Universidad Europea

TRABAJO DE FIN DE GRADO

Grado en Odontología

SALIVARY FLOW IN PREGNANCY

Madrid, curso 2020/2021

Número identificativo 164

ABSTRACT

Introduction: Saliva is an extremely specialised biofluid surrounding the oral cavity. Its functions preserve and maintain the health of the oral environment by permitting protection of oral tissues, remineralisation of the teeth and aiding alimentation whilst acting as a diagnostic marker.

Objectives: The main objective is to analyse and review the salivary parameters flow rate and pH in pregnancy.

Materials & Methods: For this literature review online articles, books, publications and journals were accessed. All of which are available on electronic data bases including PubMed, Cochrane Library, Medline and Google Scholar.

Results and Discussion: The salivary flow rate and pH are generally lower in pregnant women opposed to non-pregnant women. Contrarily, some research displays an increase or almost no difference in flow rate during pregnancy. A significant association between composition of saliva and other physiological changes in the body have a direct impact on these. The changes in flow rate can be attributed to a surge in Oestrogen and Progesterone. Modifications also arise due to a decrease in bicarbonate and calcium ions. In turn there is an increase in phosphate ions and α amylase concentration.

Conclusion: Differences are observed in the salivary parameters of flow rate and pH throughout pregnancy. These modifications along with alterations in composition of saliva contribute to the creation of an optimal environment for the development of oral pathological conditions such as caries, gingivitis and periodontitis. The ongoing assessment of salivary flow and pH throughout pregnancy is important for the diagnosis, prognosis, and monitoring of certain oral manifestations. However, more

studies need to be conducted to achieve concordant and further representative results.

RESUMEN

Introducción: La saliva es un biofluide extremadamente especializado que rodea la cavidad oral. Sus funciones preservan y mantienen la salud del ambiente oral permitiendo la protección de los tejidos orales, la remineralización de los dientes y la ayuda alimentaria mientras actúa como marcador diagnóstico.

Objetivos: El objetivo principal es analizar y revisar los parámetros salivales, flujo saliva y pH en el embarazo.

Metodología: Para esta revisión de la literatura se consultaron artículos en línea, libros, publicaciones y revistas. Todos los cuales están disponibles en bases de datos electrónicas incluyendo PubMed, Cochrane Library, Medline y Google Scholar.

Resultados y discusión: El flujo salival y el pH son generalmente más bajos en mujeres embarazadas que en mujeres no embarazadas. Por el contrario, algunas investigaciones muestran un aumento o casi ninguna diferencia en el flujo durante el embarazo. Una asociación significativa entre la composición de la saliva y otros cambios fisiológicos en el cuerpo tiene un impacto directo en estos. Los cambios en la flujo salival pueden atribuirse a un aumento en el estrógeno y la progesterona. También surgen modificaciones debido a una disminución de los iones de bicarbonato y calcio. Hay un aumento en los iones de fosfato y la concentración de α amilasa.

Conclusión: Se observan diferencias en los parámetros salivales del flujo saliva y el pH durante el embarazo. Estas modificaciones junto con alteraciones en la composición de la saliva contribuyen a la creación de un entorno óptimo para el desarrollo de condiciones patológicas orales como caries, gingivitis y periodontitis.

La evaluación continua del flujo salival y el pH durante el embarazo es importante para el diagnóstico, pronóstico y monitoreo de ciertas manifestaciones orales. Sin embargo, es necesario realizar más estudios para lograr resultados concordantes y más representativos.

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1. INTRODUCTION

Saliva is a complex variety of fluids that surrounds the oral cavity. It originates and is secreted by both small and large salivary glands as well as non-glandular sources, including oral microorganisms, crevicular fluids and host cells (1). Its capability in maintaining and preserving the health of the oral environment is not only extremely meritorious but additionally very important. The saliva plays a crucial role in the protection of the mucosal /gingival tissues, remineralisation of the teeth by forming a protective pellicle on the surface of the teeth (9), aiding alimentation (2) and sustention of tooth integrity. Moreover, its buffer capacity and clearance allow it to serve as a host defence. (3). This mechanism of defence allows the maintenance of a constant pH, therefore whenever the pH of the oral cavity begins to fall or rise as a result of ingesting specific substances, the buffering action of saliva allows it to return to its original normal level after some time. An optimal pH of saliva is within the range of 6.2-7 (5). Whereas, the pH below which any inorganic material can start to dissolve or erode is known as the critical pH. The value of critical pH is anywhere within the scope of 5.2-5.7 which can fluctuate depending on the concentrations of calcium, phosphate and fluoride ions (4, 7).

A healthy adult individual produces 500-1500ml (0.5-1.5l) of saliva per day with an average flow rate of 0.5ml/min (4). Hypo-salivation causes alterations in the defence of the oral system which in turn results in a higher susceptibility and more likelihood of dental conditions arising.

Many processes within the body give way to these changes. These are not only seen in the functions of the human body but also in the composition of the body's diverse systems. The environment of the oral cavity, in particular the salivary system and its flow are also affected as a result of the body's systemic physiological alterations - a specific alteration being Pregnancy (also known as 'Gestation'). This is the period in which offspring (either one or multiple) develop inside the womb or uterus of a woman. It is generally referred to in three divisions, further known as 'trimesters' with each trimester being roughly 3 months (6). This action results in changes that are visible in the saliva as a result of great metabolic, hormonal and biochemical modifications. One of the primary reason's differences occur in the saliva is due to hormone levels. The female steroid sex hormones - Progesterone, Oestrogen and Human Chorionic Gonadotropin (hCG) are predominantly secreted by the placenta (4) and are liable for the changes illustrated in pregnancy. A number of studies portray that during the ovulation stretch of the menstrual cycle, the composition of saliva itself is altered but during the actual pregnancy there are deeper physiological changes in saliva as a result of these complicated hormone interactions (8). The fundamental salivary differences seen during the pregnancy period are in the flow rate, biochemical composition, pH and hormone levels.

The composition of saliva plays a vital role in the prevention of caries, therefore salivary characteristics that are not within normal optimal ranges can give way to caries incidence as saliva is one of the most important intra oral host factors that can affect caries development. Several studies do indicate a higher prevalence of caries among women who are pregnant compared to non-pregnant women. Furthermore, they display an increase in the DMFT index (Decayed, Missing and Filled teeth) during

the pregnancy cycle. However, other studies do not show any correlation in pregnancy and the surge of caries advancement (8).

Along with this, other consequences of the change in salivary flow and composition on the oral environment include pregnancy-associated gingivitis with heightened tendency of gingival bleeding and formation of periodontal pockets (4). Once again, this commonly arises due to the increased levels of Progesterone in the blood stream during pregnancy. The rise makes one more vulnerable to obtaining bacterial plaque which has a negative impact on the gums.

In addition, short-term impacts can also be seen. Salivary modifications, in both flow rate and composition leads to the compromise of soft and hard tissues of the oral cavity. Pregnancy induces a greater response of gingival tissues through the disturbance of tissue metabolism; again, generally resulting in the presence of plaque and tartar (9).

Oral conditions in pregnant women can also impede with the outcome of the pregnancy. For example, periodontal disease and calculus formation as a result of salivary modifications are known risk factors for premature births as well as babies having to be born at a very low weight (8).

Moreover, saliva as a biofluid has become an extremely useful tool for the diagnosis of diseases, particularly due to its interactions with the body's systems and its function. Along with this, there has been a recent increase in the use of modern techniques to aid the outcome of laboratory investigations - its value has risen tremendously, and

many studies have been conducted to analyse its benefit in complementary tests. We can evaluate the implications of diverse salivary conditions.

In light of these recent revelations, this project aims to review salivary components, salivary changes visible during the nine months pregnancy period as well as improve understanding on the role played by pregnancy on oral health.

2. OBJECTIVES

MAIN OBJECTIVE:

- To review the salivary parameters (flow rate and pH) in pregnancy.

SECONDARY OBJECTIVES:

- To study the composition of saliva and its function.

- To review the effects and consequences of the changes in salivary parameters on the oral cavity from a dental point of view.

3. MATERIALS AND METHODS

This research is a literature review. The references for this project were found through a vast number of online sources, for example, online articles, books and journals. All of which were available on electronic data bases including PubMed, Cochrane Library, Medline and Google Scholar. These were obtained via the Universidad Europea de Madrid CRAI library online access. The inclusion criteria (Table 1) were used to explain and carry out research of the papers found. The 7 key words stated in Table 1 were taken into consideration in order to find relevant articles. They were very effective as a base on where to start and to help locate what exactly needed to be looked for.

INCLUSION CRITERIA:

Table 1. Inclusion criteria	
Type of research	Literature reviews
Type of study	Human, not experimental
Language	English
Date of research	2000 onwards (in the last 20 years). Some were published before but considered useful & appropriate to use as they are not as up to date.
Key words	“saliva”, “salivary flow”, “pregnancy”, “salivary flow rate pregnancy”, “unstimulated saliva”, “stimulated saliva”, “pH of saliva”

4. CONCEPTS

4.1 SALIVA DEFINITION

Saliva is a valuable oral secretion. It is a clear fluid present in the mouth region produced by the salivary glands. It is composed of primarily water and several other vital substances such as enzymes, electrolytes, mucus and antibacterial elements (1). It is an extremely versatile fluid which plays an important role in a vast number of physiological functions within the oral cavity. Not only does it preserve and maintain the health of the oral environment, but it also performs a large act as a diagnostic marker. Saliva can aid the diagnosis, prognosis and management of oral diseases / illnesses.

4.2 SALIVARY GLANDS

The biofluid Saliva is produced by three major glands (which can be identified in Figure 1) and several minor salivary glands, which are all located in the vicinity of the oral cavity. The three pairs of major glands are the Parotid, Submandibular and Sublingual glands. These contribute to 90% of all salivary secretions. Whilst the minor salivary glands give way to only 10% of the total secretions (12). At rest, when there is no stimulus present (the unstimulated state), close to two thirds of the total salivary volume originates from the submandibular glands. However, on the other hand, when there is a stimulus existent it is in fact the parotid glands that are liable for approximately 50% of the total salivary volume (12). In both unstimulated and stimulated circumstances, the sublingual glands endow an extremely small proportion

of saliva. Furthermore, the minor salivary glands are primarily responsible for lubricating the oral mucosa as a result of the high amounts of protein they contain.

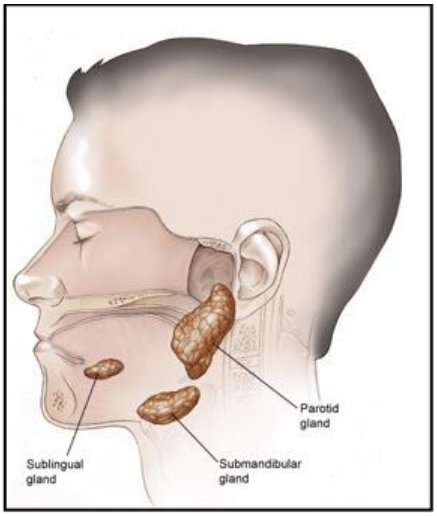

Figure 1.
Location of the three major salivary glands
(13)

Generally, acinar cells (also known as secretory cells) give way to the principal production of saliva. Where as, ductal cells contribute towards to the other further alterations of saliva until it is exposed into the oral cavity. The primitive secretory units of salivary glands are clusters of cells called an 'acini' (14). These types of cells release

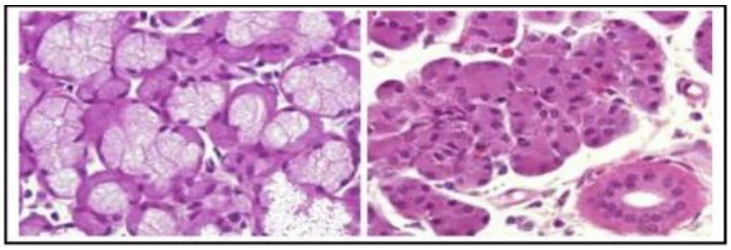

Figure 2.
Histological sections of canine salivary flow - comparison of the Submandibular & Parotid gland secretions.
(14)

fluid containing several elements that flow out of the acinus into the collecting ducts to be secreted.

The type of material secreted by the glands are confirmed with histological testing. Typically, there are two types of acinar epithelial cells - serous cells and mucous cells.

Serous cells present watery secretions, which do not void any mucous and mucous cells secret very mucous-rich content.

The three pairs of major salivary glands (mentioned above) differ depending on the type of contents they produce and what they secrete. The parotid glands which are accountable for at least 50% of total saliva production, produce a serous watery production. The submandibular glands produce a mixture of both serous and mucous production. Where as, the sublingual glands which are responsible for the smallest volume of saliva production secrete saliva that is a predominantly mucous constitution. Figure 2 portrays the difference in histology between the secretions of the submandibular gland (right) and the parotid gland (left). We know that the submandibular gland produces mixed secretions, where as the parotid gland is primarily serous. The cells that are evidently stained pink are serous cells. Whilst at the same time, the mucous secreting cells are those that are white and foamy (14).

The bodies autonomous nervous system is what controls the secretion of the saliva - in terms of both the type of saliva and volume secreted. The parasympathetic nervous system stimulates and in turn produces profuse amounts of watery saliva. However, the sympathetic system creates an abundant supply of saliva that is rich and viscous (15).

4.3 SALIVA COMPOSITION

Saliva is composed of a vast range of substances. In the human species, saliva is principally made up of water (98% of its total content). As well as this, its content entails several electrolytes including sodium, potassium, bicarbonate, magnesium and

phosphates (3). Also identified in saliva are proteins, enzymes, mucins, immunoglobins and nitrogenous products (ammonia and urea) (11). These components work simultaneously and interact in order to allow optimum functional properties.

Table 2 summarises the functions off each of the individual components specifically.

Table 2: Salivary components and their functions (11)

Salivary Component	**Function**
Water	*Mucosal integrity*
Bicarbonate	*Buffering properties, modulate pH*
Phosphate	*Buffering properties, modulate pH*
Calcium	*Remineralisation*
Amylase	*Digestion of starch*
Protease	*Digestion*
Lipase	*Digestion of fat / lipids*
Lysozyme	*Hydrolysis of cell membrane*
Lactoferrin	*Antimicrobial properties*
Mucins	*Digestion, lubrication, pellicle formation, dental plaque metabolism*
Antibodies in saliva	*Antimicrobial properties*

Regarding to the salivary ducts, the contents of the secretions are modified. For example, a lot of the Sodium contents are actively reabsorbed whilst potassium and higher amounts of bicarbonates are secreted. The production and secretion of bicarbonates are of greater relevance to humans as they along with Phosphate create a buffer which acts to neutralise a lot of acidic components that may be present in the oral cavity and / or stomach. This whole process entails small collecting ducts that can be seen in salivary glands which then branch into larger salivary ducts. After time, they ultimately harvest one individual large duct which secretes into the oral cavity region.

When one is in the resting state without any form of stimulation, saliva is formed mainly from the basal area which is present beneath the tongue. This is carried out to enable the lubrication of the oral tissues based in the oral cavity / mouth region. Along with this, if an individual undergoes any sort of muscular activity or stimulation of the olfactory senses (for example when eating or seeing food), it leads to the production of saliva but this time in its stimulated state.

4.4 FUNCTIONS OF SALIVA

Saliva serves many roles, some of which are vital for all types of species and others more specifically significant for humans. One key function of saliva is its importance in the protective properties of lubrication and binding / moistening. The aim of saliva is to provide lubrication molecules which not only surround food but also the soft tissue in the oral environment. This film of lubrication not only enables appropriate phonation and facilitates in the good articulation of speech, but it also does aid the passage of

food with minimal amount of friction (16). These lubrication properties are also attributed to mucin glycoproteins which are produced by some of the minor salivary glands and are seen in all buccal, labial and palatal mucosa. Mucins, for example MUC5B and MUC7 type mucins form high strength fluid layers which coat the oral cavity (10). The mucous visible in saliva is extremely efficient in the binding of masticated food into a bolus which allows passage down the oesophagus striking any sort of damage. Additionally, saliva has antimicrobial, antiviral, and anti-fungal functions. Salivary proteins such as lysosomes, lactoferrin and lactoperoxidases work simultaneously with other elements found in saliva that act immediately on bacteria - inhibiting multiplication of them or killing them directly. Lysozyme's give way to the lysis of bacterial cells, especially *Streptococcus mutans*, as they collaborate with anions of low charge density chaotropic ions (thiocyanate, perchlorate, iodide, bromide, nitrate, chloride, and fluoride) and with bicarbonate (11). Other functions include its defensive and buffering capacity properties - saliva entails three buffer systems (phosphate, protein and bicarbonate). These allow and help maintenance of a neutral environment in the oral region (a range of 6.0 - 7.5). Along with this, saliva contains enzymes such as α amylase and lipase - these play crucial roles in the digestion of starch as well as the decomposition of triglycerides. One article stated that Amylase is available as 6 diverse isoenzymes in saliva which can convert starch into other substances including maltotriose, maltose and maltotetroses (as well as other oligosaccharides) (11).

