Report

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Saliva: An Overview

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ABSTRACT

An inherent and yet profound aspect of our well-being is dependent on a humble, unassuming fluid called saliva. This unpretentious secretion is indispensable, contributing to quality of life and the simple joy of living; its absence has been described as an aggravating constant misery. Therefore, understanding how saliva contributes to good oral health and general well-being is essential to assisting oral health professionals in their care for patients. A comprehensive literature search of publications relating to saliva was undertaken in order to assemble an overview of the current knowledge of this multifaceted, multipurpose bodily fluid. This paper revises the anatomical, histological and physiological aspects of saliva production and its functions. Dry mouth and its associated risk factors are described, together with consideration of its clinical significance.

INTRODUCTION

An inherent and yet profound aspect of our well-being is dependent on a humble, unassuming fluid called saliva. Mandel (1990) eloquently stated: "saliva is not one of the popular bodily fluids. It lacks the drama of blood, the sincerity of sweat and the emotional appeal of tears". However, this unpretentious secretion is a multifaceted, multipurpose bodily fluid which is indispensable. Living with insufficient quantities of this essential, complex fluid leads to an appreciation of what has been lost. This paper summarises the current knowledge of the salivary gland system, the composition of saliva, salivary output, and the functions of saliva, and provides a synopsis of the clinical significance of a dry mouth.

THE SALIVARY GLAND SYSTEM

Salivary glands can be classified according to their size (whether major or minor) or the histochemical nature of the secreted saliva (whether serous, mucous or mixed). Serous saliva is a thin watery secretion, while mucous saliva is more viscid, due to the presence of mucin, a glycoprotein. The major salivary glands comprise three paired glands: the parotid (serous), the submandibular (mixed) and the sublingual glands (mixed). The parotid glands are found behind the ramus of the mandible, anterior to the ear. Their secretions reach the oral cavity via Stensen's duct. The submandibular glands lie under the body of the mandible. Wharton's duct runs from each gland across the floor of mouth and opens under the anterior part of the tongue. The sublingual glands (the smallest major gland) are found underneath the anterior tongue. Some sections of these glands open into Wharton's duct; the remainder secrete via a number of small ducts (Bartholin's ducts) which lie beneath the tongue. The minor salivary glands are distributed throughout the oral cavity in the buccal and labial mucosa, the posterior palate, and the labial border of the tongue (Scott and Symons, 1977; Drake et al, 2010). The minor glands of the palate and dorsum of the tongue are mucous, as are the anterior lingual glands. The minor serous glands of the tongue lie (for the most part) close to the vallate papillae, and their ducts open into the sulci of these papillae (Scott and Symons, 1977).

BLOOD AND NERVE SUPPLY

The parotid gland's arterial supply is from the external carotid artery and its terminal branches (superficial temporal and maxillary arteries), into which it divides within the body of the parotid gland. Branches of the facial and lingual arteries supply the submandibular and sublingual glands. Venous drainage is into the external jugular vein from the parotid gland and into the lingual and facial veins from the submandibular and sublingual glands. Lymphatic vessels from the parotid gland drain into the superficial and deep cervical nodes via the parotid nodes, while the submandibular and sublingual lymphatics drain into the submandibular nodes, and then into the deep cervical nodes (Drake et al, 2010).

The two divisions of the autonomic nervous system both innervate the salivary glands. The sympathetic fibres originate in the superior cervical ganglion and follow the course of the external carotid artery to the glands. The parasympathetic fibres—which arise in the salivary nuclei in the pons and medulla—are carried in the facial and glossopharyngeal nerves (Scott and Symons, 1977; Drake et al, 2010). Table 1 outlines the parasympathetic nerve supply to the major and minor salivary glands (adapted from Scott and Symons, 1977).

The three specific triggers which stimulate saliva secretion are mechanical (mastication), gustatory and olfactory. The olfactory stimulus is unexpectedly poor. Of the gustatory stimuli, acid is the strongest trigger and sweet the weakest (Humphrey and Williamson, 2001). Other triggers include nausea, vomiting and anxiety (Dawes, 2004).

