THE ROLE OF SALIVARY GLANDS IN ORAL CAVITY HOMEOSTASIS: SECRETION, COMPOSITION AND NEUROENDOCRINE CONTROL

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Abstract

The salivary glands play an essential role in maintaining oral homeostasis through the secretion of saliva, a complex biological fluid, indispensable for mucosal protection, digestion, microbiotic balance and prevention of dental diseases. Regulated by neuroendocrine mechanisms, salivary secretion is influenced by the autonomic nervous system and hormonal factors, adapting to mechanical, chemical and psychological stimuli. The composition of saliva includes water, electrolytes, proteins, enzymes, and immunoglobulins, each of which contributes to its essential functions, such as lubrication, pH buffering, and antimicrobial activity. Salivary secretion disorders, such as hyposalivation and hypersalivation, affect the oral health and quality of life of patients, predisposing to infections, cavities and chewing and swallowing disorders. The management of these dysfunctions requires pharmacological therapies and salivary stimulation strategies. Recent research explores salivary gland regeneration through tissue engineering, the use of advanced sialogogic agents, and the application of saliva as a biomarker in the diagnosis of systemic diseases. These innovative directions can revolutionize dentistry and general medicine, contributing to the development of personalized treatments for salivary gland dysfunctions. Thus, a better understanding of salivary physiology is essential for optimizing oral and systemic health.

Keywords: salivary glands, salivary secretion, oral homeostasis, neuroendocrine regulation, hyposalivation, hypersalivation, tissue regeneration

Introduction

The salivary glands are a set of essential structures in maintaining oral balance, being involved in the secretion of saliva, a complex biological fluid that plays a fundamental role in mucosal protection, digestion, oral microbiota homeostasis and prevention of dental diseases. Anatomically, the salivary glands are classified into major glands (parotid, submandibular and sublingual) and minor glands, dispersed at the level of the oral mucosa. Each of them contributes in a different proportion to the production and composition of saliva, adapting to physiological requirements and external stimuli. The secretory activity of the salivary glands is controlled by precise neuroendocrine mechanisms, and any imbalance in this process can have significant consequences on oral and general health [1-3].

Saliva is essential for maintaining oral health through its multiple functions: lubrication, acid neutralization, initial enzymatic digestion, and antimicrobial activity. It also plays a crucial role in taste perception and speech, facilitating interaction with food and the external environment. Salivary secretion is regulated by the autonomic nervous system, which controls both its flow and its

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composition according to the body's needs. Physiologically, there is a continuous basal secretion that ensures the hydration of the oral mucosa, and mechanical, chemical and psychological stimuli can trigger reflex secretion, adapting salivary flow to digestive and protective needs [1-4].

The composition of saliva varies depending on the secretory gland and the type of stimulation. The parotid glands secrete a predominantly serous saliva, rich in amylase, essential in the digestion of starch, while the submandibular and sublingual glands produce a mixed saliva, with a high content of mucins, having a major role in lubricating and protecting the oral mucosa. The minor salivary glands help stabilize the salivary film and maintain a protective barrier against irritants and microorganisms. Electrolytes in saliva, such as bicarbonate, calcium, and phosphate, play an essential role in maintaining a neutral pH and preventing tooth enamel demineralization, thus reducing the risk of caries lesions [2-5].

Neuroendocrine control of salivary secretion involves complex interactions between the sympathetic and parasympathetic nervous systems. Parasympathetic stimulation, through the facial (VII) and glossopharyngeal (IX) nerves, causes an abundant, watery secretion, essential for digestion and oral protection. In contrast, sympathetic stimulation favors a lower secretion, rich in proteins and mucins, especially adapted to situations of stress or intense activity. In addition, certain hormones, such as aldosterone and cortisol, influence the composition of saliva by altering the ionic concentration and secretory flow. Imbalances in the neuroendocrine regulation of salivary secretion can lead to pathologies such as xerostomia or hypersalivation, affecting the patient's quality of life and predisposing to oral infections, dysphagia or speech difficulties [2-6].