In addition, our saliva has a critical part to play in the protection of teeth and other dental related aspects of the oral cavity. In normal physiological conditions the saliva is impregnated with calcium hydroxide which is a known compound that aids and

supports the process of remineralisation and therefore preventing dental demineralisation (12).

The salivary protein pellicle allows protection of the teeth against foreign substances and irritants. It is a thin layer of organic acellular film that forms on any surface of the tooth once it has been or upon exposure to saliva. It plays a significant role in the maintenance of oral health. Moreover, the saliva contains many other organic substances. Examples are glucose, urea, cortisol, sex hormones and blood group components. These have all been used a multiple number of times in complementary tests and in helping with diagnosis / screening. In conjunction with this, studies suggest that saliva plays an alternate role in the healing of wounds. Proposed by Volker who stated that saliva in the oral cavity allows the acceleration of the coagulation of blood. Volker advocated that both by affecting the anticoagulant valuable property in a region where rough food or traumatic injury can induce bleeding and bleed readily due to inflammatory disease. (17).

As well as all the exceptional function's saliva plays in the oral cavity, it can also have a negative impact if its volume or components it is made up of are altered slightly. It is known that if there is a decreased pH evident, it can predispose and give way to the incidence of caries. Whereas an increase in pH can be held accountable for the formation of tartar which can have a harmful consequence of the alveo-gingival margins in the mouth.

Both the quantity and quality of saliva visible can be affected by a variety of factors, these including whether one is consuming any form of medication or if they are affected by any disease. Salivary flow may be reduced greatly if an individual experiences episodes of acute stress - this increases the levels of salivary cortisol as

a response of the adrenal cortex to stress triggers. A decrease in the flow may also be encountered due to psychological factors, such as depression and anxiety. Dry mouth (Xerostomia) is a condition where the salivary glands are producing a diminished quantity of saliva which in turn do not allow sufficient lubrication and moisture within the oral region. Dry mouth is also very often a result of the side effects of some medications or as a result of radiation therapy for cancer. Xerostomia is a common oral disease associated with more than five hundred medications (12). These patients can be at higher risk of developing dental conditions and diseases such as dental caries, increased plaque, gum diseases or fungal (yeast) infections in the mouth. Other complications entail mouth sores and poor nutrition due to problems chewing or swallowing adequately.

In contrast to this, hyper salivation is where there is an excess in the production and flow of saliva. This is commonly visible in people with anxiety, in those with poor oral hygiene, jaw fractures / dislocation, gastro oesophageal reflux episodes or in those with Chronic diseases which the excessive formation of saliva is called Sialorrhea. In addition, hyper salivation may be experienced during the Pregnancy process when one might be feeling nauseas or experiencing morning sickness.

4.5 SALIVARY PARAMETERS

Variables related to saliva, for example its flow rate and pH are measured using a diverse range of tests and procedures. In addition, these parameters can be used as diagnostic tools and markers to identify prognosis and further management of diseases and illnesses.

4.5.1. SALIVARY FLOW RATE

4.5.1.1 Salivary flow rate definition

Salivary flow rate (SFR) is known as the quantity of saliva that is produced by the salivary glands in the time unit which is expressed in mL/min or sometimes as g/min. Along with this, salivary flow rate can be further divided into two categories – Unstimulated salivary flow rate (USFR) and Stimulated salivary flow rate (SSFR). Salivary flow that is unstimulated is when flow is autonomous of any sort of stimulus, it is independently secreted and not induced by any other factors such as food. In addition, stimulated salivary flow is the formation of saliva as a result of sensory and masticatory stimulation (27). A stimulus is given with the intention to secrete saliva.

4.5.1.2 Whole salivary flow rate values

Between individuals, salivary flow rates tend to vary greatly.

Table 3 below displays the accepted ranges of normal flow rates as well as those rates that are considered abnormal.

Whole saliva is the total output of saliva from both the major (parotid, sublingual and submandibular) and minor salivary glands.

Table 3: Salivary flow rate normal values (12)

Type of salivary flow	**Normal flow rates (ml/min)**	**Abnormal flow rates. (hyposalivation) (ml/min)**
Daily production	500 - 1500	<500
Whole unstimulated flow	0.3 - 0.4	<0.1
Whole stimulated flow	1 - 2	<0.7

4.5.1.3 Inducers of salivary flow

In the body, the salivary centre is made up of numerous nuclei located in the medulla region (3).

There are three commonly known types of triggers (stimuli) which give way to the secretion of saliva (3).

A. Mechanical
B. Olfactory
C. Gustatory
D. Other

A. **Mechanical** triggers are those stimuli that involve an individual carrying out an action. For example, the act of chewing can induce secretion of saliva.
B. **Olfactory** stimulation includes those triggers which form saliva through the sense of smell. Although this is not as effective in producing larger quantities like the other triggering factors.
C. **Gustatory** triggers prompt the stimulation of salivary flow through the 5 basic tastes – sweet, sour, salty, bitter and umami (28). The sweeter stimuli bring about a lower production of saliva compared to the more sour and savoury tastes.
D. **Other** stimulants comprise of psychotic states such as pain and anxiety. Moreover, they constitute of specific medications and diseases (local or systemic) affecting the salivary glands specifically. These factors are all of which that can result in the induction of saliva.

4.5.2 SALIVARY pH

4.5.2.1 pH definition

The pH (power of Hydrogen) is a scale that is used to identify how acidic or basic an aqueous solution is. The pH scale ranges from 0 – 14 with 7 being neutral. Any number that is below this neutral value is known to be acidic and anything above is basic (alkaline).

Analysing the pH of saliva permits us to make comparative judgments and analyses – we are able to study the pH of saliva to determine its relevance to specific periodontal diseases as well as their severity.

4.5.2.2 Salivary pH values

4.5.2.2.1 Normal pH

The accepted normal value of salivary pH ranges from 6.2 – 7 (5).

This is within the neutral scope of the pH scale, which is maintained with the help of buffering systems present in the saliva in the oral cavity.

4.5.2.2.2 Critical pH

In saliva, the critical pH value is within the spectrum of 5.2 – 5.7 (4).

The critical pH is that at which the saliva cannot interact with calcium, phosphate and fluoride ions (4,7). This thereby provokes the hydroxyapatite present in the dental tissue enamel to dissolve. The critical pH is the highest pH at which there is a loss of enamel tissue from the tooths structure (29). Increasing the concentration of calcium and phosphate ions can reduce the critical pH which ensures that the teeth are able to withstand pH values on the lower end of the scale before they demineralise and give rise to periodontal diseases.

4.5.3 METHODS OF MEASUREMENT

Different machinery and technology are now available to allow for the diagnosis and risk assessment of diseases and illnesses. Biomarkers related to saliva have been used and are also currently being utilised to analyse the risk for obtaining cancers, infections and syndromes. Examples include HIV, ovarian / breast cancers and Sjögren syndrome. Along with this, their use is also beneficial when detecting dental caries and periodontal diseases.

Measuring the salivary flow rate of the salivary glands is called Sialometry - it allows for the collection of whole saliva and glandular saliva. It enables one to identify if there is any vivid dysfunction of the salivary glands. Likewise, saliva can also be analysed in a chemical manner. This assessment of the chemical composition of saliva is called Sialochemistry. We are able to see if the saliva has been contaminated with serum, food debris, sputum or other foreign substances such as abnormal proteins. Essentially, this diagnostic tool allows for the contrast between normal and abnormally functioning salivary glands which if present and caught early is of much benefit.

Medical professionals opt for methods to measure saliva depending on the specific needs of the patient and on what criteria they meet when completing their clinical history. Clinical evaluations are carried out in order to identify the extent of dry mouth. One of the most common methods used for collecting unstimulated whole saliva is refraining the patient from eating anything up to an hour before collection. As Figure 3 portrays, the patient leans their head forward over a test tube and funnel for a 5-minute period whilst keeping their mouth slightly open. The saliva collects into the tube and the clinician then measures the volume at the end of the indicated time.

Figure 3.
Measuring unstimulated salivary flow
(25)

Similarly, stimulated salivary flow is measured in the same manner except the subject is given a stimulant to chew. Commonly used stimulants are candy, paraffin wax, gum, bands made from rubber and citric acid. At times, salivary flow can also be stimulated with the aid of powdered toothbrushes and secretagogues, such as pilocarpine (25).

Moreover, collection of saliva is also commonly conducted by obtaining it from the individual glands themselves. These procedures are more time consuming and require great precision as custom made devices to collect the saliva need to be made beforehand. The major salivary glands are used to compile and gather saliva, opposed to the minor salivary glands as they do not have as much clinical relevance.

When collecting saliva from the parotid glands, as seen in Figure 4 a modified Lashley cup device or Carlson-Crittenden collector often is utilised. The secretion is carried out through the Stenson duct in the parotid papilla region (opposite to the superior second molar).

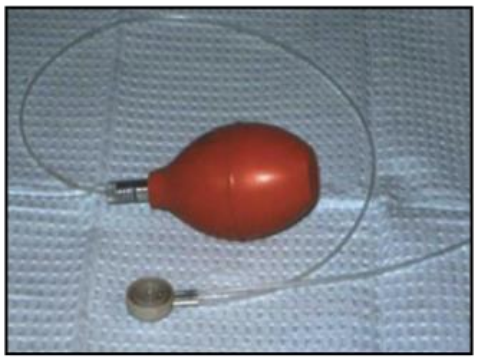

Figure 4.
Modified Carlson-Crittenden device for the Parotid gland salivary collection
(25)

Furthermore, collection from the submandibular and sublingual glands are conducted via the Wharton duct, which in fact opens into the floor of the mouth. The custom-made device used in these situations is the Wolff collector (Figure 5) (25).

These methods are particularly helpful when needing to detect developing diseases in the vulnerable population - for example in those with weakened immune systems, living with another chronic illness or in pregnant women.

Figure 5.
Wolff device for the Submandibular & Sublingual gland salivary collection (25)

With regards to Pregnancy, several changes are seen and felt during this 12-month period. These alterations are specifically seen in terms of salivary flow, composition and volume.

5. RESULTS

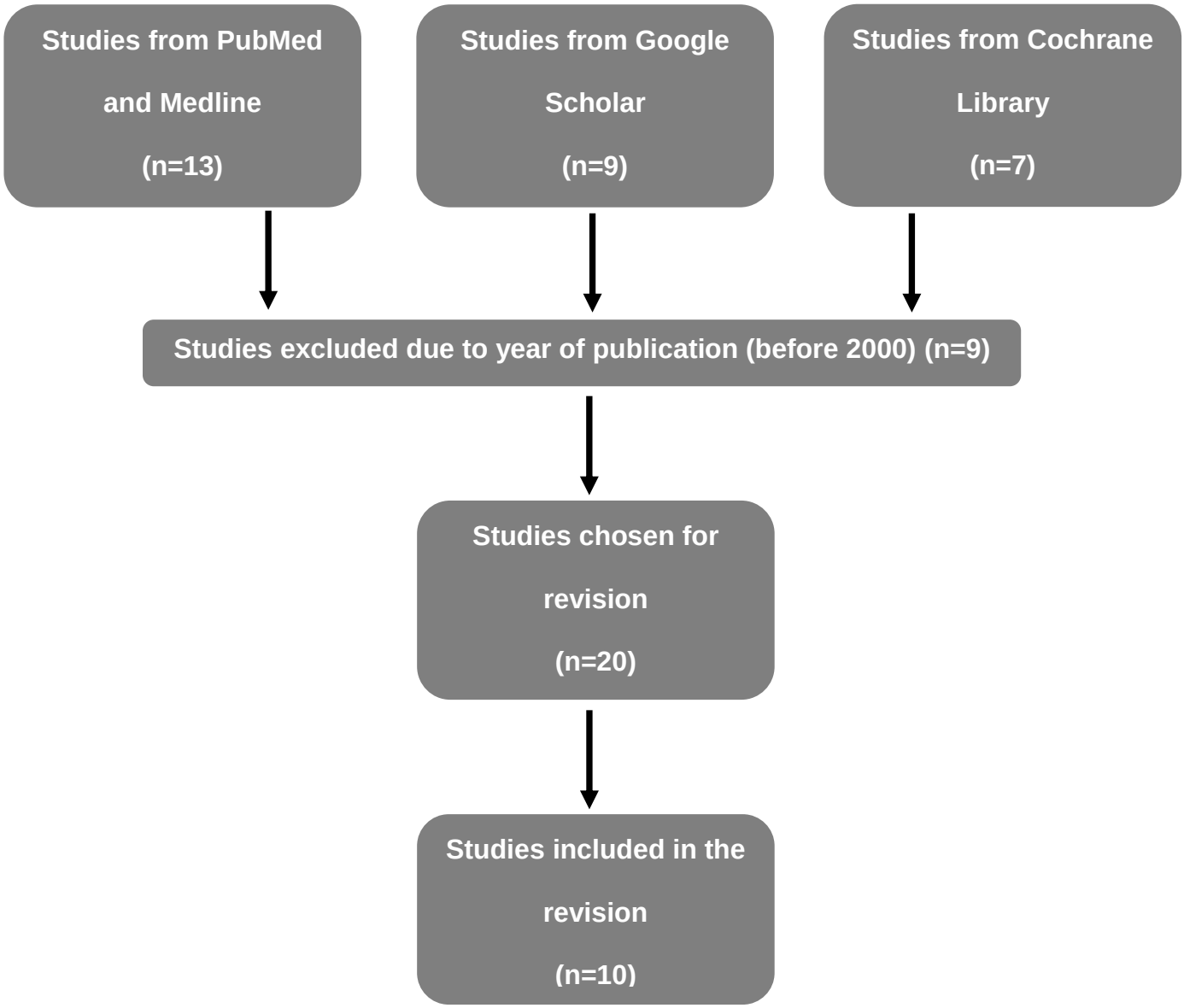

Figure 6.

Figure 6. This chart illustrates the criteria which were used in order to select the included studies. Out of a total of 29 studies that had been considered, 10 were selected based on their year of publication as well as their relevance to the topic and objectives. The 10 studies consider the variations in salivary flow rate, the composition of saliva and its function as well as how it might change during pregnancy plus the impacts these changes may have on the oral cavity from a dental perspective. These studies are displayed in Table 4 below.

Table 4: Studies included in the revision					
Name of article and reference	**Authors**	**Year published**	**Number of patients**	**Objectives**	**Significant findings**
Determination of salivary flow rate, pH, and dental caries during pregnancy: A study (2)	Karnik et al.	2015	60 (30 pregnant & 30 non-pregnant)	Rate of salivary flow and pH in pregnant and non-pregnant Indian women Correlation of salivary flow and caries prevalence in both groups	Salivary flow rate and pH were lower in pregnant women Strong correlation between lower pH and caries prevalence
Salivary Flow Rate, pH and Buffering Capacity in Pregnant and Non-Pregnant Women – A Comparative Study (4)	Naveen et al.	2014	60 (30 pregnant & 30 non-pregnant)	Analyse salivary flow rate, pH and buffering capacity in pregnant and non-pregnant women	Salivary flow rate increased in pregnant women pH decreased in pregnant women
Salivary pH: A diagnostic biomarker (5)	Baliga et al.	2013	300	pH of saliva and its relevance to severity of periodontal disease	Salivary pH more alkaline in people with generalised chronic gingivitis but lower in those with generalised chronic periodontitis

The biochemistry of saliva throughout pregnancy (8)	Rio et al.	2015	60 (30 pregnant & 30 non-pregnant)	Evolution of salivary flow rate, pH, ion concentrations, glucose and α-amylase during pregnancy	No relevant changes in salivary flow rate Lower calcium and glucose concentrations in pregnancy Increased phosphate concentration in pregnancy Acidic non-stimulated and neutral stimulated saliva in pregnant women
Changes in saliva composition of pregnant and non-pregnant patients (18)	González et al.	2001	100 (50 pregnant & 50 non-pregnant)	Changes present in the saliva of pregnant patients. Association between changes in salivary flow and pH	Salivary flow rate and pH were lower in pregnant women There is an association between decreased salivary flow and gum bleeding
Salivary factors related to caries in pregnancy (26)	Yousefi et al	2020	29 studies (1230 pregnant & 715 non-pregnant)	Saliva related risk factors of caries during the trimesters of pregnancy –, ion concentrations, flow rate, buffer	Ion concentrations decreased. Salivary flow rate increased in the third trimester

				capacity, DMFT index	Changes in buffer capacity in third trimester
Salivary flow rate, pH, and concentrations of calcium, phosphate, and sIgA in Brazilian pregnant and non-pregnant women (30)	Rockenbach et al.	2006	44 (22 pregnant & 22 non-pregnant)	Compare unstimulated whole salivary flow, pH and concentrations of calcium, phosphate and sIgA in pregnant and non-pregnant Brazilian women	No difference in salivary flow rate and ion concentrations. pH was lower in pregnant women.
Pregnancy related changes in human salivary secretion and composition in a Nigerian population (31)	TJ Lasisi & PN Ugwuadu	2014	100 (50 pregnant & 50 non-pregnant)	Changes in secretion and composition of saliva in pregnant Nigerian women	pH and concentrations of potassium and bicarbonate were lower in pregnant women. Concentrations of sodium and phosphate were higher in pregnant women. No difference in flow rate or concentrations of calcium, phosphate and protein.