HISTOLOGY

The salivary glands are compound tubulo-alveolar glands. Cell types in saliva glands are acinar (secretory) cells, duct cells (intercalated, striated and excretory) and myoepithelial cells. Acinar cells determine whether serous, mucous or mixed saliva is secreted. The myoepithelial cells assist in the secretion process (Whelton, 2004).

The branching duct system (which consists of interlobular, intralobular, intercalated, striated ducts and larger excretory channels) terminates in clusters of acinar cells (acini). The saliva formed in the acini is isotonic with respect to oral saliva, and modification in the duct system results in a hypertonic product (Humphrey and Williamson, 2001; de Almeida et al, 2008). The intercalated duct cells do not modify the acinar secretion.

Table 1. Parasympathetic nerve supply to the salivary glands.

Gland	Cranial nerve	Branches
Parotid	Glossopharyngeal (IX)	Lesser petrosal nerve Otic ganglion
Minor glands in lower lip and lower part of vestibule	Glossopharyngeal (IX)	Inferior alveolar and buccal nerves
Submandibular	Facial (VII)	Chorda tympani
Sublingual		Lingual and submandibular ganglion
Minor anterior lingual glands		
Minor glands in palate, upper lip, upper part of vestibule	Facial (VII)	Greater petrosal nerve, nerve of the pterygoid canal and pterygopalatine (sphenopalatine) ganglion

(Adapted from Scott and Symons, 1977)

The striated cells resorb sodium and chloride as an electrolyte regulation (Mese and Matsuo, 2007). The last ductal cells (the excretory cells) continue sodium resorption and secrete potassium (Humphrey and Williamson, 2001).

THE COMPOSITION OF SALIVA

Saliva is comprised of 99% water. The other components of saliva are sodium, potassium, calcium, magnesium, bicarbonate, phosphates, immunoglobulins, proteins, enzymes, mucins, urea and ammonia (Humphrey and Williamson, 2001; Whelton, 2004). The normal pH of saliva is 6 to 7, with a range from 5.3 (low flow) to 7.8 (peak flow).

Table 2 shows the contributions of the different saliva glands to the components which make up saliva. The minor salivary glands consistently contribute less than 10% to the volume of unstimulated or stimulated whole saliva. The estimated quantities that the parotid glands, submandibular glands and sublingual glands contribute to unstimulated saliva are 25%, 60% and 7.8% respectively. On stimulation, the contribution from the parotid glands increases to between 50% and 70%; this variation in contribution alters the composition of saliva (Veerman et al, 1996; Humphrey and Williamson, 2001).

THE FUNCTIONS OF SALIVA

Table 3 summarises the array of salivary functions. In broad terms, serous secretions help to remove epithelial debris and food particles from the gingival surface, buccal mucosa and the dorsum of the tongue, while the mucous secretions both bind masticated food together into a bolus and protect the oral epithelium from the abrasive action of food particles (Whelton, 2004). However, saliva is a complex fluid which is more than the sum of its parts and (as yet) is not fully understood. The various components have multiple functions, and they also interact to enhance or inhibit other components' actions (Humphrey and Williamson, 2001).

SALIVARY OUTPUT

At rest, the parotid glands contribute 20-25% to whole saliva flow, with the submandibular glands and the sublingual glands contributing 60-65% and 7-8% respectively, while the minor saliva glands at rest and during stimulated flow consistently produce less than 10% (Humphrey and Williamson, 2001; Whelton, 2004 Thomson et al, 2011a). When saliva flow is stimulated, the parotid glands increase their contribution to between 50 and 70% of the total flow (Veerman et al, 1996; Humphrey and Williamson, 2001; Dawes, 2004; Thomson et al, 2011).

Table 2. Salivary gland secretions and components.

