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Review Article

Exploring the Dynamic Realm of Gingival Epithelium: A Comprehensive Review

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Received: January 29, 2024; **Published:** March 07, 2024

Abstract

The gingival epithelium, a crucial component of the oral mucosa, plays a pivotal role in maintaining oral health and defending against microbial invasion. This review aims to provide a comprehensive overview of the structure, functions, and pathophysiological significance of gingival epithelium. Structurally, gingival epithelium consists of different layers, each serving specific functions such as barrier formation, adhesion, and immune surveillance. Functionally, it acts as a physical barrier against microbial ingress, contributes to wound healing, and regulates inflammatory responses. Moreover, gingival epithelium actively participates in host-microbe interactions by recognizing and responding to microbial stimuli through various signaling pathways. Dysregulation of gingival epithelial functions is associated with numerous oral diseases, including gingivitis and periodontitis. Understanding the intricate mechanisms underlying gingival epithelial biology is crucial for developing novel therapeutic strategies aimed at promoting oral health and preventing oral diseases. This review highlights the significance of gingival epithelium in oral health and underscores the need for further research to elucidate its complex roles in maintaining oral homeostasis.

Keywords: *Gingival Epithelium; Oral Health; Microbial Invasion; Oral Homeostasis*

Introduction

Gingival epithelium plays a vital role in gingival health and innate defense responses. It has mechanical, chemical and signaling functions. It also prevents the entry of water and microorganisms. The architectural integrity of the epithelium results with the help of cell-cell attachments, basal lamina and the keratin cytoskeleton. The major cell constituent is the keratinocyte (the one that synthesize keratin) whereas the other constituents are the Langerhans cells, melanocytes, and Merkel cells [1].

The initial line of protection against bacterial invasion in periodontal disease is the gingival epithelium, which functions as a physical barrier to keep the biofilm apart from the gingival tissue. An inflammatory reaction is sparked by the disruption of the gingival epithelial barrier, which allows exogenous pathogens to enter the host tissues and cause a chronic infection. Health depends on maintaining this barrier's functionality, as disruptions increase the chance of developing a number of illnesses and ailments [2].

Common characteristics of gingival epithelium

The unique structure of gingival tissues is required to give the foundation for protection of the peripheral body. The human body is protected by a continuous surface lining that includes the skin, nasopharyngeal mucosa, and gastrointestinal mucosa on the outside and inside. The mucosal lining's protective function is compromised when deciduous and eventually permanent teeth break through it [3].

In the deeper layers of normal epithelium, an increase in the quantity and density of cytoplasmic fibers-perhaps a reaction to function-is frequently observed. This phenomenon is likely linked to the formation of keratin [4].

Given their unique bond with the tooth surface, the gingival tissues represent the primary peripheral barrier against microbial infections that have the potential to cause periodontal disease. Major contributions to this protection come from both the connective tissue and epithelium components. Because its attachment function to the tooth is incompatible with good resistance to trauma, the non-keratinized junctional epithelium only partially fulfills its protective role, while the keratinized oral gingival epithelium offers effective protection against both mechanical trauma and bacterial invasion. Still, it acts as a fairly efficient barrier against bacterial penetration, helped along by leukocytes that live in the intercellular gaps and its fast turnover rate [3].

Through the junctional epithelium and epithelial attachment, the surrounding tissues have been designed to create a seal around the teeth, withstand the frictional forces of mastication, and protect the potential space between the teeth and the soft tissues from foreign invaders, like microorganisms. A structural framework that permits defense cells to move across different tissue compartments and act without compromising fundamental tissue integrity is responsible for achieving these specific objectives [3].

Man's oral epithelium is typically exclusively cornified on the mucosa lining the masticatory surfaces, which include the cheek, palate, gingiva, and dorsal surface of the tongue. The four layers of typical human cornified gingival epithelium-stratum germinativum, spinosum, granulosum, and corneum-were defined by Listgarten in terms of their ultrastructure [4].

