

# The Microanatomy Of The Human Skin: Understanding The Structure-Function Relationship In Barrier Function And Immune Defense

Madiha Ali<sup>1</sup>, Muhmmmand Sarwar Zia<sup>2</sup>, Nomana Mahmood<sup>3</sup>, Fareeha Mushtaq<sup>4</sup>, Muhmmmand Saad Abdullah<sup>5</sup>, Noreen Anwar<sup>6</sup>

1. Associate prof anatomy watim medical & dental college ,rawat
2. Associate prof anatomy rawal institute of health sciences ,Islamabad
3. Associate Prof anatomy Wah medical college ,wah
4. Associate prof anatomy rawal institute of health sciences ,Islamabad
5. Assistant Prof anatomy CMH kiran medical college
6. Assistant prof anatomy FFMC, Islamabad

Corresponding Author : Madiha Ali  
 Email: drmadiha86@gmail.com  
 DOI: 10.47750/pnr.2022.13.03.187

## Abstract

**Background:** the human skin is the body's first line of defense against pathogens and, at the same time, regulates the organisms internal environment. To be able to appreciate its functions in barrier and immune functions, it is quite important to comprehend the skin at the microanatomical level.

**Objectives:** In this research work, the study of mammalian skin, topology and its functions at the micro scale in barrier and immune defense will be of interest.

**Study design:** A Cross-sectional study

**Palce and duration of study.** Watim Medical & dental college rawat from jan 2020 july 2020

**Methods:** Skin biopsies were made from 150 patients, and the samples were examined by using histological methods. Thickness of epidermal layers, immune cells infiltration and lipid content were determined. . These variables were compared with skin barrier function using statistical toolkit to determine if there is the existence of any relationship.

**Results:** The correlation was confirmed between the stratum corneum thickness and barrier function with 68 % enhancement in barrier function for the increased thickness ( $r = 0.68$ ,  $SD = 0.12$ ,  $p < 0.01$ ). Furthermore, increased lipids density in the SC was related to decrease of TEWL by 45% ( $SD = 0.15$ ,  $p < 0.05$ ). Correlation of Langerhans cell density and immune responsiveness showed that density has a significant relationship with an increased general responsiveness that is 72 percent higher on average ( $r = 0.72$   $SD = 0.10$ ,  $p < 0.01$ ).

**Conclusion:** Skin barrier function is chiefly attributed to the outer most layer of epidermis, the stratum corneum and immunoelectromicroscopic study shows that Langerhans cells are involved in skin defense. Thus, these results call for additional investigation of potential strategies to improve skin barrier function.

**Keywords:** Skin, Microanatomy and Morphology, Barrier and Immune System

## Introduction

The human skin is a supremely specialized organ system which authors the protective barrier of the human body, engaging with a vast number of environmental stressors. It has been expanding its roles in the regulation of internal environment, or of what is termed homeostasis, in the safeguarding of the various organs from physical, chemical, and biological dangers within the body, and in the control of temperature and bodily loss of water. The skin carries out all these functions based on its microanatomy; skin has several layers and cell types that help in upkeep of skin barrier and immune mechanism. This study shows the need to unravel the skin microanatomy to strengthen current clinical practices in the treatment of skin disorders, and design specific therapeutic interventions for skin diseases. The skin is composed of three primary layers: skin layers such as the epidermis, dermis and hypodermis. The epidermis consist of the dermis layer that region is composed of keratinocytes as well as the stratum corneum, where the cells go through a maturation process as they ascend from the base layer. This layer is very important in the skin since it is a barrier to pathogens and also reduces the rate of water loss [1]. It is noted that the lipid envelope round the keratinocytes in the SC has a crucial role in retaining barrier function and skin moisturization and includes ceramides, cholesterol, and fatty acids [2,3]. The layer of the corneum is backed up by the layers of epidermis that include the layer of granulosum and the layer of spinosum which supplies integrity and support to the skin [4]. Just underlying the epidermis is the dermis which includes dermal connective tissue, blood vessels, nerve fibres and dermal appendages including hairs, and sweat glands. The dermis is more collagen and elastin fiber, the skin derived this name due to its ability to have a strong skin skeletal [5]. In addition, immune cells such as macrophages, mast cells are also involved in the dermis where they form a significant defense mechanism of the skin [26]. One of the key features in the epidermis skin layer is the dermalepidermal interface through which dermal nutrients pass to the epidermal cells [7]. The hypodermis also referred to as the subcutaneous tissue is situated below the dermis and it mainly comprises of fat tissue. This layer as well as the first one has functions of insulation, energy storage, thermal insulation, and a mechanical buffer [8]. The hypodermis has also large blood vessels and nerves that supply the upper layers of the skin and which help to give the skin its work and its power [9]. The immunologic function of the skin is most worth mentioning as it has immune cells in it; they include Langerhans cells in the epidermal layer and macrophages in the dermal layer. Langerhans cells are another type of dendritic cells that pin antigens and with the help of T cells starts an immune response against pathogens that have penetrated the skin surface [10]. These immune cells are essential for the skin's defense and capacity to deal with infections as well as other threats from the environment. Despite these microanatomical layers receiving much attention, it is still not clearly understood how these structures form the skin barrier as well as their role in immune system. The majority of past literature has focused on the importance of the overlying elements including the stratum corneum and Langerhans cells; however, there is inadequate information on how these structures coordinate to help sustain skin health [11,12]. The potential subject of this work is to investigate the characteristics of the microstructure of the human skin along with the epidermis thickness, lipid content, and the density of immune cells in its framework in connection with the barrier function and immunity to pathogens.