Pregnancy-induced periodontal inflammation: Influence of salivary cytokines and antimicrobial proteins (32)	TJ Lasisi & R Abdus-Salam	2018	47 (all pregnant)	Association between periodontal inflammation due to pregnancy and levels of salivary antimicrobial proteins and cytokines (compared to post-partum)	Salivary flow rate and pH, IFN-gamma and IL-1b were lower in pregnancy. Gingival, periodontal indexes and TNF- α higher during pregnancy. No differences in antimicrobial proteins.
Evaluation of salivary flow rate, pH and buffering capacity in pregnant and non-pregnant women- A comparative study (33)	Bhatia et al.	2019	90 (45 pregnant & 45 non-pregnant)	Analyse salivary flow rate, pH and buffering capacity in pregnant and non-pregnant women	Decrease in salivary flow rate, pH and buffering capacity in both pregnant and non-pregnant women

6. DISCUSSION

It is of great importance to understand that the salivary parameters (flow rate, pH and composition) during the 9-month pregnancy period have wide variability and are constantly changing. It is vital to understand that the evolution of these factors is not simultaneous and in fact vary from woman to woman. Furthermore, their evolution can give way to other changes such as the incidence of dental diseases in the oral cavity.

6.1 SALIVARY FLOW

In context of salivary flow rate, an article written in the Journal of Indian Academy of Oral Medicine and Radiology by **Karnik et al. (2015)** suggests that pregnant women had a lower salivary flow rate compared to non-pregnant women (2). This was concluded from a cross sectional study that was carried out in Mumbai, India on 60 participants within the age range of 18-37 years old. The doctors and researchers collected information from the medical charts of the subjects - including their trimester of pregnancy as well as if they were or were not taking any medication. Unstimulated saliva samples were collected in a standardised manner where the participants sat in a comfortable position with their head tilted slightly forward and then expectorated. Any saliva collected on the floor into a plastic container in ice over a 5-minute period. The salivary samples were quantified in a volumetrically approach using measuring cylinders and the rate of the salivary flow was indicated in ml/min (2).

Along with this, studies carried out **González et al. (2001), TJ Lasisi &**

R Abdus-Salam (2018) and Bhatia et al. (2019) displayed similar findings of decreased flow rate of saliva in pregnant women (18,32,33). It can be suggested that the decrease in flow rate is attributed to the increased levels of hCG (human

chorionic gonadotropin) during the pregnancy period which in turn result in reduced salivary flow (33). Furthermore, throughout the pregnancy period the quantity of human chorionic somatomammotropin (HCS) rises and consequently, the flow rate of saliva is diminished.

In contrast to this, the study conducted by **Naveen et al. (2014)** portrayed that salivary flow rate increased in pregnant women (4). The results obtained by **Yousefi et al. (2020)** are in conjunction with this as they found that the salivary flow rate increased, particularly in the third trimester of pregnancy (26). Like the numerous other process in the body, pregnancy is one in which a vast range of alterations can be seen - in terms of physical, chemical and biological factors. Chemically, steroid sex hormone levels increase gradually during the gestation period. The levels or progesterone and oestrogen (including its biologically active derivatives - estriol, estrange and estradiol) are heightened progressively. During this period, oestrogen and progesterone increase remarkably - which leads to an increase in the flow rate of saliva (2,4). The third trimester of pregnancy is the period of gestation from week 29 until week 40 (months 7-9) where many profound changes also occur –the trimester in which **Yousefi et al. (2020)** saw a vast increase in the salivary flow (26).

The biologically active states of oestrogen (mentioned above) increase in a noticeable manner - the levels rise by 100 and 1000-fold during pregnancy (2). A surge in salivary flow rate has been reported when oestrogen has been utilised for hormone replacement therapy (HRT) which implies that it might also have a huge part to play in the salivary gland functioning during pregnancy too (4).

In conjunction, it is notable that excessive drooling and salivation is related to heightened oestrogen levels according to medical professionals and experts. It is said that an increase in blood flow can result in a higher production of saliva. This

increased formation of saliva in the oral cavity during the pregnancy period is called 'ptyalism gravidarum' also known as hyper salivation or sialorrhea (24). Although it is an extremely common condition, it is not severe plus does not cause harm to the baby. It is caused by fluctuation in hormone level as well as pregnancy sickness. The feeling of nausea can naturally cause one to swallow less, especially in those situations with extreme morning sickness (known as hyperemesis gravidarum). This state often impacts women who are in the early stages of their pregnancy - the first trimester and then gradually eases as the gestation continues into the second and third trimesters.

In the study by **Karnik et al. (2015)** majority of the subjects in the pregnancy group were in their third trimester of pregnancy (73%) opposed to just 4% being in their first trimester which is where larger volumes of saliva are supposedly produced. Thus, implying that if the study was to be conducted on equal numbers of subjects in each trimester a greater statistical significance could potentially have been seen.

On the contrary, **Rio et al. (2015)**, **Rockenbach et al. (2006)** and the authors **TJ Lasisi and PN Ugwuadu (2014)** established that there were not any statistically significant and important changes in salivary flow between pregnant and non-pregnant women (8,30,31). This could suggest that other external factors apart from sex steroid hormones can regulate and have an impact on the flow rate of saliva, it is likely that in most studies risk factors were not taken into consideration meaning that they were piloted in ideal scenarios. **Rio et al. (2015)** insinuated that the dissimilarities between reported values can be due to intra-individual modifications of saliva which could be related to the menstrual cycle, medications, circadian rhythms and eating / drinking habits (8).

In majority of these studies, it was the unstimulated flow rate that was measured since unstimulated saliva plays a crucial role in the maintenance and integrity of oral health. The unstimulated saliva offers a precise manner to examine salivary gland performance whereas the stimulated saliva would just give information on the functional reserves (4).

In addition, the articles have been chosen due to their recent publication date within the last 20 years therefore being up to date. Although the contradicting results could originate from the fact that all the sample sizes are 100 or less which could imply that they are not highly indicative. An exception is the meta-analysis conducted by **Yousefi et al. (2020)** which had a larger sample size but the fact it analysed the results from several studies illustrates that it could be general. It could also be argued that they would have been conducted years ago so could potentially not be as accurate in present time.

6.2 SALIVARY pH

Another salivary parameter that can be altered during the pregnancy period is the pH. The flow rate of saliva has a direct definitive impact on the pH of saliva. Hereby, authors **Karnik et al. (2015), Naveen et al. (2014), González et al. (2001), Rockenbach et al. (2006), TJ Lasisi and PN Ugwuadu (2014), TJ Lasisi & R Abdus-Salam (2018) and Bhatia et al. (2019)** all concluded that the pH of saliva decreased in women who were pregnant (2,4,18,30,31,32,33). As mentioned above, the increase in progesterone results in as reduction in the concentration of bicarbonate therefore causing a decrease in the pH of saliva also. A decline in the

pH results in a more acidic environment which provides an optimal setting for bacteria to ferment and give way to caries incidence.

Along with this, it has been put forward that the activity of alpha amylase in saliva heightens during the 10^{th} to 21^{st} weeks of pregnancy which can cause a higher substitution of microorgansims and thus a reduction in the pH (33).

Chiefly, a pH of 5.5 or below is said to be the critical level at which demineralisation of teeth tends to begin as hydroxyapatite crystals start to dissolve (2). However, in these studies the pH remained within the 5.5-7.4 range suggesting that although it diminished, it did not drop drastically (2,4,18,30,31,32,33).

These results could be identified in all seven studies, which consisted of varying sample sizes (although not more than 100) and can therefore be generalized.

In accordance with this, **Rio et al. (2015)** stated that the non-stimulated saliva decreased in pregnant women whereas the stimulated saliva in pregnant women remained within the neutral boundaries (8). It is the non-stimulated saliva which has a true reflection of the salivary glands and their functioning therefore in this study as well as the others that measured the pH parameter, suggests that a reduction in the values are a general trend.

The described studies have been chosen, due to their wide span in publication year, indicating the accuracy of conclusions and reality of a visible lower pH in pregnancy. Although, it could be argued that the sample sizes are not representative of the population entirely.

6.3 SALIVA COMPOSITION

6.3.1 Ion concentration

Authors have also investigated the fluctuations in ion concentrations of saliva throughout the gestation period. **Rio et al. (2015)** identified lower calcium and higher phosphate levels in pregnant women (8). It is of particular interest as both calcium and phosphate metabolism have a great role to play not only in the formation of teeth, but also in the mineralisation of them. A reduced level of calcium can lead to lower remineralisation, advanced demineralisation of enamel and enhanced alveolar bone loss (8). Moreover, it is correlates with the formation of dental caries. Additionally, the phosphate homeostasis phenomena can defend the increase of phosphate concentration. This includes the secretion of the parathyroid hormone resulting in an efflux of phosphate from the GI tract, bone and kidneys all in response to the lessened calcium concentrations (8). Similarly, **TJ Lasisi and PN Ugwuadu (2014)** identified an increase in the phosphate concentrations which could be explained by the homeostasis function. However, they investigated that there were no significant differences in the concentration of calcium between pregnant and non-pregnant women (31). Along with this, potassium and bicarbonate levels were reduced in the pregnant group. The lower levels of bicarbonate are attributed to the increase in the progesterone hormone, thereby also related to the decreased pH (31).

On the other hand, **Rockenbach et al. (2006)** and **TJ Lasisi and PN Ugwuadu (2014)** studied the concentration of calcium and phosphate ions in the saliva. They identified that these ion concentrations of throughout pregnancy do not change considerably (30,31). This inconsistency could be due to the small sample size once again or because both studies investigated the modifications of salivary parameters

solely in women of one country – **Rockenbach et al. (2006)** studied solely Brazilian women and **PN Ugwuadu (2014)** were exclusive to Nigerian women (30,31). Among different cultures, the socio-economic situations vary which imply that changes could arise as a result of an individual's background which is a risk factor that might not be taken into consideration.

6.3.2 Antimicrobial proteins

Along with ions, another component of saliva are antimicrobial proteins. **TJ Lasisi & R Abdus-Salam (2018)** noted that the levels of these proteins were not altered in pregnancy. The salivary antimicrobial proteins analysed were salivary lactoferrin, lysozyme and beta defensin 1 (32). This lack of change could be attributed to the fact that this study did not have a comparison group of non-pregnant women like the other articles. Instead, the authors analysed the antimicrobial protein levels within the same group of women during the pregnancy period and then post-partum.

6.3.3 Cytokines

Salivary cytokines IFN-gamma and IL-1b decreased during pregnancy according to **TJ Lasisi & R Abdus-Salam (2018)**. Whereas, also in the same study the salivary TNF- α levels were significantly higher (32). The reduced levels of IFN-gamma and IL-1b accompanied by a higher TNF- α concentration throughout the pregnancy period advocate their involvement in the aetiology of pregnancy-induced periodontal problems and inflammation (32).

This study was elected due to its recent conclusions regarding the contribution of salivary cytokines to changes in pregnancy. However, it only did compare women

who were pregnant with results post-partum as opposed to women who were non-pregnant.

6.3.4 Glucose

Rio et al. (2015) established a progressive decrease in the concentration of glucose in saliva throughout pregnancy. A great statistical significance was documented especially in the third trimester compared to non-pregnant women (8). It is postulated that this recorded result is directly related to the levels of glucose in the plasma. During the pregnancy period, an increase in the resistance to insulin is perceived. The changes that occur as a result of this are accustomed to the hormones secreted by the fetal-placental unit. This implies that a sufficient amount of glucose is needed to provide for the fetus thereby suggesting a lower level in the oral cavity (8).
This study was selected due to its extensive span of publication year plus it is also the first in this field to exist that analyses salivary glucose levels throughout pregnancy. Although, it is vital to not generalise.

6.3.5 Alpha amylase

Rio et al. (2015) investigated that the α-amylase levels were superior in pregnant women as opposed to non-pregnant women (8). Although the principal function of α-amylase in saliva is the hydrolysis of starch into maltose, it also acts as a substrate for bacteria in the oral cavity which in turn can lead to the formation of acidic substances (8). Thereby, it has been postulated that enamel demineralisation can occur during pregnancy as a result of increased α-amylase levels as it attributes an acidic environment.

The explained articles have been selected as only a minute number of studies that concern the alterations in salivary composition whilst having been published in the last 20 years exist.

6.4. DENTAL DISEASES

6.4.1 Caries Incidence

Modifications in salivary composition during pregnancy can give way to the prevalence of caries (a dental disease that causes the decay of teeth). This is supported by **Karnik et al (2015)** who completed a Decayed-Missing-Filled Teeth (DMFT) index in order to determine the prevalence / presence of dental caries. They propose that there is a significant association between caries onset and pregnancy (2). In this study, the pregnant group were noted to have had better oral hygiene care than those in the non-pregnant group but were still more susceptible to caries with a higher DMFT index (2). **Karnik et al (2015)** argue that there is a direct correlation between decreased salivary pH and caries incidence in pregnancy (2,34). A lower pH links to an acidic environment, hereby amplifying the risk of caries. Increased levels of bacteria (particularly *Streptococcus mutans)* ferment carbohydrates such as sugars which give rise to the formation of organic acids. These acids vividly decrease the pH of saliva, creating an optimal environment for plaque to accumulate and in turn consequently result in caries (2). Thereupon, adequate and maintained oral hygiene from the beginning of the pregnancy period is immensely important to prevent formation of caries disease.

In concordance with this are **Bhatia et al. (2019)** and **Yousefi et al. (2020)** as they concluded that the buffering capacity in the saliva change immensely, specifically

reaching their lowest concentrations in the third trimester (26,33). Alterations in buffering capacities influence the ion concentrations and therefore decrease pH of the saliva which in turn gives way to caries (9). In contrast, **Rio et al. (2015)** illustrated no correlation in pregnancy and the surge of caries advancement (8). Maternal saliva is known to be the primary source and significant mode of bacterial transfer to children (21). It is essentially for this reason; it is crucial to analyse the prevalence and risk of obtaining caries in pregnant women.

An older study conducted by **Russel et al**. (22) indicates that there is no or little existing relationship between the secretion rate of saliva, the DMFT index and caries prevalence. This disputation is striking as most recent studies completed in the last 20 years are all in concordance with salivary changes in pregnancy resulting in a higher risk of caries.

6.4.2 Periodontal disease

Pregnant women are at higher risk of obtaining pregnancy induced gingivitis according to **TJ Lasisi & R Abdus-Salam (2018)** who recorded higher gingival and periodontal indexes in women during pregnancy (32). The fluctuations in hormones throughout this process, in particular Progesterone results in an induced response on the periodontium which acts as a reservoir for subgingival bacteria. This disposes plaque and bacteria accumulating in the gingival region in turn causing inflammation, redness and soreness of the gingiva. Accompanied with these symptoms, are also deeper pockets and higher tendency to bleeding (4).

González et al. (2001) harmonise with higher incidence of periodontal disease throughout pregnancy compared to non-pregnant women (18). They associate decreased salivary flow with a higher likelihood of gingival bleeding occurring.

Similarly, **Baliga et al. (2013)** indicate a correlation between salivary composition alterations and periodontal disease occurrence. The saliva comprises several host defence factors so changes in saliva impact the formation of calculus and thereby manifestation of Periodontitis (5). In those individuals where a lower salivary pH has been recorded thus are harbouring an optimal acidic environment for bacteria to ferment are more likely to acquire generalised chronic periodontitis (5).

The aforementioned studies have been elected due to their wide range in publication years, ensuring that a review of great validity and reliability of this topic can be carried out. Along with this, studies from different areas of the world were selected for the revision to permit a fair representation of the entire population.
Karnik et al. (2015) carried out a study on Indian women (2), **Rockenbach et al. (2006)** conducted their study on Brazilian women (30) and the studies by **TJ Lasisi and PN Ugwuadu (2014)** and **TJ Lasisi & R Abdus-Salam (2018)** were both completed on Nigerian women (31,32).
However, although this literature review did not just focus solely on one vicinity it does not necessarily mean there are no limitations. It is of great importance to take into account that among diverse cultures and backgrounds the socio-economic status may vary which can contribute or give way to certain risk factors. These risk factors might not have been reflected in some results and we must recall not every individual is in an 'ideal scenario'.

