4.2 Saliva, Salivation and Functional Testing

4.2.1 Saliva

The salivary glands consist of three pairs of large, or major, glands (parotid, submandibular and sublingual) and the smaller, or minor, glands distributed under the mucosa (submucosally) throughout the upper aerodigestive tract. The rate of salivary secretion of individual glands ranges from barely perceptual during sleep, to as high as 4 ml min$^{-1}$ on maximal stimulation. The true volume of saliva per day is unknown, as there is considerable variation both in flow rates among individuals and for the normal volume of mixed saliva.

The specific gravity of saliva varies between 1.000 and 1.010, and increases with increasing flow rate. The osmotic pressure is between half and three quarters that of blood. The viscosity of saliva depends on the distribution of the three glands to the saliva formed. The relative viscosities of the three main glandular secretions after citric acid stimulation were found to be:

- Parotid gland: 1.5 centipoises (cP)
- Submandibular gland: 3.4 cP
- Sublingual gland: 13.4 cP

Thus, viscosity is directly proportional to the percentage of mucus-secreting cells in these individual glands.

- Parotid glands are serous glands, which secrete fluid devoid of mucus
- Submandibular glands are of mixed type, containing serous and mucus cells
- Sublingual glands contain mainly mucus cells

The majority of saliva is secreted by the major glands, with the smaller glands contributing less than 10% either at rest or when stimulated. Saliva consists of two components that re-secrete by independent mechanisms:

- A fluid component, which includes ions, produced mainly in response to parasympathetic stimulation
- A protein component released mainly in response to sympathetic stimulation

Other factors that can affect salivary composition include:

- Flow rate
  - Flow rate will have marked effect on the concentration of various components of saliva.
- Diurnal variation
  - Unstimulated saliva shows significant circadian rhythms with regard to flow rate and in the concentrations of sodium and chloride, but not in the concentrations of protein, calcium, phosphate and urea. Therefore, the time of the day saliva is secreted has great bearing on the effects of salivary composition and function.

- Age
  - Salivary dysfunction is not a normal consequence of growing older, and is due to systemic diseases, medications, and head and neck irradiation in the majority of cases. Salivary output from the major salivary glands does not undergo clinically significant decrements in healthy individuals. Salivary constituents also appear to be age stable in the absence of major medical problems and medications. It is likely that numerous medical conditions and their treatments contribute significantly to salivary gland dysfunction in the elderly. Another theory suggested is that with ageing, due to the combined effects of atrophy of the acinar cells and progressive replacement of salivary tissue by fat, salivary dysfunction may result.

- Drugs
  - A drug may have no effect on salivary secretion, or it may stimulate or suppress the secretion of saliva. In this way, salivary composition may be altered by virtue of change in concentration of those constituents that are flow-rate dependent. Drugs exert their effects by reflex action, by action on the nervous system, through ganglionic action via the transmitter-releasing drugs, cholinesterase inhibitors, parasympathomimetic or parasympatholytic agents and α- and β-sympathomimetic or sympatholytic agents.

- Source of the saliva
  - Presently, there are at least three types of cells capable of contributing to the composition of saliva, namely the serous and mucus acinar cells and the lining cells of the ducts. Although the compositions of the mucous and serous acinar secretions differ qualitatively and quantitatively, both are concerned with the transportation of electrolytes from serum to saliva, and synthetic amylase and a variety of mucoid substances. Saliva derived from the differ-
4.2 Saliva, Salivation and Functional Testing

4.2.1 Functions of Saliva

Saliva has the following functions:

- Mechanical cleansing of food and bacteria
- Lubrication of oral surfaces
- Protection of teeth and oral–oesophageal mucosa
- Antimicrobial activity
- Dissolution of taste compounds
- Facilitation of speech, mastication and swallowing
- Formation of food bolus conducive for swallowing
- Initial digestion of starch and lipids
- Oesophageal clearance and gastric acid buffering

4.2.1.2 Salivary Output and Abnormal Functions

Evaluation of salivary output can be determined by measurements of unstimulated and stimulated saliva flow rates. There are a number of different techniques for collecting whole saliva and that of individual gland secretions. However, it is of utmost importance to select a technique that is well defined and has demonstrated high reproducibility. In healthy, nonmedicated adults, the value of unstimulated and chewing-stimulated, whole-saliva flow rates on average range from 0.3 to 1.5 ml min$^{-1}$, respectively. The salivary flow rate exhibits wide variation in range, and the limits of normalcy for salivary flow in all age groups and both genders are considerable. Salivary gland dysfunction, resulting in inadequate saliva composition and/or reduced salivary flow (hyposalivation), may be temporary or permanent. Hyposalivation is a term based on objective measures of the saliva secretion, when the flow rates are significantly lower than are the generally accepted “normal value”. Flow rates of unstimulated saliva less than 0.1 ml min$^{-1}$, and those of chewing-stimulated whole saliva of 0.5–0.7 ml min$^{-1}$, fulfil the criteria for hyposalivation.

Abnormal function of the salivary glands affects the secretion of the saliva:

- The salivary secretion may be reduced.
- The salivary secretion may be increased.
- The composition of the saliva may be changed at a reduced, increased or normal flow rate.
- The outflow of secretion may be abnormal.

Disorders of salivary secretion and composition can in general be termed dyschylia, a term derived from pathologic anatomy.

4.2.1.3.1 Hyposalivation

Inadequate salivary function is often associated with the sensation of a dry mouth, referred to as xerostomia. Xerostomia may occur without signs of hyposalivation (in

4.2.1.1 Composition of Saliva

Saliva is composed of a complex mixture of inorganic and organic substances; these can be broadly subdivided into electrolytes, enzymes, other proteins, low-molecular-weight compounds and vitamins. It is estimated that over 200 different proteins and peptides are contained in human saliva. Many of these however may be either isozymes or members of the same protein family. They may range in size from small peptides to large immunoglobulins, and include highly acidic as well as basic proteins. The chemical composition of the secretion of each type of salivary gland differs. The concentration of a given substance in whole saliva varies with species, sex, physical activities, pharmacology state, time of day, etc. No standard state is perfect for comparisons between individuals. Many substances in blood serum are found in saliva. The salivary concentration of some of these is proportional to the serum concentration. Since it is more convenient to obtain a sample of saliva than blood, the former is often used in routine tests to follow changes in disease states and to follow the progress of affected individuals undergoing treatment. With the exception of sialometry (salivary flow rate determination), most salivary function tests must be conducted in special laboratories or clinics. While these tests are helpful, they are invasive, expensive and not always conclusive. Diseases that are considered suitable for such monitoring include:

- Cardiovascular diseases
  - Measurement of serum amylase
- Endocrinology
  - Steroid levels reflect free and true levels of activity
- Infectious diseases
  - HIV testing
  - Helicobacter pylori
- Renal diseases
  - Salivary creatinine levels reflect renal function
- Oncology: screening for tumours
  - p53
  - Oral cavity cancer
- Illicit drug monitoring
  - Cocaine
  - Barbiturates
  - Opiates
  - Alcohol
- Psychiatry
  - Monitoring of therapeutic responses to treatment