Saliva has a significant impact on the oral microbiota, helping to maintain a balance between commensal and pathogenic bacterial species. The antimicrobial proteins in its composition, such as lysozyme, lactoferrin and secretory type A immunoglobulins (IgA), inhibit the development of pathogenic microorganisms and reduce the risk of infections. In addition, saliva buffering mechanisms help neutralize acids produced by cariogenic bacteria, protecting tooth enamel from demineralization. When salivary secretion is impaired, the risk of oral diseases increases, including cavities, gingivitis and fungal infections, such as oral candidiasis [1,3-6].

Changes in salivary secretion can be influenced by numerous factors, including medication, systemic conditions, and the natural aging process. Xerostomia, characterized by reduced salivary flow, is commonly found in patients undergoing treatments with antihistamines, antidepressants, diuretics or chemotherapy. Also, autoimmune diseases such as Sjögren's syndrome cause direct damage to glandular tissue, significantly reducing salivary production. On the other hand, hypersalivation can occur in neurological conditions such as Parkinson's disease or during pregnancy, having a negative impact on the patient's quality of life [3-7].

The physiology of the salivary glands is essential for maintaining oral homeostasis, and saliva plays a multidimensional role in the protection and functioning of the oral cavity. The

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regulation of salivary secretion through neuroendocrine mechanisms ensures the adaptability of this biological fluid to various physiological and pathological conditions, contributing to oral and digestive health. A better understanding of the processes involved in saliva secretion and composition can facilitate the development of effective strategies for the prevention and treatment of salivary dysfunctions, having significant clinical implications in dental and general medicine [4-8].

Salivary secretion: mechanisms and regulation

Salivary secretion is an essential physiological process for maintaining oral health, being controlled by a complex mechanism that involves neural and endocrine regulation. The salivary glands produce saliva both continuously (basal secretion) and in response to specific stimuli (reflex secretion), adapting salivary composition and flow to the functional needs of the oral cavity. Factors that influence secretion include nerve stimulation, circadian rhythm, hydration, diet, and emotional state [6-10].

Aspect	Description
Types of salivary secretion	Basal secretion (continuous, maintains oral mucosa hydration); Reflex secretion (triggered by external stimuli, adapted to needs)
Involved glands	Parotid glands (serous secretion, rich in amylase); Submandibular glands (mixed secretion, predominantly serous); Sublingual and minor glands (mixed secretion, predominantly mucous)
Neural regulation	Regulated by the autonomic nervous system: the facial (VII) and glossopharyngeal (IX) nerves control parasympathetic secretion, while sympathetic nerves modulate protein secretion
Influence of the autonomic nervous system	The parasympathetic system stimulates abundant, watery secretion rich in enzymes; The sympathetic system stimulates reduced, viscous secretion rich in mucins
Triggering factors	Mechanical (chewing), chemical (taste, pH), olfactory, psychological (anticipation of food intake), pharmacological (medications that stimulate or inhibit salivary secretion)
Role of hormones	Aldosterone (electrolyte balance, Na+ reabsorption); Cortisol (reduces secretion during prolonged stress); Thyroid hormones (maintain normal salivary flow); Insulin (influences saliva composition)
Saliva composition based on stimulation	Parasympathetic stimulation: watery saliva, rich in amylase and electrolytes; Sympathetic stimulation: viscous saliva, rich in mucins and proteins
External influencing factors	Hydration, diet (carbohydrate intake stimulates secretion), medications (antihistamines, antidepressants, diuretics – reduce secretion; sialogogues – stimulate secretion), stress, systemic conditions (diabetes, Sjögren's syndrome, hypothyroidism)
Effects of hyposalivation	Xerostomia (dry mouth sensation), increased risk of cavities, oral infections (candidiasis), difficulty chewing and swallowing, halitosis, altered taste perception
Effects of hypersalivation	Sialorrhea (excessive secretion), hypersensitivity to gustatory stimuli, difficulty controlling saliva, oral mucosa irritation and perioral skin irritation, social and functional discomfort