7. CONCLUSION

Main objective

The salivary flow rate and pH are significant for the maintenance and integrity for not only oral tissues, but for the oral cavity as an entirety. During the pregnancy period, these parameters present alterations. The contrast in findings between the salivary flow and pH of pregnant and non-pregnant women is striking. Some studies suggest are in accordance with one another and follow general trends by suggesting that both salivary flow rate and pH decrease throughout pregnancy. However, other studies postulate an increase in these parameters, say there are ever so small modifications or almost no variance in values. These differences can be attributed to increase in hormone (progesterone and oestrogen) levels or as a result of decreased bicarbonate ion and increased α amylase concentrations. In order to retrieve a conclusion that is more indisputable, a higher number of studies or studies with larger sample sizes need to be conducted to allow the comparison of more subjects and data using different variables. It is important to take into consideration that risk factors play a huge role in the outcomes of research – not every study has been conducted in the most ideal situation. As well as this, dissimilarities between conveyed values exist due to intra-individual modifications of saliva which could be related to the menstrual cycle, therapeutic drugs / medications, circadian rhythms and eating / drinking habits. Although there is reason to affirm that modifications of salivary flow and pH do exist during the pregnancy period, more research is required to obtain representative results.

Secondary objectives

The functions of saliva are unique to its spectacular composition. Its protective role in buffering and remineralisation, digestion and defence properties plus its diagnostic purpose enable it to be a diverse fluid within the human body. For these reasons, recognition should be given to the beneficence it has towards upholding and conserving oral health. The formation and secretion of saliva are secondary to a vast number of factors which in turn can heighten or reduce the total salivary volumes produced. Due to this, it is key to assess the functions appropriately as well as conduct Sialochemistry and Sialometry tests - enabling it to be more clinically valuable and useful as well as important when analysing statistical relationships.

Modifications in the salivary composition have a cumulative effect on its parameters. Small changes in concentrations of ions, proteins, cytokines, glucose or α amylase result in a change in flow rate or pH but also give way to dental conditions arising as a result. The decrease in bicarbonate, calcium and certain cytokines and increase of α amylase heightens the likelihood of caries and periodontal diseases occurring. These alterations in pregnancy can not only cause more demineralisation of enamel but also create an optimal acidic environment for bacteria to ferment carbohydrates resulting in tooth decay.

Many alterations in salivary parameters that do exist, principally occur during the third trimester. Due to this, intervention procedures for the prevention of caries and onset of dental diseases, such as Periodontitis and Gingivitis should begin earlier on in the first and second trimesters, opposed to later. Along with this, advances in the medicinal field allows for dental professionals to identify high risk patients for certain

diseases, particularly in pregnant women which enables them to act with correct preventative measures or treat accordingly.

As professionals, it is vital to understand the functions and composition of saliva along with the implications when changes appear as well as the techniques of salivary flow and pH assessment. The sequential evaluation of salivary flow and pH throughout pregnancy is important for the diagnosis, prognosis, and management of certain oral and systemic conditions.

8. SOCIAL RESPONSIBILITY

The presented work **“Salivary flow in Pregnancy”** indicates the importance of **environmental sustainability**. It is hereby based on the revision of several different pieces of literature which focus on the changes that occur in saliva during pregnancy as well as how these modifications can impact the human body. It enables women who may be vulnerable or at risk of obtaining certain dental conditions to be educated. Herewith the knowledge of the impacts salivary parameters can have on the oral cavity can improve both the length and quality of life of the patient. They can act quicker by carrying out certain oral hygiene measures and take preventive actions from early on during their pregnancy period. Furthermore, it also addresses the importance of **economic sustainability.** The early prevention of dental diseases such as caries, gingivitis and periodontitis ensure better oral health thus averting the need for time and cost consuming treatments. Additionally, this work also incorporates **social sustainability** since I have analysed the changes experienced in pregnancy as a result of salivary flow and the possible pathological implications associated with these. This can further be used to support intervention initiatives and promote early prevention, ensuring the health and safety of multiple lives as it impacts not only women but the children they are bearing too.

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10. ANNEXES

10.1 GLOSSARY

Abbreviations

hCG - Human Chorionic Gonadotropin

DMFT - Decayed, Missing and Filled teeth

MUC5B - Mucin 5b precursor

MUC7 – Mucin 7 precursor

SFR – Salivary flow rate

USFR – Unstimulated salivary flow rate

SSFR – Stimulated salivary flow rate

pH – Power of Hydrogen

HRT - Hormone Replacement Therapy

HCS - Human Chorionic Somatomammotropin

IFN gamma – Interferon gamma

IL1b – Interleukin 1 beta

TNF α – Tumor necrosis factor alpha

Salivary characteristics and dental caries

Evidence from general dental practices

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Saliva is the complex mixture of fluids that surrounds the oral tissues, and it originates from major and minor salivary glands and nonglandular sources such as crevicular fluids, oral microorganisms and host cells.[1] The consistency of saliva can be watery, thick, sticky or frothy depending on its composition; the amount of proteins in saliva mainly will determine its thickness or frothiness. A basal unstimulated secretion is produced continuously to moisturize and lubricate the oral tissues for more than 90 percent of the day.[2] The normal resting salivary flow rate ranges from 0.25 to 0.35 milliliter per minute. Mechanical, gustatory, olfactory or pharmacological stimuli increase the production and secretion of saliva. Stimulated saliva represents 80 to 90 percent of daily salivary production, and the stimulated flow rate varies from 1 to 3 mL/minute.[3] The salivary pH and the salivary buffering capacity are determined by the hydrogen

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ABSTRACT

Background. Saliva is one of the intraoral host factors that influence caries development. The authors conducted a study to investigate whether salivary characteristics are associated with recent dental caries experience.

Methods. Dentist-investigators and dental staff members collected data pertaining to a two-year cumulative incidence of dental caries (previous 24 months) and salivary characteristics during baseline assessment in an ongoing longitudinal study. The systematic random sample consisted of patients (n = 1,763) visiting general dental practices (n = 63) within the Northwest Practice-based REsearch Collaborative in Evidence-based DENTistry (PRECEDENT). The authors estimated adjusted rate ratios (RRs) by using generalized estimating equations log-linear regression to relate salivary characteristics to coronal carious lesions into dentin.

Results. Low resting pH (≤ 6.0) in the overall sample and low stimulated salivary flow rate (≤ 0.6 milliliter/minute) in older adults (≥ 65 years old) were associated with increased dental caries (RR, 1.6; 95 percent confidence interval [CI], 1.1-2.2; RR, 2.4; 95 percent CI, 1.5-3.8, respectively). Low buffering capacity was associated with decreased dental caries in children and adolescents (RR, 0.3; 95 percent CI, 0.1-1.0; RR, 0.2; 95 percent CI, 0.1-0.7, respectively). A thick, sticky or frothy salivary consistency also was associated with decreased dental caries in adults (RR, 0.6; 95 percent CI, 0.4-1.0). Associations between other salivary characteristics and dental caries for the overall sample and within each age group were not statistically significant.

Conclusions. Salivary characteristics were associated weakly with previous dental caries experience, but the authors did not find consistent trends among the three age groups. Different salivary characteristics were associated with an increased caries experience in older adults and a lowered caries experience in children and adolescents and adults.

Practical Implications. Further investigations are needed in this population setting to understand the study's conflicting results. The study findings cannot support the use of salivary tests to determine caries risk in actual clinical settings.

Key Words. Saliva; practice-based research; Northwest Practice-based REsearch Collaborative in Evidence-based DENTisty; dental caries.
JADA 2013;144(5):e31-e40.

Original Article

Determination of salivary flow rate, pH, and dental caries during pregnancy: A study

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ABSTRACT

Introduction: Saliva is an important diagnostic biofluid and the salivary composition is affected by various systemic conditions including pregnancy. **Aims:** The study was conducted to evaluate the salivary flow rate and pH in pregnant and non-pregnant Indian women and, consequently, to compare and correlate the salivary flow rate, pH, and prevalence of dental caries in both groups. **Settings and Design:** A cross-sectional study was conducted in our institute on a sample of 30 pregnant and 30 non-pregnant women. **Materials and Methods:** The clinical findings for Decayed-Missing-Filled Teeth (DMFT) index were recorded. Unstimulated whole saliva was collected to determine the salivary flow rate and pH. **Statistical Analysis Used:** Data were statistically analyzed using Student's *t*-test. **Results:** Salivary flow rate was lower in pregnant women (0.63 ml/min) as compared to that in non-pregnant women (0.81 ml/min) ($P < 0.05$) and the pH was also lesser in pregnant women (6.56) than in non-pregnant women (6.86) ($P < 0.05$). DMFT index showed a strong negative correlation with pH in pregnant women and non-pregnant women ($P < 0.05$). **Conclusion:** A difference was observed between the salivary parameters of pregnant and non-pregnant women in this sample. However, all the values were within the normal range. A significant inverse relation was found between salivary pH and dental caries for both the groups.

Key words: DMFT index, pH of saliva, pregnancy, salivary flow rate, unstimulated whole saliva

Introduction

Saliva is essential for the maintenance of oral health and it is an important diagnostic biofluid.[1] It plays a pivotal role in protection and lubrication of oral mucosal tissues, remineralization of teeth, and alimentation.[2,3] The salivary composition gives it many important physical and biochemical properties.[4] It is useful for diagnosis, prognosis, and management of patients with oral and systemic diseases.[1] There is increasing inclination toward using saliva samples for the diagnosis of oral and systemic diseases.[1] Salivary research has gained importance in the fields of dentistry and oral biology.[5]

Oral health is affected by many systemic conditions. It is influenced by female steroid sex hormones through different mechanisms. The composition of human saliva is altered during pregnancy, menstruation, and menopause due to changes in steroid hormone levels.

Access this article online	
Quick Response Code:	Website: www.jiaomr.in
	DOI: 10.4103/0972-1363.170454

How to cite this article: Karnik AA, Pagare SS, Krishnamurthy V, Vahanwala SP, Waghmare M. Determination of salivary flow rate, pH, and dental caries during pregnancy: A study. J Indian Acad Oral Med Radiol 2015;27:372-6.

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Received: 10-03-2015 **Accepted:** 05-11-2015 **Published:** 25-11-2015

A review of saliva: Normal composition, flow, and function

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An adequate supply of saliva is critical to the preservation and maintenance of oral tissue. Clinicians often do not value the many benefits of saliva until quantities are decreased. Much is written on the subject of salivary hypofunction, but little attention is paid to normal salivary flow and function. This article is a brief, up-to-date overview of the literature on the basics of normal salivary composition, flow, and function. A review of the literature was conducted using MEDLINE and Healthstar (1944 through 1999); articles were selected for inclusion on the basis of relevance and significance to the clinician. (J Prosthet Dent 2001;85:162-9.)

Saliva is a most valuable oral fluid that often is taken for granted. It is critical to the preservation and maintenance of oral health, yet it receives little attention until quantity or quality is diminished. There has been much recent research on the topic of salivary dysfunction as it relates to disease or as a side effect of certain medications. Saliva also has become useful as a noninvasive systemic sampling measure for medical diagnosis and research. Consequently, it is necessary for clinicians to have a good knowledge base concerning the norm of salivary flow and function. This article reviews the biomedical literature on normal salivary composition, flow, and function. A search of the literature was conducted by using the MEDLINE and Healthstar search engines (years 1944 through 1999). Articles from the primary, secondary, and tertiary literature were selected for inclusion on the basis of relevance and significance to the clinician.

ORIGIN AND ANATOMY

Saliva is a clear, slightly acidic mucoserous exocrine secretion. Whole saliva is a complex mix of fluids from major and minor salivary glands and from gingival crevicular fluid, which contains oral bacteria and food debris.[1,2] The major salivary glands include the paired parotid glands, which are located opposite the maxillary first molars, and the submandibular and sublingual glands, which are found in the floor of the mouth. Minor glands that produce saliva are found in the lower lip, tongue, palate, cheeks, and pharynx.[2] The terms *major* and *minor* refer to the anatomic size of the glands. Paradoxically, it could be argued that the minor salivary glands are the most important because of their protective components.[3] Major glands do produce more saliva than minor glands, but the quality of content and thus the type of protection varies.

The average daily flow of whole saliva varies in health between 1 and 1.5 L. Percentage contributions of the different salivary glands during unstimulated flow are as follows: 20% from parotid, 65% from submandibular, 7% to 8% from sublingual, and less than 10% from numerous minor glands. Stimulated high flow rates drastically change percentage contributions from each gland, with the parotid contributing more than 50% of total salivary secretions.[3]

The types of cells found in the salivary glands are acinar cells, various duct system cells, and myoepithelial cells. Acinar cells, in which saliva is first secreted, determine the type of secretion produced from the different glands. Secretion can be classified as serous, mucous, or mixed; serous secretions are produced mainly from the parotid gland, mucous secretions from the minor glands, and mixed serous and mucous secretions from the sublingual and submandibular glands.[2] Duct system cells found in the salivary ducts are classified as intercalated, striated, and excretory. Intercalated duct cells are the first duct network connecting acinar secretions to the rest of the gland. These cells are not involved in the modification of electrolytes, as are the remaining duct cells. Striated cells are second in the network, functioning as electrolyte regulation in resorbing sodium. The final duct cells, the excretory duct cells, contribute by continuing sodium resorption and secreting potassium. Excretory duct cells are the last part of the duct network before saliva reaches the oral cavity. Myoepithelial cells, which are long cell processes wrapped around acinar cells, contract on stimulation to constrict the acinar. This function, secreting or "squeezing out" accumulating fluid, is the result of a purely neural process.[1,2,4]

Understanding the source of saliva as well as the anatomy and location of salivary glands can impact the management of diminished flow in relationship to localized disease, systemic disease, radiation therapy, and/or salivary duct stones (sialoliths).[1,3,5]

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IBIMA Publishing
JMED Research
http://www.ibimapublishing.com/journals/JMED/jmed.html
Vol. 2014 (2014), Article ID 506946, 8 pages
DOI: 10.5171/2014.506946

Research Article

Salivary Flow Rate, pH and Buffering Capacity in Pregnant and Non Pregnant Women – A Comparative Study

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Received: 30 October 2013; Accepted: 19 December 2013; Published: 26 February 2014

Academic Editor: Yun Fu Zhao

Abstract

The objective of this article is to evaluate salivary flow rate, pH and buffering capacity of saliva in pregnant and non pregnant women.

The present study was a comparison between 30 pregnant women in their third trimester and 30 non pregnant women, in the age group of 19-34 years.

The salivary flow, pH, and buffering capacity was measured using Saliva-check BUFFER kit (GC Corporation). Both unstimulated and paraffin stimulated saliva was measured for 5 min by asking the subjects to spit passively into a measuring jar provided in the kit.

The pH and buffering capacity of unstimulated saliva was measured using a pH and buffering strips provided in the kit.

Unpaired Student t test showed a statically significant increase in the salivary flow and a decrease in the pH and buffering capacity in the pregnant group when compare to the non pregnant group.

The increase in the salivary flow rate in pregnant women could be attributed to the increase in the estrogen and progesterone concentration during pregnancy. The decrease in the pH and buffer capacity is due to the decrease in the plasma HCO_3^- ion concentration and an increase in a amylase concentration during pregnancy.

Keywords: Pregnancy, salivary flow rate, pH, buffering capacity.

Cite this Article as: Naveen, S., Asha, M. L., Shubha, G., Atul Anand Bajoria and Anju Anu Jose (2014), "Salivary Flow Rate, pH and Buffering Capacity in Pregnant and Non Pregnant Women - A Comparative Study," JMED Research, Vol. 2014 (2014), Article ID 506946, DOI: 10.5171/2014.506946

Original Article

Salivary pH: A diagnostic biomarker

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Abstract:

Objectives: Saliva contains a variety of host defense factors. It influences calculus formation and periodontal disease. Different studies have been done to find exact correlation of salivary biomarkers with periodontal disease. With a multitude of biomarkers and complexities in their determination, the salivary pH may be tried to be used as a quick chairside test. The aim of this study was to analyze the pH of saliva and determine its relevance to the severity of periodontal disease. **Study Design:** The study population consisted of 300 patients. They were divided into three groups of 100 patients each: Group A had clinically healthy gingiva, Group B who had generalized chronic gingivitis and Group C who had generalized chronic periodontitis. The randomized unstimulated saliva from each patient was collected and pH was tested. Data was analyzed statistically using analysis of variance technique. **Results:** The salivary pH was more alkaline for patients with generalized chronic gingivitis as compared with the control group ($P = 0.001$) whereas patients with generalized chronic periodontitis had more acidic pH as compared with the control group ($P = 0.001$). **Conclusion:** These results indicate a significant change in the pH depending on the severity of the periodontal condition. The salivary pH shows significant changes and thus relevance to the severity of periodontal disease. Salivary pH may thus be used as a quick chairside diagnostic biomarker.