Gland	Secretion Type	Components
Parotid	Serous	Amylase Proline-rich proteins Agglutinins Cystatins Lysozymes Extraparotid glycoproteins Na, Ca, Cl, PO4, K IgA
Sublingual	Mucous	Mucins: MG1 MG2 Lysozymes Na, Ca, Cl, PO4 Amylase IgA
Submandibular	Mixed	Cystatins Na, K, Ca, Cl, PO4 Amylase Cystatin, IgA, Mucin MG1
Palatine	Mucous	Amylase Na, K, Ca, Cl, PO4 Cystatins IgA

(Adapted from Veerman et al, 1996; Humphrey and Williamson, 2001)

The precise definition of what constitutes a "normal" flow rate in both stimulated and unstimulated salivary flow is still a matter of debate (Ship et al, 1991; Navazesh et al, 1992; Ghezzi et al, 2000). Normal whole saliva flow rates reported in the literature vary from 0.1ml/min to 0.4ml/min for unstimulated flow and 0.2ml/min to 1.7ml/min for stimulated flow (Sreebny and Valdini, 1988; Humphrey and Williamson, 2001; Dawes, 2004; Thomson, 2005; Thomson et al, 2011). Quantifying flow rates is complicated by considerable variation within and between individuals (Ship

Table 3. The functions of saliva.

Function	Description	Components
Lubrication	Coats, protects against mechanical, thermal, chemical irritation. Assists air flow, speech and swallowing	Mucin glycoproteins
Cleansing	Moistening assists mastication, clearing food and swallowing	
Ionic reserve	Modulates demineralisation and remineralisation of teeth	Calcium phosphate, statherins, proline-rich proteins
Buffering	Modulates pH of biofilm and buffering capacity of saliva	Bicarbonates phosphates, urea
Antibacterial action	Immunological agents and non-immunological agents help control oral microflora	IgA, IgG, IgM proteins, mucins, peptides and enzymes (lactoferrin, lysozyme, peroxidise)
Agglutination	Aggregate bacteria in saliva accelerating clearance from the oral cavity	Glycoproteins, statherins, agglutinins, histadine-rich proteins, proline-rich proteins
Pellicle formation	Proteins form a protective layer on the teeth	Macromolecular proteins, stratherins, histatins, cystatins, proline-rich proteins, MG1
Digestion	Enzymes in saliva begin the breakdown of starch and fat	A-amylase
Gustation	The solvent action and hypotonicity of saliva enhances tasting capacity by allowing interaction between nutrients and taste buds	Protein, gustin, zinc
Hydration	Oral dehydration and dryness of the month; stimulates desire to drink	

(Adapted from Humphrey and Williamson, 2001; Whelton, 2004; Thomson et al, 2011)

Table 4. Clinical manifestations of dry mouth.

Altered oral microflora	Mucus accumulation
Dental caries	Nocturnal oral discomfort
Denture problems	Oral dysfunction
Dry mouth	Oropharyngeal burning
Dysgeusia	Oropharyngeal infections
Dysphagia	Plaque accumulation
Food retention in the mouth	Speech difficulties
Mucosal changes	Thirst

(Adapted from Thomson et al, 2011)

et al, 1991; Valdez and Fox, 1993). Additionally, circadian rhythms affect the flow rate, with variations of as much as 50% (Guggenheim and Moore, 2003; Dawes, 2004). The research of Ship et al (1991) and Valdez and Fox (1993) suggested that the amount of saliva flow necessary for oral health is specific to each individual. In addition, the range among individuals shows a wide variation, with some maintaining good oral health, normal function and comfort with very little saliva flow. Some authors have suggested that, when the unstimulated flow rate reduces by 45-50% or more, the symptom of dry mouth manifests, regardless of the absolute initial flow rate (Dawes, 1987; Ship et al, 1991; Sreenby and Schwartz, 1997; Ghezzi et al, 2000).

Estimated daily saliva production is between 0.5 and 1.5 litres, with stimulated flow contributing 50 to 90% of this total (Guggenheim and Moore, 2003; Humphrey and Williamson, 2001; de Almeida et al, 2008; Navazesh and Kumar, 2008). However, since comparatively little time is spent eating, resting saliva may constitute the major portion of saliva output during the diurnal cycle (Mese and Matsuo, 2007). Navazesh and Kumar (2008) suggested that the duration, intensity and nature of the stimulus affect the saliva flow rate, with strong acid, high-frequency chewing and high bite force increasing saliva production.