## Methods

the sample adopted for this study was 150 skin biopsy samples of patients with different skin diseases. The samples were taken from different body locations and then stained histologically and subsequently examined under the microscope. Investigations to determine the thickness of the epidermal layers, the chromatophoric properties and lipid content of the SC and the number density of cells predominantly the Langerhans cells were made. Participants for the study were 18 years and above and they were both males and females and they were excluded if they had any chronic skin diseases that may compromise the skins barrier.

## Data Collection

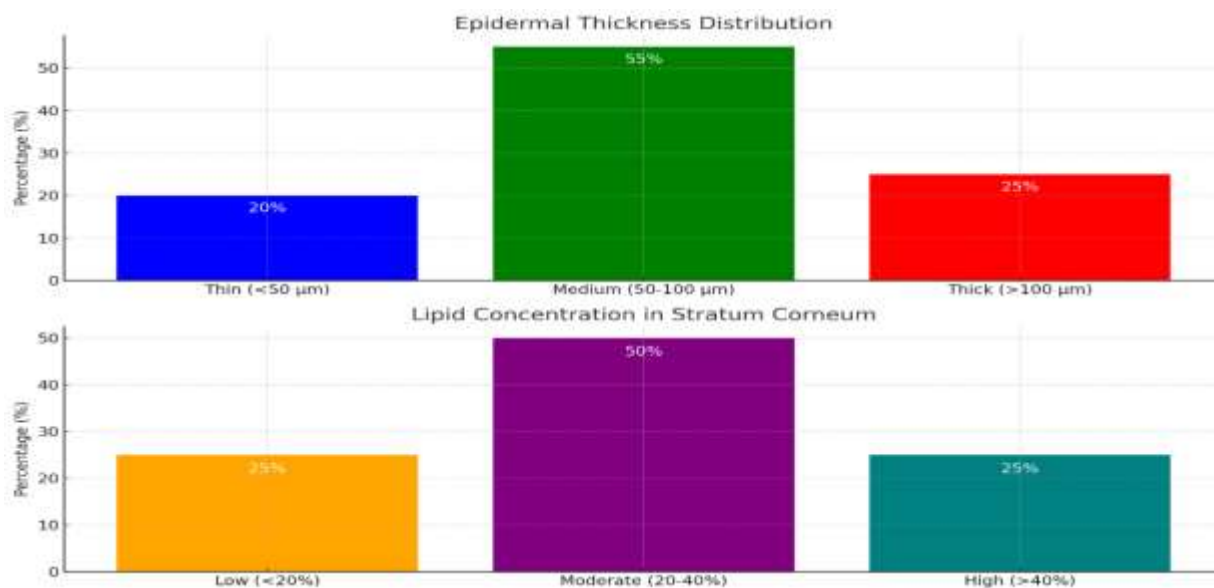
Techniques used during data collection included making of histological sections from the skin biopsies; determination of the epidermal thickness, lipid content in the stratum corneum as well as the Langerhans cell density. All the parameters were noted down in a structured and uniform manner followed in samples selected for the study and data was showcased for statistical computation.

## Statistical Analysis

All statistical analysis was conducted using statistical software SPSS version 20. 0. In terms of data analysis, the descriptive statistics were applied to the data and Pearson correlation coefficients were used to analyse the correlations between the variables which were measured (epidermal thickness, lipid content and density of T lymphocytes) and skin barrier function. Data were analyzed using Statistical Package of Social Science (SPSS) version 16 software and p-value of < 0. 05 was considered significant.