Key words:

Gingivitis/physiopathology, hydrogen-ion concentration, periodontitis, saliva/physiology

Access this article online

Website: www.jisponline.com

DOI: 10.4103/0972-124X.118317

Quick Response Code:

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Submission: 07-10-2012
Accepted: 12-07-2013

INTRODUCTION

Oral diseases such as dental caries, periodontitis and oral malodor are always initiated at the interface between microbial ecosystem and host tissue. Changes in microbial and environmental dynamics in microbial ecosystems may increase the potential for pathogenicity within a microbial ecosystem and subsequently initiate and promote oral diseases. These successional changes have recently and tentatively been referred to by Marsh as the ecological plaque hypothesis.[1]

Thus, the properties of the environment determine, which microorganisms can occupy a site while the metabolic activities of those microbial communities subsequently modify the properties of the environment.[1]

It is known that periodontal diseases in humans and other mammals are predominantly associated with Gram-negative anaerobic organisms and that, before destructive periodontal diseases are initiated, these microorganisms must colonize tooth surfaces at and just below the gingival margin.[2,3] Strong evidence exists to consider *Aggregatibacter actinomycetemcomitans*, *Porphyromonas gingivalis* and *Tannerella forsythia* as etiologic agents. There is moderate evidence for the association of the following with periodontal disease: *Campylobacter rectus*, *Eubacterium nodatum*, *Fusobacterium nucleatum*, *Prevotella intermedia/nigrescens*, *Peptostreptococcus micros*, *Streptococcus intermedius*-complex, *Treponema denticola* and spirochetes. *Eikenella corrodens*, *Staphylococcus* and yeasts associated with human immunodeficiency virus periodontitis and peri-implantitis have shown weak association.[4] A study by Takahashi *et al*.[5,6] on the effect of pH on the growth of microorganisms showed that *P. gingivalis* grows at a pH of 6.5-7.0, *P. intermedia* grows at a pH of 5.0-7.0 and *F. nucleatum* grows at a pH of 5.5-7.0.

The diagnosis of active phases of periodontal disease and the identification of patients at risk for active disease represents a challenge for both clinical investigators and clinicians. In general, clinical parameters including probing depth, attachment level, bleeding on probing plaque index (PI) and radiographic loss of alveolar bone are used to assess disease severity.[7]

Occasionally, monitoring of the microbial infection[8] and analysis of the host response in gingival crevicular fluid (GCF) are utilized in an attempt to identify individuals at risk for future breakdown.[9,10]

Compelling reasons exist t
diagnostic fluid. It meets the c
inexpensive, non-invasive and easy-to-use diagnostic methods.[11] As a clinical tool, saliva has many advantages over serum, including ease of collection, storing and shipping and it can be obtained at low cost in sufficient quantities for analysis.[12] For patients, the non-invasive collection techniques dramatically reduce anxiety

About Pregnancy

Pregnancy is the term used to describe the period in which a fetus develops inside a woman's womb or uterus.

Pregnancy usually lasts about 40 weeks, or just over 9 months, as measured from the last menstrual period to delivery. Health care providers refer to three segments of pregnancy, called trimesters. The major events in each trimester are described below.[1]

First Trimester (Week 1 to Week 12)

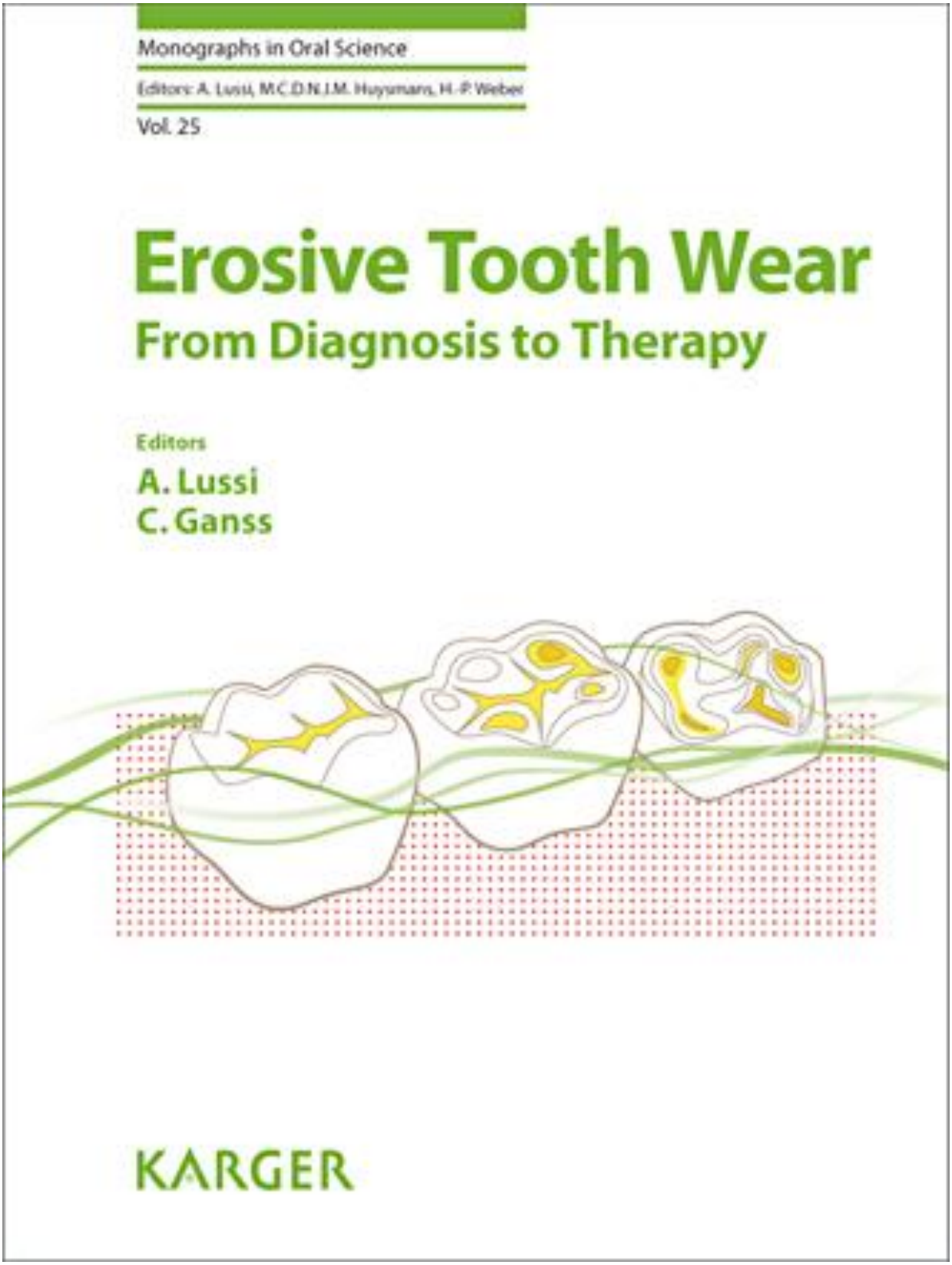
The events that lead to pregnancy begin with conception, in which a sperm penetrates an egg. The fertilized egg (called a zygote) then travels through the woman's fallopian tube to the uterus, where it implants itself in the uterine wall. The zygote is made up of a cluster of cells that later form the fetus and the placenta. The placenta connects the mother to the fetus and provides nutrients and oxygen to the fetus.[2]

Second Trimester (Week 13 to Week 28)

Between 18 and 20 weeks, the typical timing for ultrasound to look for birth defects, you can often find out the sex of your baby.
At 20 weeks, a woman may begin to feel movement.
At 24 weeks, footprints and fingerprints have formed and the fetus sleeps and wakes regularly.
According to research from the NICHD Neonatal Research Network, the survival rate for babies born at 28 weeks was 92%, although those born at this time will likely still experience serious health complications, including respiratory and neurologic problems.[3]

Third Trimester (Week 29 to Week 40)

At 32 weeks, the bones are soft and yet almost fully formed, and the eyes can open and close.
Infants born before 37 weeks are considered preterm (/health/topics/preterm/Pages/default.aspx). These children are at increased risk for problems such as developmental delays, vision and hearing problems, and cerebral palsy.[4] Infants born between 34 and 36 weeks of pregnancy are considered to be "late preterm."[4]
Infants born in the 37th and 38th weeks of pregnancy—previously considered term—are now considered "early term." These infants face more health risks than infants who are born at 39 weeks or later, which is now considered full term.[6]
Infants born at 39 or 40 weeks of pregnancy are considered full term. Full-term


Monographs in Oral Science
Editors: A. Lussi, M.C.D.N.J.M. Huysmans, H.-P. Weber
Vol. 25
Erosive Tooth Wear
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Editors
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ORIGINAL RESEARCH

The biochemistry of saliva throughout pregnancy

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BACKGROUND & OBJECTIVE: Sialometric and sialochemical analyses during pregnancy are not consistent, and frequently contradictory in terms of salivary flow rate, pH, and concentration of calcium, phosphorous, sodium, potassium, chloride, glucose and α-amylase. We, therefore, measured the evolution of these parameters throughout pregnancy.
METHOD: A cross-sectional study compared sialometric and sialochemical analyses of 30 pregnant women vs. 30 age-matched non-pregnant women, and a longitudinal study evaluated the pregnant women in the first and third trimester of pregnancy.
RESULTS: Pregnant women presented acidic non-stimulated saliva, but neutral stimulated saliva pH, and no relevant changes in salivary flow rate. Scialochemical analysis showed decreased calcium levels, increased phosphate levels, and a progressive decrease in glucose levels throughout pregnancy.
CONCLUSION: Pregnancy significantly changes the oral biochemical milieu, creating a favorable environment for the development of oral pathology, in particular, dental caries.

KEYWORDS: Saliva; pregnancy; pH; calcium; phosphorous; glucose

Rio R, Azevedo A, Simões-Silva L, Marinho J, Silva MJ, Sampaio-Maia B. The biochemistry of saliva throughout pregnancy. MedicalExpress (São Paulo, online). 2015;2(5):M150506.

Received for Publication on July 31, 2015; **First review** on August 16, 2015; **Accepted for publication** on September 12, 2015

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INTRODUCTION

Pregnancy entails a number of physiological changes apparently centered on the main objective of adapting the human body to the specific needs of the mother-fetus complex. The progressively increasing level of hormones, such as estrogen, progesterone and human chorionic gonadotropin, are the driving force behind these alterations; the results are reflected in hematological, genitourinary, cardiovascular, respiratory, gastrointestinal, endocrine, muscular and skeletal systems.[1]

The oral cavity environment is also altered due to these systemic physiological changes. The pregnancy-associated gingivitis is a well-known and common pathology, reflecting this condition.[2,3] Some studies suggest a higher prevalence of caries rate among pregnant women compared to non-pregnant controls, and an increase in the decayed, missing and filled teeth (DMFT) index throughout pregnancy,[4,5] but others found no increase in cariogenic activity during pregnancy.[6] On the other hand, oral pathology may also severely interfere with pregnancy outcome; in pregnant women periodontal disease represents a risk factor for preterm birth and low birth weight babies.[7,8]

Some short-term changes in salivary flow rates, pH, buffering capacity, and biochemical composition, during pregnancy have been reported.[3,6,9-15] Changes in salivary composition and flow rate may compromise the integrity of the soft and hard tissues in the oral cavity. Saliva provides calcium, phosphate and proteins and

DOI: 10.5935/MedicalExpress.2015.05.06

> Br J Obstet Gynaecol. 1998 Jun;105(6):656-60. doi: 10.1111/j.1471-0528.1998.tb10181.x.

Biochemical modifications of human whole saliva induced by pregnancy

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Affiliations + expand

PMID: 9647157 DOI: 10.1111/j.1471-0528.1998.tb10181.x

Abstract

Objective: To assess human unstimulated whole saliva components during pregnancy, to determine the relation, if any, between pregnancy and oral health, particularly total protein concentration, alpha-amylase activity, sialic acid content and calcium and phosphate concentrations were evaluated.

Design: Cross-sectional study.

Participants: Forty-five healthy primigravid women; 15 nonpregnant women acted as controls.

Results: 1. A higher total protein content at 10 and 21 weeks of gestation with respect to the controls and to pregnant women at 40 weeks; 2. a higher alpha-amylase activity at 10 and 21 weeks of gestation compared with the controls and to pregnant women at 40 weeks; 3. an increased sialic acid content at 21 and 40 weeks; 4. decreased calcium and phosphorus concentrations at 21 and 40 weeks of gestation.

WORLD JOURNAL OF PHARMACY AND PHARMACEUTICAL SCIENCES
SJIF Impact Factor 7.632
Volume 9, Issue 6, 1552-1567 Review Article ISSN 2278 – 4357

COMPOSITION AND FUNCTION OF SALIVA: A REVIEW

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Article Received on
19 April 2020,
Revised on 09 May 2020,
Accepted on 29 May 2020
DOI: 10.20959/wjpps20206-16334

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ABSTRACT

Saliva is a secretion produced by exocrine gland called the salivary gland. 1-1.5L of saliva is produced daily on average in a normal person. Oral mucosal cells that need to be lubricated all the time so that aberrations and injuries to the oral cells could be lowered thus oral cavity has a constant flow of saliva all the time and it's important to omit infections in the salivary gland entering through the mouth. Saliva plays and important role in scattering the food all over the oral cavity and taking the tastant toward the specified region of taste while the salivary enzymes help in digestion of food. Saliva also help control buildup of plaque or dental carries and protect the enamel of teeth at the same time. Salivary proteins also have protective functions against bacteria, viruses and fungi and it's also involved in healing processes. In this review we will discuss the major functions and composition of saliva and this will help the future and current researchers.

KEYWORDS: Exocrine gland, Infections, Bacteria, Viruses and Fungi.

INTRODUCTION

Saliva is a secretion produced by exocrine gland called the salivary gland. The saliva producing glands include major glands i.e. parotid gland, submandibular gland and sublingual gland while others are also present called the minor salivary glands. It consists mainly of

Chapter

Functions of Saliva

Narendra Maddu

Abstract

Saliva is produced and secreted by salivary glands. The basic secretary units of salivary glands are clusters of acini cells. It is fluid that contains water, electrolytes, mucus, and enzymes, all of which flow out of the acinus into collecting ducts, certainly one of the most important components and an integral component to oral health. The protective role and benefits including buffering, remineralization in the healthy oral mucosa, immune defense, digestion, lubrication, diagnostic purpose, and proteome analysis are fulfilled by saliva. It aids in maintaining mucosal integrity and indigestion through salivary enzymes. The functions of saliva in maintaining oral health and the main factors that cause alterations in salivary secretion and the importance of saliva in caries development and bacterial plaque formation are discussed, and also its role and functions and organic and inorganic constituents in saliva are discussed. This is of great importance in ruminants, which have non-secretory forestomachs. Diseases of the salivary glands and ducts are not uncommon in animals and man, and excessive salivation is a symptom of almost any lesions in the oral cavity.

Keywords: functions of saliva, role of lubrication, antimicrobial functions of saliva

1. Introduction

The secretions of the major and minor salivary glands, together with the gingival crevicular fluid, constitute whole saliva which provides the chemical milieu of the teeth and oral soft tissues [1]. Saliva formation can be evoked by sympathetic and parasympathetic stimulations [2]. The critical function of saliva is required for the preservation and maintenance of oral tissue [3]. Saliva is a complex secretion. About 93% by volume is secreted by the major salivary glands and the remaining 7% by the minor glands. About 99% of saliva is water and the other 1% is composed of organic and inorganic molecules [4]. Saliva consists of both full-length and partially degraded forms of mRNA, and its association with macromolecules may protect salivary RNA from degradation [5]. The proteome of the whole saliva will be relevant to oral health and be crucial for the identification of meaningful biomarkers for oral disease [6]. Sialometry and sialochemistry are used to diagnose systemic illnesses, monitoring general health, and as an indicator of risk for diseases creating a close relation between oral and systemic health [7]. Saliva acts as a mirror of the body's health and could constitute the first line of defense against oxidative stress by controlling and/or modulating oxidative damages in the oral cavity [8].

The analysis of salivary transcriptome may be beneficial effects in the detection of oral cancer and salivary diagnostics [9]. Cationic peptides and other defense proteins like lysozyme, bactericidal–/permeability-increasing protein (BPI), BPI-like proteins, PLUNC (palate lung and nasal epithelial clone) proteins, salivary amylase, cystatins,

Saliva between normal and pathological. Important factors in determining systemic and oral health

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Abstract

There is a tendency in current medical research to explore the importance and symptomatology of saliva. The question to which increasingly more researchers from the medico-legal, systemic and dental fields tried to answer and bring together arguments for a greater emphasis is referring to the role of saliva in the health of the patient.

Up until our time, people have looked at the importance of saliva from another perspective: saliva helped in pasting envelopes or stamps, or mostly in reported cases of public speakers faced with the impossibility of having a coherent speech due to sensations of dry mouth.

This 'dry mouth' condition, named *xerostomia* in medical terms, has been used since antiquity as a test in detecting lies, knowing since then that the inhibition of emotional salivary glands, the feeling of 'dry mouth' is caused by anxiety, thus being a potential incrimination.

Although hundreds of publications have insisted on the etiology and complications of the salivary gland hypofunction, only a few health professionals used to harvest saliva tests.

As in the case of urine and blood, saliva quality and quantity are affected by a multitude of medical conditions and treatments, as well as the patient's psychological state.