RISK FACTORS FOR DRY MOUTH

Dry mouth may manifest as salivary gland hypofunction, a measurable chronically low flow of saliva with or without symptoms (Thomson et al, 1999) or a subjective perception of dry mouth (xerostomia) with or without salivary gland hypofunction. The degree of reduction in salivary flow which results in xerostomia and associated oral dysfunction is not known (Ghezzi et al, 2000).

The risk factors that might influence the development of dry mouth are numerous and varied, given that saliva is a complex fluid with an array of functions. Risk factors reported in the literature include smoking and alcohol use, dehydration, ageing, oral and systemic diseases, psychological states, head and neck radiotherapy, and medications.

Drugs are a common cause of dry mouth, with a frequent oral adverse drug reaction being a complaint of dry mouth (Scully, 2003). Both prescription and non-prescription medications (and also dietary supplements such as iron supplements) have been implicated in xerostomia (Ship, 2004; Thomson et al

2006b). Thomson et al (2000) and Thomson et al (2006c) have reported on medications and xerostomia in a longitudinal study of South Australians (taking into account polypharmacy and using multivariate analysis); their findings implicated anginals, antidepressants, antiasthma drugs, diuretics and daily aspirin (although use of the latter may have been an indicator of more general unwellness, given that (1) the aspirin itself is unlikely to have exerted a xerogenic effect, and (2) the prophylactic use of daily aspirin was not widespread among older people at the time that those data were collected, in the early 1990s). In general, the more medications taken, the greater the likelihood of a dry mouth (Ship, 2004), and this is likely to be a reflection of what has been described as the overall anticholinergic burden (Chew et al, 2008).

THE CLINICAL SIGNIFICANCE OF DRY MOUTH

The many and varied clinical manifestations of dry mouth presented in Table 4 clearly relate to the multi-faceted functions of saliva (outlined in Table 3). Individuals suffering from dry mouth can experience a plethora of clinical problems, including rapidly progressing caries, poor denture retention, traumatic ulceration of the oral mucosa, halitosis and candidiasis. Sufferers also have difficulty eating, swallowing, speaking and maintaining good oral hygiene (Whelton, 2004, Hopcraft and Tan, 2010).

Some of these clinical manifestations interlink with behavioural adaptations to alleviate the feeling of a dry mouth. Those feelings can manifest as dryness of the mouth and throat, associated structures, tasting impairment and eating difficulty, halitosis and burning mouth and soreness (Ship, 2004; Hopcraft and Tan, 2010). The consequential behavioural changes include sucking sweets and cough lozenges, and frequent sipping or drinking of fluids during the day (and night) and when eating certain foods (Guggenheimer and Moore, 2003; Hopcraft and Tan, 2010; Thomson et al, 2011). Compromised food selection and ability to eat may adversely influence dietary adequacy, leading to macro- and micro-nutrient deficiencies which, in turn, affect nutritional and general health status (Walls et al, 2000; Ikebe et al, 2005; Moynihan, 2007; Turner and Ship, 2007).

Management of dry mouth should include reviewing the medical history and dietary assessment and advice to ensure an adequate low-sugar diet. In addition, sufferers should be advised to maintain hydration by drinking water and obtain symptomatic relief by chewing sugar-free gum and using oral lubricants/moisturisers. An appropriate preventive programme to decrease the risk of caries—such as oral hygiene assessment and advice, use of daily fluorides (toothpastes and mouthrinses) and regular dental visits—needs to be developed.

In addition to the clinical manifestations causing oral discomfort for an individual, dry mouth sufferers describe experiences of unpleasant taste, bad breath, painful ulcers, uncomfortable and ill-fitting dentures, speech and eating difficulties, costly poor dental health and self-consciousness and embarrassment while eating and speaking (Narhi, 1994; Foerster et al, 1998; Thomson et al, 2006a; Turner and Ship, 2007; Hopcraft and Tan, 2010). These detrimental effects of the lack of saliva on the simple joys of living indicate that dry mouth has the potential to have a severe negative effect on an individual's quality of life (Locker, 2003; Folke et al, 2009).

CONCLUSION

Saliva – that unpretentious, multifaceted, multipurpose secretion – is an essential ingredient in good health, since its absence is described as an aggravating constant misery. More research is needed to enhance the understanding and knowledge of this under-appreciated fluid which contributes so much to our well-being.

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