The basal cells in the stratum spinosum share structural similarities with the basal cells, with the exception of their separation from the basement membrane. Compared to basal cells, the limiting membrane of cells in this stratum is abundantly supplied with well-developed desmosomes. Furthermore, the cytoplasm of the stratum spinosum cells seems to have a higher relative quantity of tonofibrils and less cytoplasmic granules than the cytoplasm of the basal cells. Thick bundles of tonofilaments, each representing a tonofibril, develop on the periphery of the cells, aligned perpendicular to the cell surface, and seem to connect to the desmosome attachment plaques. The desmosomes consist of several layers that are stacked parallel to one another [5].

The lamina propria's cellular and fibrous components serve as the gingiva's primary anchor to the tooth. It also contains the biological systems required to defend the host from bacterial invasion and encourage tissue growth and repair. Especially in young people, gingival inflammatory cell infiltrates have a preventive role and don't always signify a disease that may worsen or even develop in the future. There may be qualitative as well as quantitative differences in the cellular infiltrates seen in adults and children with periodontitis, according to the knowledge currently available on different inflammatory cell types [3].

Anatomical and functional aspects of various sites

There are three areas that make up gingival epithelium: junctional epithelium (JE), sulcular epithelium (SE), and oral gingival epithelium (OGE) [6].

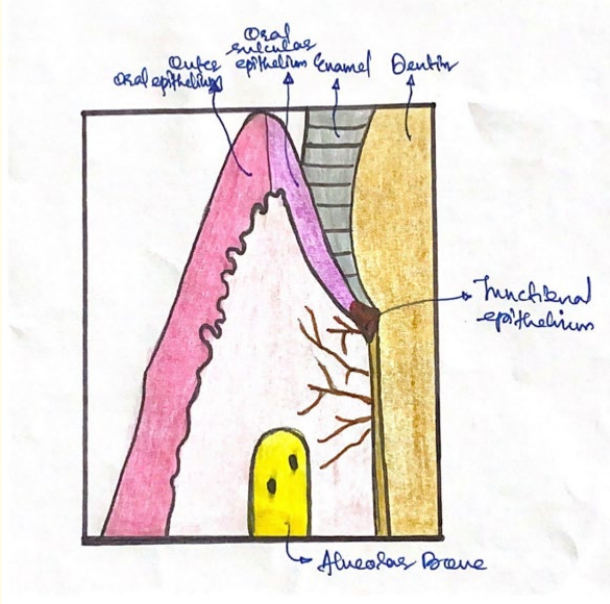

Figure 1

Oral epithelium

Particularly for the oral epithelium, cell surface ultrastructure is not species- or even location-specific; rather, it can vary depending on the type of epithelium that is there, such as non-keratinized or keratinized [7].

Sulcular epithelium

It Is generally accepted that the sulcular epithelium lacks a granular or cornified layer, whereas the gingival epithelium is either keratinized or parakeratinized. It has been demonstrated that the properties of the epithelial surface are determined by the connective tissue base. The connective tissues beneath the sulcular and surface gingival epithelium appear to be identical, however the sulcular epithelium lacks keratinization in contrast to the gingival surface. In three adult Rhesus monkeys, the role of the sulcular environment in determining keratinization was investigated. The research by Caffesse., *et al*. indicates that keratinization of the sulcular epithelium may be possible. It seems that the sulcular epithelium's lack of keratinization is determined by contact with the tooth [8].

Junctional epithelium

Specialized gingival epithelium known as JE attaches itself like a collar to the crown or root, meeting at the point where periodontal soft tissue and hard tissue converge. Because of their loosened cell connections, JE cells have a uniform shape (either flat or spindle) and are oriented parallel to the tooth surface. They also have a lot of intercellular gaps [6].

Because of its special structural and functional flexibility, the junctional epithelium can regulate the ever-present microbial threat. Gingival and periodontal diseases can nevertheless form despite the junctional epithelium's antimicrobial defense systems. Studies have indicated that the innate defense systems may involve junctional epithelial cells far more actively than was previously thought. They create a wide range of compounds that are specifically used to fight bacteria and the things they produce. Furthermore, they express substances that mediate polymorphonuclear leukocyte migration toward the gingival sulcus bottom [9].