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Table 1. This table details the physiological mechanisms and factors that influence salivary secretion. The types of secretion (basal and reflex), the glands involved and the role of neuroendocrine regulation are presented. Triggers, the influence of the autonomic nervous system and the impact of hormones on saliva composition are also highlighted. The last sections look at the external factors that can alter the secretion and effects of salivary dysfunctions, providing a clinical perspective on the importance of oral homeostasis [4-12].

Salivary secretion is an exocrine process coordinated by the autonomic nervous system. The parasympathetic nerves, through the facial nerve (VII) for the submandibular and sublingual glands and the glossopharyngeal nerve (IX) for the parotid gland, cause an abundant, watery secretion, rich in enzymes and electrolytes. It is essential for digestion and protection of the oral mucosa. In contrast, the sympathetic nervous system, through the postganglionic fibers in the upper cervical ganglia, modulates secretion by stimulating myoepithelial cells and increasing the release of proteins, causing a more viscous, mucin-rich saliva. This secretion is adapted to situations of stress and intense activity, having an important role in lubricating the oral mucosa and protecting against dehydration [8-12].

Salivary secretion is triggered by specific stimuli, classified into mechanical (chewing), chemical (taste and pH), olfactory and psychological stimuli. The salivary reflex is initiated by taste and mechanical receptors in the oral cavity, which transmit impulses to the salivary nuclei in the brainstem. Taste stimulation is a powerful factor in secretion, as acidic or spicy foods cause an increased activation of the salivary glands, favoring the secretion of an electrolyte-rich saliva to buffer acidity. Also, smells and anticipation of food can trigger salivary secretion through psychogenic mechanisms, involving the cerebral cortex [6,8-12].

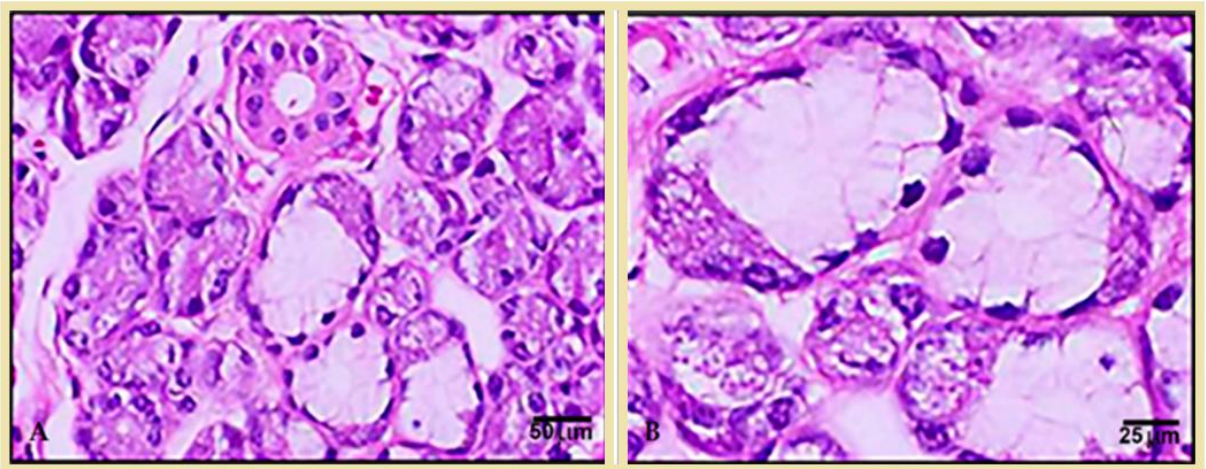


Figure 1. A/B. Microscopic Examination of Submandibular Gland Tissue:
(A) The histological structure of the submandibular gland shows a mixture of serous and mixed acinar cells at 200x magnification, stained with hematoxylin and eosin (H and E).
(B) Detailed visualization of acinar formations within the submandibular gland, highlighting

