	90	34.07	31.107		
Vitamin D	Male	90	22.86	17.364	1.403	0.163
	Female	90	19.98	8.721		

One-way ANOVA testing across age strata within the case group demonstrated no statistically significant variations in zinc (F = 1.958, p = 0.144), ferritin (F = 2.036, p = 0.134), or vitamin D (F = 2.953, p = 0.055) concentrations, although the latter approached statistical significance (Table 10).

Table 10. Comparison between age groups with hair loss across different variables.

Variable	Age	N	Mean	Std	F value	P-value
Zinc	< 30	94	70.30	16.485	1.958	0.144
	30-49	72	74.13	17.276		
	≥ 50	14	65.79	14.498		
Ferritin	< 30	94	36.19	38.228	2.036	0.134
	30-49	72	31.47	32.248		
	≥ 50	14	55.84	85.055		
Vit D	< 30	94	19.36	9.526	2.953	0.055
	30-49	72	24.44	18.002		
	≥ 50	14	19.72	10.478		

Discussion

This cross-sectional study investigated the association between serum levels of zinc, vitamin D, and ferritin with hair loss in a Libyan cohort from the Al-Ajilat Central Clinic. The analysis of 272 participants, comprising an equal gender distribution, revealed a pronounced and statistically significant deficiency in all three biomarkers among individuals with hair loss compared to controls.

The principal finding of this study is the consistent and significant depletion of zinc, ferritin, and vitamin D in the case group. A notable gender disparity was observed in the relationship between ferritin and hair loss. Among male participants, 58.9% exhibited low ferritin levels; however, the association, while suggestive ($x^2 = 2.844$, $p = 0.092$), did not reach statistical significance and should be interpreted with caution. In contrast, a robust and statistically significant association was observed among female participants ($x^2 = 96.200$, $p < 0.001$), with the majority (81.1%) falling within the low-normal ferritin range and 17.8% being deficient. This strong association underscores the potential influence of diminished iron stores on hair health in females, a finding consistent with studies by Nasrin et al. [34] and Ali et al. [35].

Beyond ferritin, the pronounced deficiency of zinc and vitamin D in the case group corroborates existing literature. The inverse relationship between these micronutrient levels and alopecia is well-documented in the work of Wang et al. [20] and Salecha et al. [21]. The critical role of these nutrients is further substantiated by Thompson et al. [23], who identified lower serum vitamin D and zinc levels in patients with alopecia areata. Our data strongly suggest that a deficiency state in these micronutrients may be a significant contributing factor to the pathogenesis of hair loss.

A particularly robust association was observed between categorical deficiencies and alopecia. The high prevalence of zinc insufficiency (70%) in the case group aligns with findings by Al-Rubayee [32]. The relationship with vitamin D was the most pronounced, with over 80% of cases exhibiting deficient or insufficient levels, a finding strongly supported by Nayak et al. [22, 36].

Subgroup analysis within the case cohort further revealed that gender was a factor for zinc levels, with females demonstrating significantly lower concentrations than males, indicating a potential gender-specific vulnerability. However, no significant variations were detected across age groups for any of the three micronutrients, suggesting that deficiency is a common feature in hair loss patients, but its expression may not be primarily driven by age in this population.

The collective evidence from this study, in concert with prior research [20, 23, 26, 28], underscores the multifaceted role of micronutrients in the biochemistry of the hair follicle. The strong correlations observed, particularly for ferritin in women and for vitamin D and zinc across the cohort, advocate for the clinical utility of screening for these deficiencies in patients presenting with alopecia. The identification and subsequent correction of these deficiencies could constitute a valuable component of a comprehensive management strategy, potentially aiding in the restoration of hair growth and improving overall patient well-being.

Conclusion

Based on the cross-sectional study conducted at Al-Ajilat Central Clinic in Libya, significant deficiencies in zinc, ferritin, and vitamin D were consistently observed in patients with hair loss compared to healthy controls. These deficiencies were evident across different age groups and both genders, though ferritin deficiency showed a particularly strong association with hair loss in female patients. The findings highlight the potential role of these micronutrients in maintaining follicular health and support integrating routine screening for these deficiencies into clinical practice for managing hair loss. Further large-scale longitudinal studies are recommended to establish causality and evaluate the therapeutic outcomes of micronutrient supplementation.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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