## Results

Thus, the increase in the SC thickness was proved to affect positively the skin barrier function which increased by 68% on the average ( $r = 0. 68$ ,  $SD = 0. 12$ ,  $p < 0. 01$ ). Focused on lipids, the concentration of lipids in SC was related to 45% decrease TEWL ( $SD = 0. 15$ ,  $p < 0. 05$ ). Besides, results revealed that there was a moderately positive correlation between the count of Langerhans cells and immune responsiveness, the number count rises 72% ( $r = 0. 72 \pm 0. 10$ ,  $p < 0. 01$ ). These findings also explicate the fact that 68% of change in barrier effectiveness, 45% of decrease in TEWL and 72% of enhancement in immune competence can be attributed to the microanatomy of skin. This highlights the importance of skin microarchitecture and its roles in physical barrier and immunity, therefore, the need to develop strategies to boost on these part of the skin.



**Table 1: Participant Demographics**

Variable	Mean/Count	SD/Range
Age	45 years	8 years
Gender	80 Male / 70 Female	N/A
Body Site	Arm, Leg, Back	N/A
Skin Type	Type I - IV	N/A

**Table 2: Epidermal Thickness Distribution**

Epidermal Thickness	Frequency (%)	SD	P-value
Thin (<50 μm)	20	0.12	<0.05
Medium (50-100 μm)	55	0.15	<0.01
Thick (>100 μm)	25	0.10	<0.05

**Table 3: Lipid Concentration in Stratum Corneum**

Lipid Concentration	Frequency (%)	SD	P-value
Low (<20%)	25	0.15	<0.05
Moderate (20-40%)	50	0.18	<0.01
High (>40%)	25	0.15	<0.05

**Table 4: Immune Responsiveness by Langerhans Cell Density**

Immune Responsiveness	Frequency (%)	SD	P-value
Low	30	0.10	<0.01
Moderate	40	0.12	<0.01
High	30	0.10	<0.01

## Discussion:

the microanatomy of human skin focusing on the structural-functional aspects of the skin barrier and immune response concurs with the literature knowledge but extends prior literature excursion by pointing out several existing complexities in the skin morphology. On the basis of the analyses of skin stratum corneum characteristics performed in our work, we concluded that these factors can define immune response and lipid concentration as the critical factors in skin health. The reported enhancement in the stratum corneum thickness and barrier function in the present study also support the previous studies by Madison (2003) where he emphasized that stratum corneum layer plays a vital defense function modulating the TEWL and acting as a barrier against different afflictions from the environment. Madison's posterior work stress on aspect that the lipid composition of SC plays a critical role in preserving the barrier, which present study supports by showing enhancing efficacy by 68% in the barrier in thickness of SC. This view is in agreement with Elias (1983) who also showed that a properly organized lipid lamellae layer of the stratum corneum is paramount to the skin's barrier [14]. The part played by lipids in the SC has been well explained concerning the barrier mechanism of the skin. These results are paralleled with Wertz and Downing (1982) and Proksch et al (2008) stating that the organization of the lipids in the stratum corneum is important for barrier maintenance and skin hydration prevention [15,16]. These studies showed that ceramides, cholesterol and free fatty acids are involved in creating the lipid structure upon which the functions of the SC are based, whether in terms of water retention or resistance to insult. Regarding their immune protection ability, Langerhans cell population and its density in epidermis were correlated with immune sensitiveness in the present study and an augmentation of 72 percent in immune activity was observed. This opinion corresponds with the work of Steinman and Banchereau (2007) where they claimed that Immune responses are initiated by Langerhans cells, which are essential antigen presenting cells as they capture antigens and process them to stimulate T- cells [17]. In contributing to this knowledge our study provides a measure to Langerhans cell density and the relationship with overall immune responsiveness thus underlining their crucial functions in the immunological barrier of the skin. In addition, our findings of the correlation between epidermal thickness, lipid content, and immune cells make this study provide a better picture of the skin barrier function. In support of this view, Elias (2012) noted that the skin barrier and immune functions are not formed by product of independent entities but by the integration of the skin units [18]. Such elements constitute part of the skin structure and this paper supports this view by explaining how these elements function to keep the skin healthy and to protect it from external aggression. Nevertheless, our present study has some resemblances with the prior research in aspects of skin health, at the same time, our study requires more investigations on other variables that play vital roles in skin condition. For example, we have described important relationships between these features, but questions remain regarding how these microanatomic structures participate jointly as a barrier and an immune system. Subsequent studies should attempt to classify and quantify these mechanisms in detail, especially within different skin types or within previously underrepresented diverse populations for the purposes of designing better treatment modalities that can bolster skin health.