A layer of cuboidal basal cells located away from the tooth surface and resting on a basement membrane gives rise to the flattened cells that make up this epithelium, which is aligned parallel to the tooth. Remarkably, suprabasal cells retain the capacity for cell division despite sharing a comparable ultrastructure. The actual attachment of the gingiva to the tooth surface is provided by the cell layer confronting the tooth through a structural complex known as the epithelial attachment [9].

Bacteria, including *P. gingivalis*, have the ability to directly disrupt the junctional epithelium's structural and functional integrity [10].

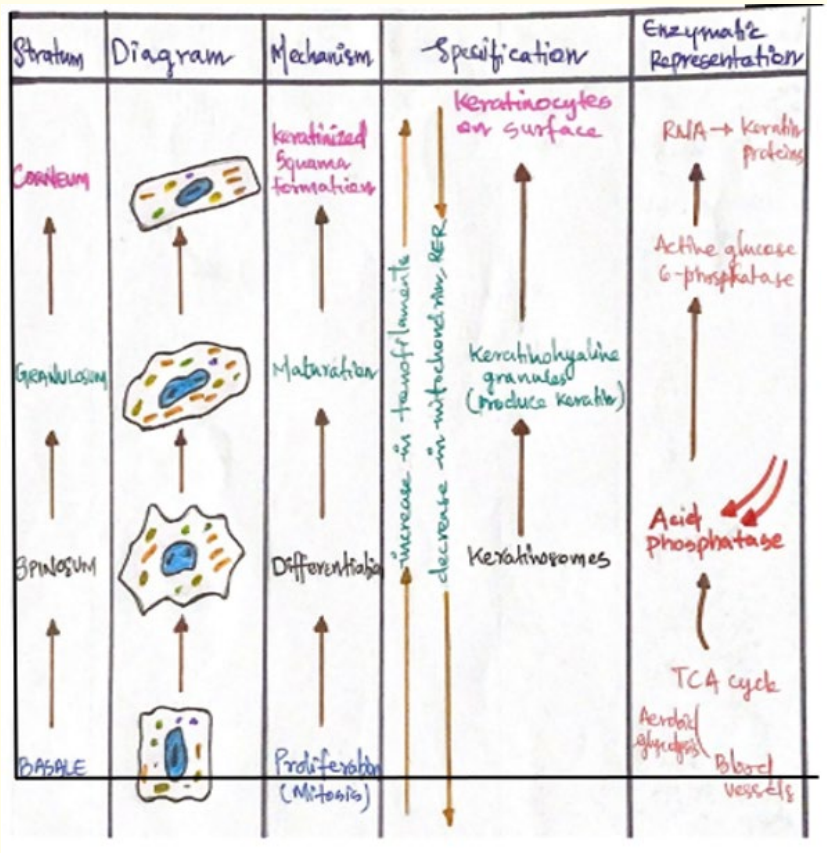

Figure 2

Progression of gingival sulcus

The gingival sulcus, alternatively referred to as the gingival crevice or gingival groove, is a v shaped space that bound around each tooth. On one side, its right next to the tooth surface, and on the other side, it's lined by the epithelium of the gingiva's free margin. Its shape and structure allow for the attachment of the gingival tissue to the tooth surface, forming a protective barrier [11].

The formation of the gingival sulcus occurs during the development of the tooth and its supporting structures. The process can be divided into distinct stages:

1. Initiation: During the early stages of tooth development, the oral epithelium thickens and invaginates, forming the dental lamina. This structure ultimately give rise to the tooth bud, including the enamel organ and dental papilla.
2. Enamel organ formation: The enamel organ. An epithelial component of the developing tooth, undergoes further growth and differentiation. It consists of several layers, including the outer enamel epithelium, stellate reticulum, stratum intermedium, and inner enamel epithelium [12].
3. Formation of the junctional epithelium: As the tooth continues to develop, the inner enamel epithelium transforms into the reduced enamel epithelium (REE). The REE fuses with the oral epithelium, forming the junctional epithelium (JE) at the future location of the gingival sulcus.
4. Sulcus formation: With the eruption of tooth into the oral cavity, the JE migrates coronally, creating a space between the tooth surface and the oral epithelium. This space is known as gingival sulcus, which is typically shallow and measures around 0.5 - 3 mm in healthy individuals [13].