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both serous and mucous components, with distinctive crescent structures evident under 400x magnification using H and E staining. [12]

Salivary flow varies significantly depending on the time of day and the physiological state of the body. Basal secretion maintains the moisture of the oral mucosa during rest, and reflex secretion is activated during meals. The circadian rhythm influences salivary production, the flow being minimal during the night, which explains the increased susceptibility to oral dryness and bacterial proliferation during sleep [9-12].

Hormones play an important role in modulating salivary secretion. Aldosterone influences the electrolyte balance of saliva by regulating sodium reabsorption and potassium excretion. Thyroid hormones help maintain normal salivary flow, and cortisol can reduce salivary secretion under prolonged stress, predisposing to xerostomia. Endocrine dysfunctions, such as diabetes or hypothyroidism, can significantly affect salivary secretion, causing changes in saliva composition and volume [9-13].

Certain external factors can influence salivary secretion. Insufficient fluid intake and nutrient-poor diet negatively affect salivary flow. Medication, especially antihistamines, antidepressants, and diuretics, can reduce salivary secretion by blocking cholinergic receptors, leading to a feeling of dry mouth. In contrast, certain substances, such as sialogogea (pilocarpine), can stimulate salivary secretion, being used in the treatment of xerostomia [10-14].

Imbalances in the regulation of salivary secretion can have negative consequences on oral health. Hyposalivation, characterized by reduced salivary flow, increases the risk of cavities, fungal infections, and swallowing difficulties. On the other hand, hypersalivation, seen in neurological conditions such as Parkinson's disease, can cause discomfort and speech difficulties [10-15].

In conclusion, salivary secretion is a process regulated by complex neuroendocrine mechanisms, adapting to the physiological needs of the body. Nerve control ensures rapid responses to external stimuli, and hormonal influences contribute to the regulation of saliva composition. Understanding the mechanisms of salivary secretion is essential for the prevention and treatment of salivary disorders, having important clinical implications in dentistry and general medicine [10-15].

Saliva composition and its functions

Saliva is a biological liquid essential for maintaining oral and general health, having a complex composition adapted to its multiple functions. It is made up of about 99% water, the remaining 1% being electrolytes, proteins, enzymes and molecules with an antimicrobial role. The variability of saliva composition depends on the type of salivary gland secretion and external stimuli, influencing its ability to protect and maintain oral cavity homeostasis [11-16].

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Component	Description	Function
Water	Represents about 99% of saliva; essential for lubrication and solubilization of food	Maintains oral hydration, facilitates mastication and swallowing
Electrolytes	Includes sodium, potassium, calcium, chloride, bicarbonate, and phosphate; regulates pH and remineralization	Buffers acids, protects enamel, and aids in remineralization
Proteins	Mucins, proline-rich proteins; contribute to lubrication, protection, and viscoelastic properties	Enhances viscosity, protects mucosa, and forms a protective film
Enzymes	Amylase, lipase; initiate digestion by breaking down starch and fats	Facilitates early digestion and food processing
Antimicrobial factors	Lysozyme, lactoferrin, peroxidase; inhibit bacterial growth and maintain oral microbiota balance	Prevents infections, controls bacterial and fungal growth
Immunoglobulins	Secretory IgA; provides immune defense by preventing pathogen adhesion	Strengthens immune response, defends against pathogens

Table 2. The table shows the main components of saliva, their description and essential biological functions. Water, electrolytes, proteins, enzymes and antimicrobial factors contribute to lubrication, digestion, protection of the oral mucosa and microbiological balance. Secretory IgA provides immunological defense, preventing the colonization of pathogens and maintaining oral health [11-17].