A review of the formation, function and dysfunction of salivary glands may convey the significant role played by saliva in health and disease, especially in detection and recognition of salivary gland hypofunction, systemic disease, and the psychological states, and thus prevent complications caused by these conditions.

Study of the Function and Dysfunction of Saliva

Saliva Formation

Saliva is produced by three pairs of major glands and numerous minor salivary glands located in the oral cavity. The parotid, submandibular, and sublingual salivary glands contribute to 90% of total saliva secretions, while minor salivary glands contribute to the remaining 10%. The amount of saliva secreted by the major and minor glands is referred to as whole saliva. In the resting (unstimulated) state, approximately two-thirds of the total volume of the whole saliva is produced by submandibular glands. Upon stimulation, the parotid glands are responsible for at least 50% of the total volume of saliva from the mouth. Sublingual glands contribute to a small percentage, both in the unstimulated or stimulated states of the salivary glands. Minor salivary glands contribute significantly to the lubrication of the oral mucosa because of their high protein content. Unlike some other minor salivary glands which are composed exclusively of mucous cells, parotid glands are serous and produce water like secretions. Submandibular and sublingual glands are mixed.

In general, acinar (secretory) cells are responsible for the production of the primary saliva. The ductal cells are responsible for further modifications of saliva until it is secreted in the mouth. Saliva is 99% water and 1% protein and salts. The normal daily production of saliva varies between 0.5 and 1.5 liters. The whole unstimulated saliva flow rate is approximately 0.3-0.4 ml / min. This rate decreases to 0.1 ml / min during sleep and increases to about 4, 0-5, 0 ml / min during eating, chewing and other stimulating activities. Saliva is always hypotonic to plasma. As the whole saliva flow rate will increase, the tonicity of the saliva will increase too. Salivary glands secretion is mainly controlled by the autonomous nervous system. Parasympathetic stimulation produces abundant quantities of watery saliva, whereas sympathetic stimulation produces more viscous saliva (Bardow, Nauntofte and Pedersen, 2004).

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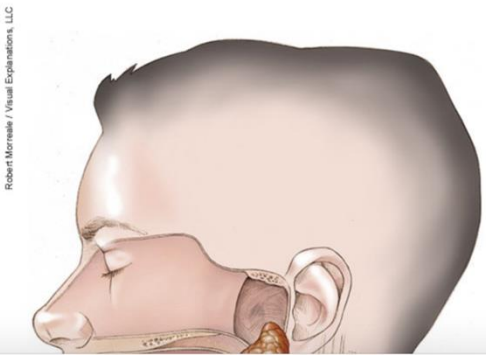
Salivary Gland Cancer: Medical Illustrations

Aprobado por la Junta Editorial de Cancer.Net, 05/2020

ON THIS PAGE: You will find a drawing that shows the location of the major salivary glands. Use the menu to see other pages.



Feedback

Salivary Glands and Saliva

Saliva is produced in and secreted from salivary glands. The basic secretory units of salivary glands are clusters of cells called an acini. These cells secrete a fluid that contains water, electrolytes, mucus and enzymes, all of which flow out of the acinus into collecting ducts.

Within the ducts, the composition of the secretion is altered. Much of the sodium is actively reabsorbed, potassium is secreted, and large quantities of bicarbonate ion are secreted. Bicarbonate secretion is of tremendous importance to ruminants because it, along with phosphate, provides a critical buffer that neutralizes the massive quantities of acid produced in the forestomachs. Small collecting ducts within salivary glands lead into larger ducts, eventually forming a single large duct that empties into the oral cavity.

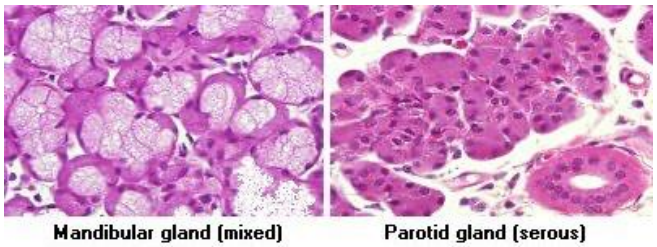
Most animals have three major pairs of salivary glands that differ in the type of secretion they produce:

- *parotid glands* produce a serous, watery secretion
- *submaxillary (mandibular) glands* produce a mixed serous and mucous secretion
- *sublingual glands* secrete a saliva that is predominantly mucous in character

The basis for different glands secreting saliva of differing composition can be seen by examining salivary glands histologically. Two basic types of acinar epithelial cells exist:

- *serous cells*, which secrete a watery fluid, essentially devoid of mucus
- *mucous cells*, which produce a very mucus-rich secretion

Acini in the parotid glands are almost exclusively of the serous type, while those in the sublingual glands are predominantly mucus cells. In the submaxillary glands, it is common to observe acini composed of both serous and mucus epithelial cells.



Oral Diseases (2002) 8, 117–129

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SALIVARY GLANDS AND SALIVA
Number 5

Saliva and gastrointestinal functions of taste, mastication, swallowing and digestion

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Saliva has multiple essential functions in relation to the digestive process taking place in the upper parts of the gastrointestinal (GI) tract. This paper reviews the role of human saliva and its compositional elements in relation to the GI functions of taste, mastication, bolus formation, enzymatic digestion, and swallowing. The indirect function of saliva in the digestive process that includes maintenance of an intact dentition and mucosa is also reviewed. Finally, pathophysiological considerations of salivary dysfunction in relation to some GI functions are considered.
Oral Diseases (2002) **8**, 117–129

Keywords: saliva; human salivary glands; taste; mastication; swallowing; digestion

Introduction

Control of gastrointestinal (GI) functions, in response to a stimulus such as a meal, is regulated by a number of neural reflexes. For example, the presence of food in the mouth initiates both mechanical and chemical stimuli via neural reflexes that results in an increased secretion of fluid (saliva) into the oral cavity. The major functions of the oral phase in response to a meal are the mechanical disruption of food into smaller particles by chewing and addition of saliva which aids in taste, bolus formation for swallowing (water and mucin), and initiates digestion of starch (amylase) and lipids (lipase) (Nauntofte and Jensen, 1999). In this review, we describe the role of human saliva in the upper parts of the GI tract in relation to ingestion of food, its transfer from the mouth to the esophagus, and transport of the bolus from pharynx to the stomach (Figure 1). Special attention will be paid to the multiple functions of saliva in taste, mastication, bolus formation, swallowing, enzymatic digestion, and maintenance of tooth and mucosal integrity. Moreover, we outline the impact of salivary dysfunctions on a number of GI functions and their mutual interactions.

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Received and accepted 15 March 2002

Functions of saliva

The multiple functions of saliva relate both to its fluid characteristics and specific components (Table 1). Cleansing of the oral cavity, solubilization of food substances, bolus formation, facilitation of mastication and swallowing, food and bacterial clearance, dilution of detritus and lubrication of mucosa as well as facilitation of speech are examples of functions at least in part related to saliva's fluid characteristics. On the other hand, protection of the teeth by neutralization of acid by buffering actions, maintenance of supersaturated calcium phosphate concentrations with regard to hydroxyapatite, and participation in enamel pellicle formation are examples of functions related to specific components of saliva (see earlier article in this series by Nieuw Amerongen and Veerman). Furthermore, saliva components contribute to mucosal coating and provision of antimicrobial action and defense as well as digestive actions. Accordingly, saliva plays an important role in the maintenance of oral health and changes affecting salivary function may compromise the integrity of hard and soft tissues in the mouth as well as oral and GI functions.

Saliva and the salivary glands

The mixed fluid (whole saliva) in the mouth, which is in contact with the teeth and oral mucosa, is derived predominantly from three paired major salivary glands, i.e. the parotid, submandibular and sublingual glands (together accounting for about 90% of the fluid production) as well as from the minor salivary glands in the oral mucosa. Whole saliva also contains gingival

International Journal of Contemporary Dental and Medical Reviews (2017), Article ID 011217, 6 Pages

REVIEW ARTICLE

The composition, function and role of saliva in maintaining oral health: A review

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Received: 30 October 17
Accepted: 15 December 17

doi: 10.15713/ins.ijcdmr.121

How to cite this article:
Brij Kumar, Nilotpol Kashyap, Alok Avinash, Ramakrishna Chevvuri, Mylavarapu Krishna Sagar, Kumar Shrikant, "The composition, function and role of saliva in maintaining oral health: A review," Int J Contemp Dent Med Rev, vol.2017, Article ID: 011217, 2017.
doi: 10.15713/ins.ijcdmr.121

Abstract

Saliva is certainly one of the most important components in the oral environment and an integral component to oral health. The components of saliva, its functions in maintaining oral health and the main factors that cause alterations in salivary secretion will be reviewed, the importance of saliva in caries development and bacterial plaque formation will be discussed, and its role as an aid to diagnosing certain pathologies will also be discussed here. Saliva aids in maintaining mucosal integrity and in digestion through salivary enzymes. Saliva is essential information of the pellicle, which protects the tooth after eruption. Saliva has several oral benefits including buffering, remineralization, and lubrication. Consider the acid attack on the teeth after a cariogenic episode, saliva aids in mechanically removing food debris and bacteria from the oral cavity and teeth, reduced salivary flow causes ill effects to the oral tissues.

Keywords: Caries, dental plaque, saliva, salivary flow rate, salivary proteins, xerostomia

Introduction

A critical component of the oral environment is saliva, a dilute aqueous solution containing both inorganic and organic constituents. Saliva plays an essential role during mastication, in swallowing and in speech. The substances dissolved in saliva during mastication are transported to stimulate taste receptors for taste perception.

The salivary amylase is a digestive enzyme responsible for the initial stage in starch and glycogen breakdown, and salivary lipase secreted by lingual salivary glands (Von Ebner's glands) may play a significant role in fat digestion. In many animals evaporation of saliva spread on fur or while panting is important in temperature regulation during heat stress.[1]

The functions of saliva are to protect the oral tissues by keeping them moist and by providing a lubricating mucoid secretion, by maintaining a fluid environment with high calcium and phosphate concentrations and the power of buffering acids and to initiate the digestion of starch. Impaired salivary secretion (hyposalivation) increases the risk of oral diseases such as dental caries and oral candidal infection.[2]

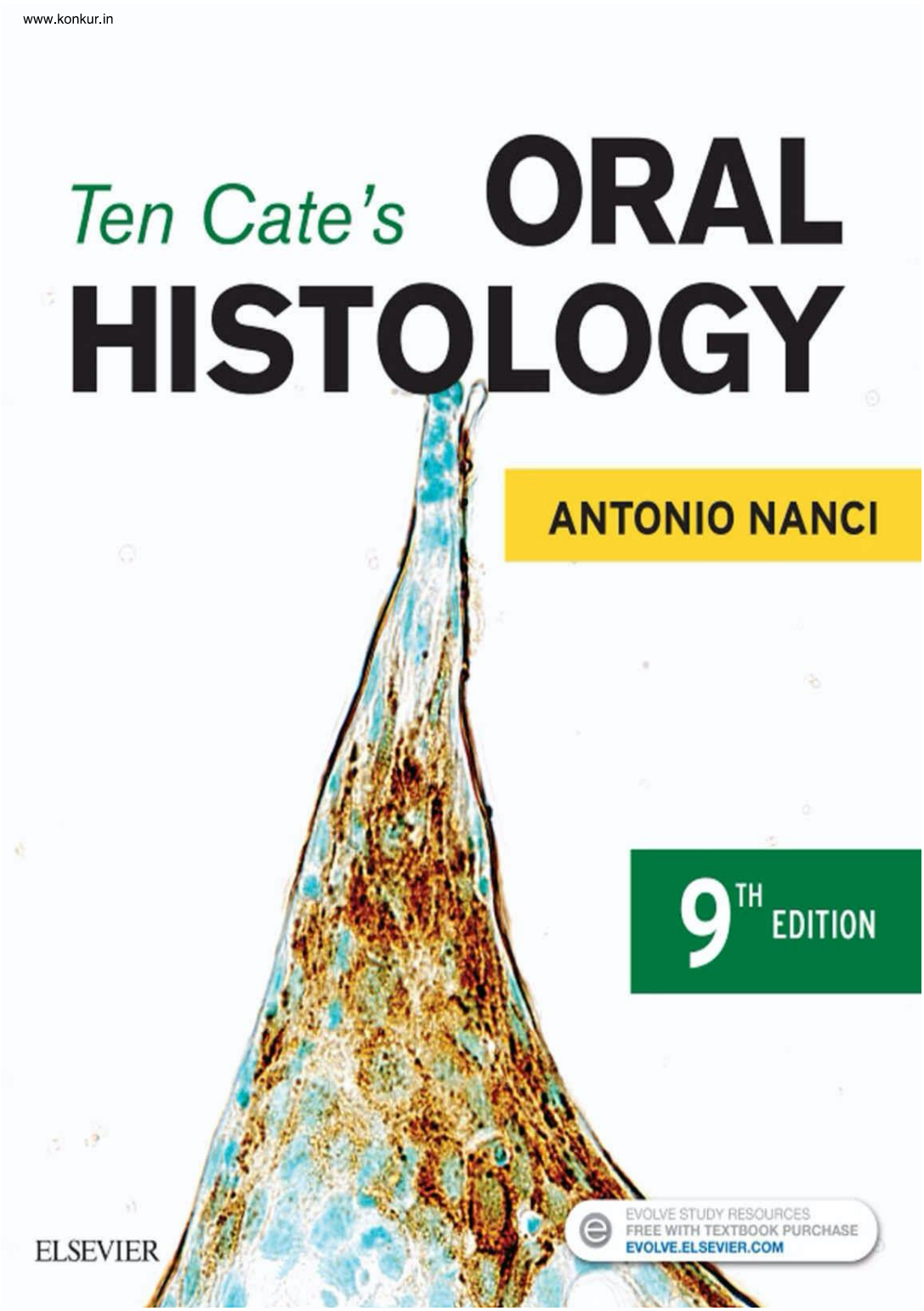
Recently, additional functions of salivary glands have been uncovered. Salivary glands have been shown to contain, and possibly secrete, a large number of physiologically active substances, such as nerve growth factor, vasoactive peptides, and regulatory peptides. Thus salivary glands may have a role in functions not normally associated with that traditional alimentary function.[3,4]

Composition of Saliva [Table 1][5]

Functions of saliva in humans

Digestive functions

Although amylase is a major component of the parotid secretion and is present at an appreciable level in the submandibular fluid as well, its salivary role in the digestion of carbohydrates is really minimal. The only effective conversion of starch to maltose that occurs in the oral cavity is in food-retentive sites, and this benefits primarily the plaque bacteria. Most of the food is swallowed rather quickly, and in the stomach salivary amylase would be minimally effective, given the low pH and high proteolytic activity of the gastric juice.[6]



Perinatol Reprod Hum 2001; 15: 195-201

Cambios en la composición de la saliva de pacientes gestantes y no gestantes

MIREYA GONZÁLEZ,[a] LUCILA MONTES DE OCA,[a] GUSTAVO JIMÉNEZ[b]

RESUMEN

Objetivo: Identificar los principales cambios presentes en la composición salival (sialoquímica) de las pacientes embarazadas.

Material y métodos: Se colectó saliva total estimulada a 50 pacientes embarazadas del hospital de Gineco-Obstetricia del DIFEM y a 50 mujeres no embarazadas. A cada muestra se le determinó el flujo salival gravimétrico y el pH salival. En todos los casos se realizó evaluación de los signos y síntomas más prevalentes en cavidad bucal.

Resultados: El flujo salival (87 ± 0.49 mL/min) y el pH salival (6.6 ± 0.19) de las pacientes gestantes fueron más bajos que los informados en la literatura; a diferencia de las pacientes no gestantes donde el pH salival se mantuvo dentro del intervalo de normalidad para la saliva estimulada [flujo salival (0.94 ± 0.54 mL/min) y el pH salival (7.09 + 0.19)]. Se demostró una asociación significativa entre el flujo salival disminuido y la presencia de mal sabor de boca (χ^2 = 4.6; p = 0.03) y entre la disminución de flujo salival y sangrado de las encías (χ^2 = 3.56; p = 0.05). También se observó una asociación significativa entre el embarazo y las siguientes variables: agrandamiento gingival (p = 0.01); dificultad para deglutir (p = 0.05) y disminución de la secreción salival (p < 0.001).

Conclusiones: Los cambios presentes en la composición de la saliva posiblemente coadyuven a la severidad en las alteraciones presentes en cavidad bucal de estas pacientes, ya que al existir una alteración en la composición de la misma, la función homeostática de la saliva se ve mermada.

PALABRAS GUÍA: Embarazo, saliva, flujo salival, sialoquímica, salud bucal.