The anatomy of the gingival sulcus provides an ideal environment for bacterial growth. Due to its narrow and secluded nature, the sulcus is resistant to washing and cleansing action of saliva, making it suitable habitat for bacteria to thrive. Additionally, the gingival fluid, also known as sulcular fluid, present in the sulcus, serves as a rich nutrient source for microorganisms. The measurement of the gingival sulcus depth is an important diagnostic parameter in dentistry. It allows dental professionals to assess the health of the periodontium and detect early signs of periodontal disease [14].

Consistent dental check-ups and professional cleanings are essential in overseeing the well-being of the gingival sulcus, while also serving as a pivotal preventive measure against the onset of periodontal diseases [14].

Re-establishment of gingival epithelium

The renewal of gingival epithelium is a dynamic process that ensures the continuous turnover and maintenance of the protective outer layer of the gingiva. The gingival epithelium, consisting of oral epithelial cells, undergoes a constant process of renewal to maintain its integrity and functionality. This renewal process involves the proliferation, migration, and differentiation of epithelial cells [15].

The process of gingival epithelium renewal initiates through cellular division occurring in the basal layer of the epithelium. The basal cells divide and give rise to new cells, which then migrate upwards towards the surface. As these cells migrate, they undergo a process of differentiation and maturation, gradually transforming into the specialized cells of the gingival epithelium. This process is tightly regulated by various signaling pathways and molecular mechanisms.

Once the cells reach the surface of the gingival epithelium, they undergo terminal differentiation and eventually slough off, making way for the newly generated cells from the basal layer. This constant turnover of cells ensures the maintenance of a healthy and functional gingival epithelium [16].

The renewal of gingival epithelium is essential for maintaining a continuous barrier between the oral environments and underlying periodontal tissues. This barrier plays a crucial role in preventing the invasion of bacteria, toxins, and other irritants into the periodontium [17].

In cases of injury or inflammation, the renewal process of the gingival epithelium is accelerated to facilitate wound healing. The renewal of the gingival epithelium helps maintain the stability of the epithelial attachment to the tooth surface. Continuous renewal ensures the proper sealing of the gingival sulcus, preventing the migration of bacteria and toxins into the underlying tissues [18].

Contribution of epithelium in health and disease

The gingival epithelium, a specialized type of epithelial tissue, plays a critical role in maintaining oral health and preventing various dental diseases.

The gingival epithelium acts as a protective barrier between the oral cavity and underlying tissues, including the periodontal ligament and alveolar bone. It prevents the invasion of harmful microorganisms, such as bacteria, fungi, and viruses, into the deeper oral structures. The integrity of the gingival epithelial barrier is essential in maintaining oral health by preventing the onset of periodontal diseases [19].

The gingival epithelium acts as an active participant in the immune response within the oral cavity. It plays a crucial role in recognizing and responding to pathogenic microorganisms, initiating an immune cascade to eliminate them. Gingival epithelial cells produce various antimicrobial peptides, cytokines, and chemokines that contribute to the local immune defense against oral infections [20].

The gingival epithelium demonstrates exceptional regenerative capabilities, aiding in wound healing within the oral cavity. Following injury or dental procedures, such as scaling and root planing, the gingival epithelium can rapidly proliferate, migrate, and reestablish a functional barrier. This regenerative capacity is vital in maintaining the integrity of the gingiva and promoting oral tissue repair [21].

The gingival epithelium contains specialized sensory receptors that contribute to oral sensory perception. These receptors enable the detection of tactile stimuli, temperature, and pain within the gingival tissues. By relaying sensory information to the brain, the gingival epithelium assists in maintaining oral health by allowing individuals to identify potential oral health issues promptly [22].

Long junctional epithelium

The long junctional epithelium (LJE) is a specialized type of epithelial tissue that plays a critical role in the maintenance of periodontal health.