The electrolytes present in saliva include sodium, potassium, calcium, chlorine, bicarbonate and phosphates, having an important role in maintaining ionic balance and oral pH. Bicarbonate and phosphates act as buffer systems, neutralizing the acids produced by bacteria in dental plaque and preventing enamel demineralization. Calcium and phosphate contribute to remineralization processes, which are essential for the protection of dental structures against cavities [14-17].

Salivary proteins are varied and include mucins, amylase, lysozyme, lactoferrin, and immunoglobulins. Mucins are glycoproteins with the role of lubricating and protecting the oral mucosa against irritants and pathogenic microorganisms. Salivary amylase initiates the digestion of starch, facilitating the process of enzymatic degradation even in the oral cavity. Lysozyme and lactoferrin have antimicrobial action, destroying the cell wall of bacteria and limiting the proliferation of pathogenic microorganisms [11,15-17].

Saliva also contains secretory type A immunoglobulins (IgA), which play an essential role in defending the oral mucosa against infection. The presence of these immunological molecules helps to maintain the balance of the oral microbiota and prevent the colonization of pathogens. In addition to its protective and digestive role, saliva contributes to the perception of taste by dissolving sapid substances and activating taste receptors. It also facilitates chewing, swallowing, and speaking, ensuring effective interaction with the external environment [1,15-17].

In conclusion, the composition of saliva is adapted to the physiological needs of the body, providing dental protection, initial digestion and antimicrobial defense. Any change in this composition can affect oral health, emphasizing the importance of

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maintaining optimal salivary secretion for oral cavity homeostasis [15-18].

Salivary secretion disorders and the impact on oral homeostasis

Salivary secretion is essential for maintaining oral balance, and any disruption to it can have significant consequences on the health of the oral cavity. The main disorders include hyposalivation (decreased salivary flow) and hypersalivation (excessive increase in secretion), both of which have important clinical implications [15-18].

Hyposalivation is characterized by a reduction in the amount of saliva secreted, which leads to dryness of the oral cavity (xerostomia). Causes of this condition include aging, dehydration, autoimmune conditions (such as Sjögren's syndrome), drug treatments (antihistamines, antidepressants, diuretics), chemotherapy and radiation therapy to the head and neck. The lack of adequate secretion favors the development of dental caries, fungal infections (oral candidiasis) and gingival inflammation, affecting swallowing and speaking. Patients with xerostomia experience significant discomfort, having difficulty eating food and an increased sensitivity to irritants [12,15-18].

Hypersalivation or sialorrhea is a less common condition, characterized by excessive saliva production. It can occur in the context of neurological conditions such as Parkinson's disease, cerebral palsy or amyotrophic lateral sclerosis. It can also be seen during pregnancy or as a side effect of certain medications (clozapine). Hypersalivation affects patients' quality of life, causing difficulties in controlling saliva and causing irritation in the oral mucosa and the skin around the mouth [15-19].

Salivary secretion disorders have a direct impact on the oral microbiota, favoring imbalances that can lead to bacterial and fungal infections. The lack of protective effect of saliva increases susceptibility to conditions such as halitosis, tooth erosion and oral mucosal lesions [16-19].

Maintaining optimal salivary secretion is essential for oral health. Early identification and treatment of salivary gland dysfunctions can prevent associated complications and improve patients' quality of life [15,17-19].

Future prospects and clinical implications

Research on salivary glands and salivary secretion has evolved significantly, opening up new perspectives in diagnosis, treatment, and tissue regeneration. Understanding the physiological mechanisms involved in salivary secretion provides opportunities for the development of innovative therapies that can improve the management of conditions associated with salivary dysfunction [16-20].

The regeneration of glandular tissues is one of the major directions of research. Stem cell therapy and tissue engineering are promising solutions for patients with irreversible salivary gland damage, especially those affected by Sjögren's syndrome or the effects of radiotherapy. Recent studies explore the use of mesenchymal stem cells for the regeneration of glandular acini and the restoration of secretory function [17-21].