INTRODUCCIÓN

La saliva es un fluido acuoso hipotónico secretado tanto por las glándulas salivales mayores como las menores, cuya finalidad es mantener la homeostasis de la cavidad bucal.[1]

En la actualidad pocos estudios se han realizado enfocándose al uso de la sialoquímica como medio de diagnóstico para la caracterización de cambios salivales presentes durante el embarazo. En lo que respecta a las hormonas sexuales, se ha observado que durante el periodo de embarazo en ratas, la secreción salival disminuye, presentándose este mismo signo después de la menopausia, en comparación con ratas en años reproductivos.[2]

En otro estudio realizado en mujeres a las que se les administró anticonceptivos, se encontró que tanto la secreción de la saliva parotídea como la

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Recibido: 04 de mayo de 2001
Aceptado: 29 de mayo de 2001


ACTA
ODONTOLOGICA
SCANDINAVICA

COMPARATIVE ANALYSIS OF SALIVA IN PREGNANT AND NONPREGNANT WOMEN

I. Calcium and pH

S. LEONARD ROSENTHAL, ROBERT ROWEN, AND A. J. VAZAKAS

Temple University School of Dentistry, Philadelphia, Pa.

PREGNANCY may be accompanied by an increased incidence of dental caries unless unusually frequent prophylactic measures are instituted as a preventive. There is much diversity of opinion on the subject. Some authorities believe that pregnancy predisposes dental caries,[1, 2] while others feel it plays no role in this condition.[3, 4]

It has been suggested[5] that teeth decay during pregnancy because of changes in the secretions in the mouth. Since pregnancy is accompanied by metabolic changes, caries during this period may well be the result of a change in salivary composition and the ensuing modification of environment.

To determine what changes, if any, occur in the salivary composition during pregnancy, a series of salivary analyses has been undertaken. This is a report of the first series: a determination of the calicum content and pH of saliva of a group of pregnant women as compared with a nonpregnant group.

EXPERIMENTAL METHODS

For the purpose of determining the concentration of salivary calcium to be considered as normal for nonpregnant women, a group of 56 women, ranging in age from 17 to 27 years, was selected from the Temple University School of Oral Hygiene.

The saliva samples of the pregnant women were obtained from the out-patients of the obstetric clinics of 2 hospitals. The ages in the second group ranged from 14 to 38.

The women in both groups were all apparently normal healthy individuals. No physical examinations were given. However, care was taken to exclude women who had any recent history of illness.

All samples were collected in the morning, at least 1 hour after breakfast, and consisted of unstimulated saliva. For the collection of these samples, the subjects were kept as quiet as possible, usually in a seated position. They were instructed to allow the saliva to flow into the mouth as normally as possible, and to expectorate into large test tubes provided for the collection of the samples.

This investigation was supported in part by a research grant (D-461) from the Division of Research Grants of the National Institutes of Health, U. S. Public Health Service.

Received for publication Dec. 12, 1958; revised by authors May 19, 1959.

Clinical Trial > J Am Dent Assoc. 1998 Jul;129(7):871-7. doi: 10.14219/jada.archive.1998.0351.

Caries prevention during pregnancy: results of a 30-month study

E Brambilla [1], A Felloni, M Gagliani, A Malerba, F García-Godoy, L Strohmenger

Affiliations + expand

PMID: 9685762 DOI: 10.14219/jada.archive.1998.0351

Abstract

The purpose of this 30-month study was to explore the effectiveness of a caries-preventive regimen in lowering the salivary mutans streptococci level in pregnant women and, subsequently, in inhibiting the growth of these bacteria in their young children. Beginning at the end of the sixth month of pregnancy and continuing until delivery, subjects rinsed daily with 0.05 percent sodium fluoride and 0.12 percent chlorhexidine. The authors monitored the salivary mutans streptococci levels during the last six months of pregnancy and every six months thereafter for 24 months. They also measured bacterial levels in the children every six months until they reached age 24 months. The results show that treatment significantly reduced salivary mutans streptococci levels in mothers and delayed the colonization of bacteria in their children for about four months.

> Community Dent Oral Epidemiol. 1990 Jun;18(3):120-5.
doi: 10.1111/j.1600-0528.1990.tb00035.x.

Caries prevalence and microbiological and salivary caries activity tests in Scottish adolescents

J I Russell [1], T W MacFarlane, T C Aitchison, K W Stephen, C K Burchell

Affiliations + expand

PMID: 2350947 DOI: 10.1111/j.1600-0528.1990.tb00035.x

Abstract

Salivary and microbiological caries activity tests were investigated on three occasions in a group of 372 Scottish adolescents. Counts of lactobacilli, mutans streptococci, and candida were consistently and significantly associated with caries prevalence, as either DS or DMFS score, and buffering capacity was consistently inversely related to DMFS score. However, veillonella counts and salivary flow rate were not correlated with caries prevalence. Significant improvements in the associations were obtained when the results of more than one test were included using stepwise regression analysis. On an individual basis, at most, stepwise discriminant analysis identified the DMFS group correctly in 49% of all subjects, and the DS group in 47%.

Fogorv Sz. 1975 Nov;68(11):327-32.

[Relationship between pregnancy and dental caries]

[Article in Hu]

M Orosz, O Rigó, J Bánóczy

PMID: 1060575

Excessive saliva in pregnancy

Share

Read time 2 minutes

You're probably getting a few odd pregnancy symptoms you hadn't been (ptyalism) might be one of the most unexpected...

What is ptyalism?

Ptyalism is a condition where you make too much saliva. People with ptyalism might prod
Ptyalism is also known as hypersalivation or sialorrhea, and often affects women in the early stages of pregnancy . Ptyalism won't harm your baby and is not a serious condition but that doesn't mean you can't find it upsetting and uncomfortable.

Excessive saliva and the first trimester

Ptyalism is common during the first trimester of pregnancy. You might need to spit out some saliva as it sue[illegible] and the bitter taste of the saliva can cause nausea and vomiting. The good news for most women is that it should ease after the first trimester.

Causes of excessive saliva

As with most things in pregnancy, your hormones are to blame for excessive saliva. It can also be caused by pregnancy sickness, as nausea can make women try to swallow less, especially in those with hyperemesis gravidarum (ext :).

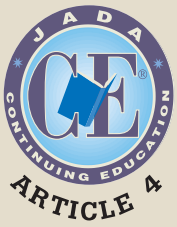
Other causes include heartburn, which is common in pregnancy, and irritants like smoke, toxins and some medical conditions.

Treatments for excessive saliva

Measuring salivary flow
Challenges and opportunities

Mahvash Navazesh, DMD; Satish K.S. Kumar, MDSc

ABSTRACT



Background. Saliva is being studied extensively and is being used for risk assessment, diagnosis and monitoring high-risk behavior and disease progression. A variety of medical conditions and medications are associated with salivary gland hypofunction. The major disadvantage in the use of saliva for health-related purposes is the lack of standardization in saliva collection methods.

Methods. The authors provide a brief overview of different methods of saliva collection and the advantages and disadvantages associated with each method, as well as of how to assess the salivary flow rate.

Results. The authors present the complete set up and step-by-step guidelines for the collection of unstimulated and stimulated whole saliva.

Conclusions. The life expectancy of people will continue to increase with advances in medicine and therapeutic modalities, and the prevalence of salivary gland hypofunction in the elderly population will increase owing to their longevity. The assessment of salivary gland hypofunction will need to be incorporated into everyday clinical practice.

Clinical Implications. The saliva collection methods outlined in this article can be used by dentists to assess patients at risk of developing diseases and by scientists for scholarly activities.

Key Words. Saliva; saliva collection; salivary flow rate; salivary glands; salivary gland hypofunction; xerostomia.

JADA 2008;139(5 suppl):35S-40S.

Promoting health by preventing disease is a goal of health care providers, and risk assessment and disease prevention are common themes in the surgeon general's report on oral health in America.[1] Clinicians commonly use health questionnaires and clinical evaluations to identify patients at risk of developing diseases. Hematologic, serologic and imaging diagnostic modalities are used to assess these patients further. In recent years, saliva-based diagnostic tests have been increasing in popularity because of their noninvasive nature.[2,3]

Technologies are available that use saliva to diagnose, follow and assess the risk and severity of diseases, high-risk behaviors or both. Salivary biomarkers have been used to assess the risk of developing oral, ovarian and breast cancers; HIV infection; Sjögren syndrome; and dental caries and periodontal diseases, as well as to detect exposure to alcohol and illegal drugs. Nicotine and cotinine levels also can be measured in saliva and be used by the life insurance industry to verify the smoking status of applicants. Hormone levels detected in saliva

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Systematic Review

Salivary factors related to caries in pregnancy

A systematic review and meta-analysis

Mahtab Yousefi, DDS; Parvin Parvaie, MSD; Seyed Mohammad Riahi, PhD

Supplemental material is available online.

ABSTRACT

Background. The authors of this meta-analysis aimed to assess saliva-related caries risk factors, including calcium and phosphate, hydrogen ion concentration, buffer capacity, *Streptococcus mutans* and *Lactobacillus* counts, flow rate, and decayed, missing and filled teeth index in each trimester during pregnancy.

Types of Studies Reviewed. The authors searched electronic databases up to July 1, 2019. Eligible observational studies were included. The authors assessed the quality of the included studies by using the Joanna Briggs Institute scale. To estimate the effects of pregnancy, standardized mean differences with 95% confidence intervals were pooled using the random-effects model. Subgroup analysis and meta-regression were used to explore heterogeneity. Publication bias was assessed using Begg and Egger tests.

Results. Twenty-nine studies were included in the meta-analysis, representing 1,230 pregnant women in the case groups and 715 in the control groups (nonpregnant women). The results showed that salivary calcium concentration decreased in the third trimester, salivary phosphate decreased in the second and third trimesters, saliva hydrogen ion concentration decreased in the first and third trimesters, stimulated saliva flow rate increased in the third trimester, and salivary *S mutans* count increased in the second and third trimesters. In addition, the results showed that saliva calcium, phosphate, *S mutans*, and buffer capacity amounts had changed from the first trimester to the third.

Conclusions and Practical Implications. In the third trimester, most salivary factors related to caries change and can increase the risk of developing caries in the future. Interventions and screening for caries prevention in pregnancy should start in the first or second trimesters.

Key Words. Pregnant women; saliva; caries; calcium; *Streptococcus mutans*; hydrogen ion concentration; phosphates; buffer capacity; flow rate; DMFT; meta-analysis.

JADA 2020:151(8):576-588
https://doi.org/10.1016/j.aime.2020.04.021

Pregnancy affects many organ systems and results in physical and physiological changes in various parts of body, including the oral cavity,[1] and researchers have reported a higher incidence of caries during pregnancy.[2] However, caries onset and activity are complex; saliva is a primary modifying factor[3] and alterations in saliva property during pregnancy might explain the increased incidence of caries.[2] These alterations might be related to estrogen effects, dietary changes, oral hygiene habits, and taste changes in pregnancy.[4,5] Inhibition of bacteria and their substrates, dilution, and elimination of bacteria and their substrates, buffering bacterial acids, and remineralization are effects of saliva on caries.[6] Assessment of caries activity by evaluating salivary biomarkers, hydrogen ion concentration (pH), buffer capacity (BC), calcium, phosphorous, and acidogenic oral bacteria has been reported in some studies.[7,8]

Researchers around the world have reported inconsistent findings on salivary changes during pregnancy; some investigators reported a decrease in salivary flow rate (FR) during pregnancy[9] and others found an increase.[10] *Streptococcus mutans* and *Lactobacillus*, the bacteria that are the main pathogens associated with caries,[11] were counted in saliva during pregnancy and conflicting results were derived from several studies.[12-14] Because salivary calcium and phosphate concentration are

This article has an accompanying online continuing education activity available at: http://jada.ada.org/ce/home.

European Review for Medical and Pharmacological Sciences 2017; 21: 369-374

Salivary flow rate and pH in patients with oral pathologies

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Abstract. – OBJECTIVE: Determine salivary pH and flow rate (FR) in a sample of 164 patients who came to Oral Pathology ambulatory, 84 suffering from oral lesions and 80 without oral lesions. Another aim was to evaluate factors that influence salivary flow rate.

PATIENTS AND METHODS: Subjects underwent clinical examination and completed an anamnestic questionnaire in order to obtain useful information that was used to classify participants in different groups. Unstimulated whole saliva (UWS) was collected using the spitting method at 11:00 am. The FR was evaluated with the weighing technique and a portable pHmeter, equipped with a microelectrode, was used to measure pH. Both univariate and classification (single and Random Forest) analyses were performed.

RESULTS: The data analysis showed that FR and pH showed significant differences ($p < 0.001$) between patients with oral lesions (FR = 0.336 mL/min, pH = 6.69) and the ones without oral lesions (FR = 0.492 mL/min, pH = 6.96). By Random Forest, oral lesions and antihypertensive drugs were ranked in the top two among the evaluated variables to discretize subjects with FR = 0.16 mL/min.

CONCLUSIONS: Our study shows that there is a relationship between oral lesions, antihypertensive drugs and alteration of pH and FR.

Key Words:
Human saliva, Salivary pH, Salivary flow rate, Oral diseases.

Introduction

Saliva is a remarkably complex fluid with a large number of properties and functions which are indispensable for both general and oral health like lubrication, moistening, taste, digestion, protection of the oral and esophagus mucosa and tooth protection[1]. The salivary flow rate (SFR) is the amount of saliva produced by salivary glands in the time unit, expressed in mL/min or g/min. It can be divided into unstimulated (USFR) which is independent of the presence of stimuli (food, chewing, etc.) and stimulated (SSFR), secreted in response to sensory stimulation, gustatory and masticatory mainly[2,3]. Moreover, saliva can be divided into "Duct saliva" that is the fluid obtained immediately downstream of the ducts of the salivary glands and "Whole saliva", the fluid composed by "Duct saliva" with the addition of the secretions of oral, nasal and pharynx mucosa; this fluid also contains microorganisms, desquamated epithelial cells, blood cells, food debris, e.g.[4,5].

Saliva chemical and physical properties play an important role in maintaining the health and functions of the oral cavity. Lubrication of alimentary bolus, protection against virus, bacteria, and fungi, buffer capacity, protection and reparation of oral mucosa and dental remineralization are some of the functions of saliva[3,4,6]. The buffer capacity depends on the acids and bases contained in the secreted saliva[7,8]. Bicarbonate is the main buffer that opposes acids, but is completely effective only at high salivary flow rates, because its concentration increases markedly with SFR rise[8,9]. It's well known that patients with quantitative and/or qualitative alterations in saliva may complain about oral dryness sensation, suffering from difficulties in eating, speaking and swallowing; furthermore, in these altered conditions, dental caries, opportunistic infections, and diseases of the oral cavity may increase[2-6,10-14]. About 20% of the general population suffer from dry mouth[11,13,15].