The long junctional epithelium refers to the epithelial attachment that forms along the tooth surface during the process of gingival recession. It occurs when the gingival margin moves apically, exposing the underlying cementum. The LJE is located along the cementoenamel junction (CEJ) and acts as a protective barrier between the tooth surface and the underlying connective tissue [23].

The long junctional epithelium serves as a barrier to prevent the ingress of oral bacteria and their by-products into the underlying connective tissue and alveolar bone. While not as effective as the original junctional epithelium, which is closely adapted to the tooth surface, the LJE still contributes to maintaining periodontal health by reducing the risk of bacterial invasion and inflammation [1].

The long junctional epithelium plays a critical role in the process of periodontal attachment and reattachment. During the healing of periodontal tissues after periodontal therapy or surgical procedures, the LJE plays a role in establishing a new attachment between the tooth surface and the gingiva. This attachment helps stabilize the periodontal tissues and promotes periodontal health [23].

In the presence of periodontal disease, the long junctional epithelium may undergo pathological changes. In cases of chronic inflammation, the LJE may migrate further apically, leading to an increase in pocket depth and exposure of the root surface. This migration can result in the loss of attachment and exacerbation of periodontal disease. Therefore, maintaining the integrity of the LJE is crucial for preventing disease progression [23].

Dento-alveolar unit

The dento-alveolar unit is a critical anatomical complex that encompasses the teeth, surrounding alveolar bone, periodontal ligament, and supporting soft tissues.

The dento-alveolar unit provides essential support and stability to the teeth within the oral cavity. The alveolar bone, along with the periodontal ligament, anchors the tooth roots firmly in place. This stability allows for proper mastication, speech, and overall oral function. The integrity of the dento-alveolar unit is crucial for maintaining a healthy occlusion and preventing tooth mobility or premature tooth loss [23].

The dento-alveolar unit plays a significant role in periodontal health. The periodontal ligament, located between the tooth root and alveolar bone, cushions the tooth against occlusal forces and helps distribute the forces during chewing. The health of the periodontal ligament and the surrounding alveolar bone ensures the stability of the tooth within its socket and contributes to the overall periodontal health [1].

The dento-alveolar unit is subject to constant remodelling throughout life. The alveolar bone undergoes a dynamic process of bone formation and resorption in response to functional demands and oral health status. This remodelling allows for tooth eruption, orthodontic tooth movement, and adaptation to occlusal forces. Proper bone remodelling within the dento-alveolar unit is essential for maintaining optimal oral health and function [23].

The dento-alveolar unit plays a crucial role in prosthetic rehabilitation, such as the placement of dental implants or fixed dental prostheses. Dental implants are anchored in the alveolar bone, relying on the integrity of the dento-alveolar unit for stability and successful Osseo integration. Proper assessment and preservation of the dento-alveolar unit are vital for achieving favorable outcomes in prosthetic rehabilitation [24].

Conclusion

The gingival epithelium serves important functions in gingival health and innate defense responses, acting as a barrier against water and microbes. It consists mainly of keratinocytes, along with Langerhans cells, melanocytes, and Merkel cells. The keratinization process within the gingival epithelium leads to the creation of various epithelial layers with distinct characteristics. It also explains the structural and metabolic characteristics of different areas of the gingival epithelium, such as the oral epithelium, sulcular epithelium, and junctional epithelium.

Furthermore, the development of the gingival sulcus during tooth eruption and its importance in maintaining periodontal health. It emphasizes the role of regular oral hygiene practices and dental visits in keeping the sulcus clean and preventing periodontal diseases. The renewal of the gingival epithelium is described as a dynamic process involving cell division, migration, and differentiation, ensuring the continuous turnover of cells. The gingival epithelium's role in health and disease is highlighted, emphasizing its protective function, immune response, and maintenance of tissue integrity.

Overall, this provides a comprehensive overview of the biology and functions of the gingival epithelium in maintaining gingival health and preventing periodontal diseases.

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Volume 23 Issue 3 March 2024