The salivary glands play an essential role in oral homeostasis by

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secreting saliva, maintaining microbiological balance and protecting the mucosa. Neuroendocrine regulation ensures the adaptability of secretion, influencing the composition rich in electrolytes, enzymes and immunoglobulins. The use of essential oils, such as peppermint, clove or tea tree, can support oral health through antimicrobial, anti-inflammatory and salivary flow stimulating properties. They contribute to the prevention of xerostomia, reduce inflammation and balance the oral microbiota, having a synergistic effect on the physiological functions of the salivary glands and the protection of the oral cavity [22-25].

The salivary glands maintain oral homeostasis by secreting saliva, regulating the microbiota and protecting the mucosa. The neuroendocrine control of salivary secretion influences its composition, which is essential for lubrication, digestion and antimicrobial defense. In the case of dental inclusion, especially wisdom teeth, saliva plays a crucial role in preventing pericoronary infections, reducing inflammation and facilitating the eruption process. Low salivary flow can promote bacterial accumulation, increasing the risk of pericoronaritis, which is why maintaining optimal secretion is essential [26-36].

The salivary glands maintain oral homeostasis by secreting saliva, regulating the microbiota and protecting the mucosa, being neuroendocrine controlled. The composition of saliva, rich in enzymes, electrolytes and immunoglobulins, influences tissue regeneration and repair processes. Biomaterials have significant potential in oral medicine, being used to stimulate the regeneration of affected tissues, including salivary glands in xerostomia. Bioactive hydrogels, nanocomposites and polymer matrices can support the release of growth factors, optimizing salivary secretion and oral homeostasis, opening new perspectives in the treatment of salivary dysfunctions [37-48].

New pharmacological therapies are being investigated to stimulate salivary secretion. Silogogic agents, such as pilocarpine and cevimelin, are already used in the treatment of xerostomia, but research is moving towards developing drugs with more specific effects and fewer side effects. Also, nanotechnology-based compounds could improve the distribution and efficacy of topically administered drugs [49-51].

Saliva as a diagnostic biomarker is another important direction in research. Due to its variable composition and ease of collection, saliva can be used for the early detection of systemic conditions such as diabetes, autoimmune diseases, and even certain types of cancer. The development of saliva-based tests could revolutionize medical diagnosis by providing non-invasive and rapid methods for identifying pathological markers [13,49-51].

Research into the physiology of the salivary glands opens up new possibilities for innovative treatments and early diagnosis. The implementation of these findings in medical practice can significantly improve the quality of life of patients affected by salivary dysfunctions, emphasizing the importance of continuing studies in this field [49-58].

Conclusions

The physiology of the salivary glands plays an essential role in

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maintaining oral homeostasis, and salivary secretion is a complex process, regulated by neuroendocrine mechanisms and influenced by internal and external factors. Saliva contributes to the protection of the oral cavity by lubricating the mucosa, regulating pH, preventing dental demineralization and defending against pathogens.

Its varied composition, including water, electrolytes, proteins, enzymes and immunoglobulins, ensures multiple essential physiological functions, such as initial digestion, taste perception and oral microbiota balance. The regulation of salivary secretion depends mainly on the autonomic nervous system, and any disturbance can have negative consequences for oral and general health.

Disorders of salivary secretion, such as hyposalivation and hypersalivation, affect the quality of life of patients and can promote the appearance of cavities, infections and difficulties in chewing and speaking. Early identification and appropriate treatment are essential to prevent complications.

Future research perspectives include the regeneration of salivary glands through tissue engineering, the development of advanced pharmacological therapies, and the use of saliva as a biomarker for early diagnosis. These findings may revolutionize therapeutic approaches and significantly improve the prognosis of patients with salivary dysfunction.

Saliva is not just a biological fluid, but an essential factor for oral and systemic health. Further research in this field can have a major impact on dental and general medicine, contributing to the development of innovative solutions for salivary gland disorders.

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