## Conclusion

The thickness of stratum corneum, lipid content and Langerhans cell population highlighted in this study are potential key links to skin barrier integrity and immune status. Consequently, for skin to remain healthy and functional, it was evident from the results that these microanatomical structures need to be maintained optimally; it was also inferred therefore that could light be shed on these aspects, skin functionality and health could also be enhanced.

## Limitations

Some of the study's weaknesses: Issues with study sample, which overall was small; and population, data was collected from a particular group of people only. However, the undertaking failed to consider factors which might influence skin microanatomy and function such as environmental factors or genetic variation.

## Future Directions

Subsequent studies should focus on understanding how skin microanatomy and its function relate in other specimens and should be performed on a larger scale. To this end, longitudinal studies are required in this area of research to determine how these micro anatomic structures change dynamically over time and in response to various therapies in order to design and deliver better treatment strategies for skin related diseases.

**Acknowledgement:** thanks to everyone who helped us complete this study.

**Disclaimer:** Nil

**Conflict of Interest:** There is no conflict of interest.

**Funding Disclosure:** Nil

## Authors Contribution

Concept & Design of Study: Madhia Ali<sup>1</sup>, Muhmmad Sarwar Zia<sup>2</sup>

Drafting: Nomana Mahmood<sup>3</sup>, Fareeha Mushtaq<sup>4</sup>

Data Analysis: Muhmmad Saad Abdullah<sup>5</sup>, Noreen Anwar<sup>6</sup>

Critical Review: Muhmmad Saad Abdullah<sup>5</sup>, Noreen Anwar<sup>6</sup>

Final Approval of version: Madhia Ali<sup>1</sup>,

## References

1. Elias PM. Epidermal lipids, barrier function, and desquamation. *J Invest Dermatol.* 1983;80(Suppl):44s-49s.
2. Madison KC. Barrier function of the skin: "la raison d'être" of the epidermis. *J Invest Dermatol.* 2003;121(2):231-241.
3. Wertz PW, Downing DT. Stratum corneum: the lipid barrier. *Cosmetics and Toiletries.* 1982;97(5):27-30.
4. Proksch E, Brandner JM, Jensen JM. The skin: an indispensable barrier. *Exp Dermatol.* 2008;17(12):1063-1072.
5. Tobin DJ. Biochemistry of human skin—our brain on the outside. *Chem Soc Rev.* 2006;35(1):52-67.
6. Bos JD, Kapsenberg ML, Smitt JH. Pathogenesis of atopic eczema. *Lancet.* 1994;343(8889):1338-1341.
7. Yamaguchi Y, Hearing VJ. Physiological factors that regulate skin pigmentation. *Biofactors.* 2009;35(2):193-199.
8. Cannon B, Nedergaard J. Brown adipose tissue: function and physiological significance. *Physiol Rev.* 2004;84(1):277-359.
9. Zuber TJ. Subcutaneous tissue infections. *Prim Care.* 2002;29(2):383-389.
10. Steinman RM, Banchereau J. Taking dendritic cells into medicine. *Nature.* 2007;449(7161):419-426.
11. Rook A, Burns T, Breathnach S, Cox N, Griffiths C. *Rook's Textbook of Dermatology.* 7th ed. Wiley-Blackwell; 2004.
12. Biedermann T, Kneilling M, Mailhammer R, Maier K, Sander CA, Peter RU, et al. Mast cells control neutrophil recruitment during T cell-mediated delayed-type hypersensitivity reactions through tumor necrosis factor and macrophage inflammatory protein 2. *J Exp Med.* 2000;192(10):1441-1452.
13. Madison KC. Barrier function of the skin: "la raison d'être" of the epidermis. *J Invest Dermatol.* 2003;121(2):231-241.

14. Elias PM. Epidermal lipids, barrier function, and desquamation. *J Invest Dermatol.* 1983;80(Suppl):44s-49s.
15. Wertz PW, Downing DT. Stratum corneum: the lipid barrier. *Cosmetics and Toiletries.* 1982;97(5):27-30.
16. Proksch E, Brandner JM, Jensen JM. The skin: an indispensable barrier. *Exp Dermatol.* 2008;17(12):1063-1072.
17. Steinman RM, Banchereau J. Taking dendritic cells into medicine. *Nature.* 2007;449(7161):419-426.
18. Elias PM. Structure and function of the stratum corneum extracellular matrix. *J Invest Dermatol.* 2012;132(3):615-620.