The evaluation of the unstimulated whole salivary flow rate (UWSFR), is carried out by an easy, non-invasive and comfortable procedure, which favors its use in clinical environmental (public or private). UWSFR is the basal rate of saliva flow and it's the greatest contributor to the total salivary

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Hindawi
BioMed Research International
Volume 2018, Article ID 3847075, 12 pages
https://doi.org/10.1155/2018/3847075

Research Article

Effects and Mechanisms of Tastants on the Gustatory-Salivary Reflex in Human Minor Salivary Glands

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Academic Editor: Elsa Lamy

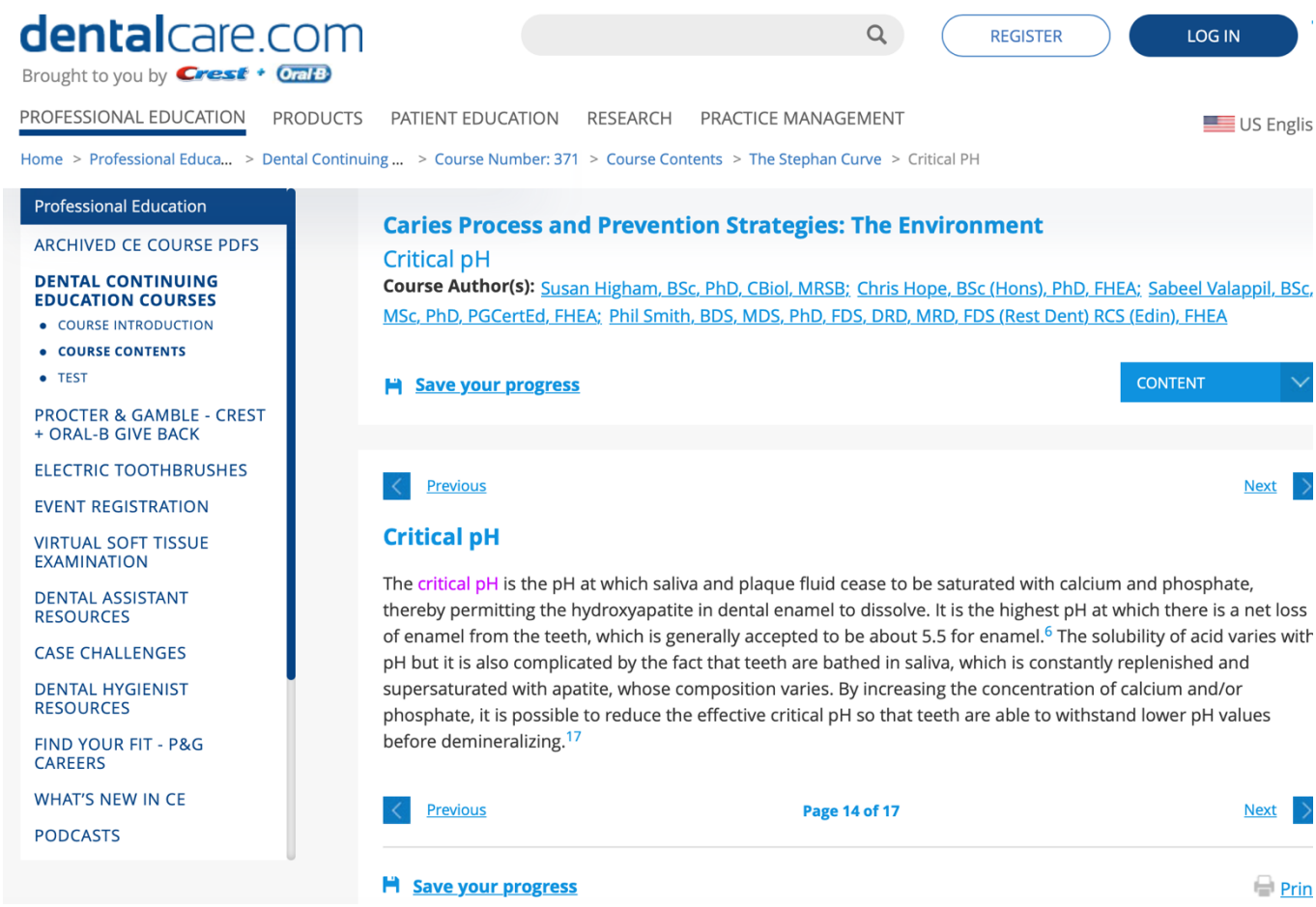
The effects and mechanisms of tastes on labial minor salivary gland (LMSG) secretion were investigated in 59 healthy individuals. Stimulation with each of the five basic tastes (i.e., sweet, salty, sour, bitter, and umami) onto the tongue induced LMSG secretion in a dose-dependent manner. Umami and sour tastes evoked greater secretion than did the other tastes. A synergistic effect of umami on LMSG secretion was recognized: a much greater increase in secretion was observed by a mixed solution of monosodium glutamate and inosine 5′-monophosphate than by each separate stimulation. Blood flow (BF) in the nearby labial mucosa also increased following stimulation by each taste except bitter. The BF change and LMSG secretion in each participant showed a significant positive correlation with all tastes, including bitter. Administration of cevimeline hydrochloride hydrate to the labial mucosa evoked a significant increase in both LMSG secretion and BF, while adrenaline, atropine, and pirenzepine decreased LMSG secretion and BF. The change in LMSG secretion and BF induced by each autonomic agent was significantly correlated in each participant. These results indicate that basic tastes can induce the gustatory-salivary reflex in human LMSGs and that parasympathetic regulation is involved in this mechanism.

1. Introduction

The minor salivary glands are vital for the maintenance of oral health because they secrete abundant mucin, which acts as a lubricant [1], and are involved in immunoactivity through secretion of immunoglobulin A [2]. Although the minor salivary glands contain less volume than the major salivary glands [3], they are widely distributed throughout the oral mucosa [4].

Eating is a strong stimulus for the secretion of saliva by the major salivary glands [5]. Large volumes of saliva are secreted before, during, and after eating via the gustatory-salivary reflex, masticatory-salivary reflex, olfactory-salivary reflex, and esophageal-salivary reflex. Parasympathetic efferent activities induced by taste stimuli have been shown to involve salivation and vasodilation in the major salivary glands [6]. However, the details of secretion mechanisms in the minor salivary glands remain unclear because of difficulties in collecting and quantifying the minute secretion volume from the minor salivary glands. We previously developed a new technique for measuring the minor salivary gland flow using a simple iodine-starch filter paper method [7] and demonstrated that the subjective feeling of dry mouth was more strongly related to a reduction in minor salivary gland flow than in whole salivary flow [8]. This finding suggests an important role of the minor salivary glands in xerostomia.

In the present study, we examined the effects of five basic taste stimuli (sweet, salty, sour, bitter, and umami) on reflex salivation in the human labial minor salivary glands (LMSGs). Specifically, we studied the synergistic effect of the umami taste on reflexive LMSG secretion because the combined umami taste of monosodium glutamate (MSG) and inosine 5′-monophosphate (IMP) is widely known to have a strong effect on taste perception as a characteristic feature of the umami taste [9]. Additionally, we investigated the nervous control of LMSG secretion using autonomic agents while monitoring the nearby blood flow (BF) in the labial mucosa where LMSG secretion was observed.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Critical pH
The critical pH is the pH at which saliva and plaque fluid cease to be saturated with calcium and phosphate, thereby permitting the hydroxyapatite in dental enamel to dissolve. It is the highest pH at which there is a net loss of enamel from the teeth, which is generally accepted to be about 5.5 for enamel.[6] The solubility of acid varies with pH but it is also complicated by the fact that teeth are bathed in saliva, which is constantly replenished and supersaturated with apatite, whose composition varies. By increasing the concentration of calcium and/or phosphate, it is possible to reduce the effective critical pH so that teeth are able to withstand lower pH values before demineralizing.[17]
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Salivary flow rate, pH, and concentrations of calcium, phosphate, and sIgA in Brazilian pregnant and non-pregnant women

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Published: 28 November 2006

Head & Face Medicine 2006, **2**:44 doi:10.1186/1746-160X-2-44

Received: 20 February 2006
Accepted: 28 November 2006

This article is available from: http://www.head-face-med.com/content/2/1/44

Abstract

Background: Studies on salivary variables and pregnancy in Latin America are scarce. This study aimed to compare salivary flow rate, pH, and concentrations of calcium, phosphate, and sIgA of unstimulated whole saliva in pregnant and non-pregnant Brazilians.

Methods: Cross-sectional study. Sample was composed by 22 pregnant and 22 non-pregnant women attending the Obstetrics and Gynecology Clinics, São Lucas Hospital, in Porto Alegre city, South region of Brazil. Unstimulated whole saliva was collected to determine salivary flow rate, pH, and biochemical composition. Data were analyzed by Student t test and ANCOVA (two-tailed α = 0.05).

Results: No difference was found for salivary flow rates and concentrations of total calcium and phosphate between pregnant and non-pregnant women ($p > 0.05$). Pregnant women had lower pH (6.7) than non-pregnant women (7.5) ($p < 0.001$), but higher sIgA level (118.9 mg/L) than the latter (90.1 mg/L) ($p = 0.026$).

Conclusion: Some of the tested variables of unstimulated whole saliva were different between pregnant and non-pregnant Brazilians in this sample. Overall, the values of the tested salivary parameters were within the range of international references of normality.

Background

Hormonal changes in females may affect the physiology of the entire body including the oral cavity. Besides the direct effect on the metabolism of periodontal tissues, pregnancy, menstruation, and hormone replacement therapy may induce short-term changes in salivary flow rates, buffering capacity, and biochemical composition [1-5]. Changes in salivary composition and flow rates may compromise the integrity of the soft and hard tissues in the oral cavity, because saliva functions include food and bacteria clearance, mastication and digestion, lubrication, antimicrobial defense, and buffering effect [6,7]. Saliva is composed of water and organic and inorganic molecules, but a large intra- and inter-subject variability in composition is reported [2,6].

Afr. J. Med. med. Sci. (2014) **43**,

Pregnancy related changes in human salivary secretion and composition in a Nigerian population

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Abstract
Background: A variety of physiological changes occurring during pregnancy has been shown to affect the oral health. Saliva is critical for preserving and maintaining the health of oral tissues and has been used as a source of non-invasive investigation of different conditions in human and animal studies.
Aim: This study was designed to evaluate changes in secretion and composition of saliva in pregnant women in a Nigerian population.
Methods: This was a descriptive cross-sectional study using purposive sampling technique. Saliva samples were collected from 50 pregnant and age matched 50 non-pregnant women. Salivary flow rate, pH, total protein and concentrations of sodium, potassium, calcium, phosphate and bicarbonate were determined and compared using paired independent sample t test.
Results: Salivary pH,mean concentrations of potassium and bicarbonate were significantly reduced while mean concentrations of salivary sodium and phosphate were significantly elevated in pregnant women compared to non-pregnant women ($P< 0.05$). However, there was no significant difference in the salivary flow rate, concentrations of total protein and calcium.
Conclusion: Salivary pH, bicarbonate and potassium concentrations were reduced while sodium and phosphate concentrations were elevated in pregnant women. These findings suggest that pregnant women may be predisposed to higher caries incidence.

Keywords: P*regnant women, non-pregnant women, salivary flow rate, salivary pH, total protein*,

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Introduction

Saliva is a watery fluid produced by the major and minor salivary glands situated in the oral cavity and parts of the upper respiratory tract. Saliva consists of approximately 99% water and a variety of electrolytes and proteins. The components interact and are responsible for the various functions attributed to saliva [1]. Saliva is critical for preserving and maintaining the health of oral tissues and has been used as a source of non-invasive investigation of different conditions in human and animal studies [2-5]. The physiological functions of saliva include initial food digestion, taste perception, maintenance of tooth integrity, oral clearance, lubrication, and protection of the oral cavity against infections. The contribution of the salivary glands to the secretion and composition of saliva depends on various physiological factors including pregnancy, age, sex, time of the day, diet, exercise, type and

Saudi Dental Journal (2018) **30**, 306–311

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ORIGINAL ARTICLE

Pregnancy-induced periodontal inflammation: Influence of salivary cytokines and antimicrobial proteins

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Received 21 March 2018; revised 2 June 2018; accepted 1 July 2018
Available online 6 July 2018

KEYWORDS

Pregnancy;
Saliva;
Cytokines;
Gingivitis;
Antimicrobial proteins

Abstract The aim of this study was to evaluate the association between pregnancy-induced periodontal inflammation and levels of some salivary cytokines and antimicrobial proteins (AMPs). The study was a cohort longitudinal study that included pregnant women attending a secondary health facility. Consented participants had oral examination and saliva sampling during pregnancy and post-partum (three months after pregnancy). Saliva samples were used for the analysis of cytokines (TNF-α, IFN-gamma and IL-1β) and AMPs (Lactoferin, Lysozyme, and β defensin-1) using ELISA. Data are presented as median with interquartile range and compared using related sample Wilcoxon signed rank test. Correlations between levels of the salivary factors and indices of periodontal inflammation were determined using Spearman's correlation test. Salivary flow rate, pH, levels of salivary IL-1β and IFN-gamma were significantly lower; while gingival index, periodontal index and level of salivary TNF-α were significantly higher during pregnancy compared with postpartum period. However, salivary lactoferin, lysozyme and β defensin-1 did not show significant difference comparing during pregnancy and postpartum period. Level of salivary IFN-gamma showed negative correlation with gingival index while level of salivary TNF-α showed positive correlation with gingival and periodontal indices. Lower levels of salivary IL-1β and IFN-gamma along with higher TNF-α concentration during pregnancy suggest their contributions to the pathophysiology of pregnancy-induced periodontal inflammation.

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Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.sdentj.2018.07.001
1013-9052

Journal of Advanced Medical and Dental Sciences Research

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Journal home page: www.jamdsr.com doi: 10.21276/jamdsr ICV 2018= 82.06

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Original Research

Evaluation of salivary flow rate, pH and buffering capacity in pregnant and non pregnant women- A comparative study

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***ABSTRACT*:**

Background- Saliva plays an important part in the maintenance of oral health as it contains many innate and acquired factors with a protective role on the oral tissue. A variety of hormonal changes occur throughout the life of females with a sheer peak during the time of pregnancy. The present study was carried out to determine the changes in flow rate of saliva, ph and buffering capacity in pregnant & non pregnant females. **Materials & Methods-** The present study comprised of 45 pregnant female and 45 non pregnant females of the same age group. Both stimulated and non stimulated saliva was collected from the patients and was compared. The salivary flow, pH and buffering capacity were measured by GC saliva collection buffer kit. **Results-** The mean± SD unstimulated flow rate was 5.32 ±1.64 and 4.47±1.45 in non pregnant and pregnant patients. The mean± SD unstimulated salivary flow rate was 9.38±2.15 in pregnant patients and 7.76± 1.75 in non- pregnant patients. The mean pH was 6.20 ± 0.32 and 6.90 ± 0.36 in pregnant and non pregnant patients respectively. The mean buffering capacity was 7.34 ± 1.62 in pregnant females and 10.1 ± 1.40 in non pregnant females. **Conclusion-** A significant decrease in the flow rate of both stimulated and non stimulated saliva was seen in the present study. pH and buffering capacity of saliva was also less in pregnant females as compared to non pregnant females.

Keywords: Bicarbonate, Buffer, Pregnancy

Received: 13 March, 2019 Revised: 10 June 2019 Accepted: 12 June 2019

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This article may be cited as: Bhatia A, Bains SK, Mehta R. Evaluation of salivary flow rate, pH and buffering capacity in pregnant and non pregnant women- A comparative study. J Adv Med Dent Scie Res 2019;7(8):42-45.

INTRODUCTION

Saliva plays an important part in the maintenance of oral health, as it contains many innate and acquired factors with a protective role on the oral tissue.[1] It plays key roles in lubrication, mastication, taste perception, prevention of oral infection and dental caries. There is increasing inclination towards using saliva samples for the diagnosis of oral and systemic diseases.[2] Many studies have indicated that hormones influence the composition of women's saliva.

A buffer is a solution that tends to maintain a constant pH. Whenever the pH starts falling after the ingestion of a substrate, it returns back to the original resting level after a period of time because of the inherent buffers in the saliva. Critical pH is the pH of the saliva below which the inorganic material of tooth starts dissolving and it varies according to the calcium and phosphate ion concentration. The value of critical pH is usually about 5.5 ranging anywhere between 5.2 and 5.7.[3]

Saliva contains water, organic and inorganic molecules which are exposed to hormonal changes in females. So, pregnancy, menstruation, and hormone replacement therapy can have a direct effect on the entire body including the metabolism of the periodontal tissues. During pregnancy, various complex interactions are occurring in the body, thereby changing the ph, biochemical composition and flow rate of saliva. Various hormones secreted by the body

Saliva and Dental Caries

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Adv Dent Res 14:40-47, December, 2000

Abstract – Caries is a unique multifactorial infectious disease. Our understanding of etiological factors, the progress of the disease, and the effectiveness of prophylactic procedures have led us to believe that we understand the disease. However, we still have too few answers to many questions: "Why can we not predict who will get the disease?" "Why do we not become immunized?" "How much saliva is enough?" or "Which salivary components are protective?" and "Which salivary components predispose for caries?" It is generally accepted, however, that saliva secretion and salivary components secreted in saliva are important for dental health. The final result, "caries to be or not to be", is a complex phenomenon involving internal defense factors, such as saliva, tooth surface morphology, general health, and nutritional and hormonal status, and a number of external factors-for example, diet, the microbial flora colonizing the teeth, oral hygiene, and fluoride availability. In this article, our aim is to focus on the effects of saliva and salivary constituents on cariogenic bacteria and the subsequent development of dental caries.

Human saliva not only lubricates the oral tissues, making oral functions such as speaking, eating, and swallowing possible, but also protects teeth and oral mucosal surfaces in different ways. The lubricating and antimicrobial functions of saliva are maintained mainly by resting saliva. Stimulation of saliva results in a flushing effect and the clearance of oral debris and noxious agents.

However, the protective functions of saliva are not limited to the above-mentioned functions. Recent studies have revealed a large number of functions, mediated by both the inorganic and organic components of saliva, that should be considered in assessments of the effects of human saliva on dental caries. Some of these studies have introduced a new approach to dental caries from being a bacterially induced multifactorial disease to a disease which may also be influenced by inherited salivary factors. Such genetically regulated salivary components may influence both the colonization and the clearance of micro-organisms from the oral cavity.

Caries–Who, When, and Where?

The notion that dental caries in animals is an infectious, transmissible disease was first demonstrated by Keyes (1960). Since then, a group of phenotypically similar bacteria, collectively known as mutans streptococci, has been implicated as the principal bacterial component responsible for the initiation and the development of dental caries (Loesche, 1986).

The tooth surface is unique among all body surfaces in two ways. First, it is a non-shedding hard surface, and, second, this surface is introduced into the human mouth during the first years of life. The earliest point at which the cariogenic mutans streptococci may become established is when the first teeth erupt. Solid surfaces are required for both streptococcal colonization and multiplication (Loesche, 1986).

The relationship between the establishment of mutans streptococci and the initiation of dental caries in young children has been extensively studied. Several studies have shown that children who experience colonization by mutans streptococci early in life are at greater risk of developing dental caries than those who are colonized later (Alaluusua and Renkonen, 1983; Caufield *et al.*, 1993). The extent of colonization of mutans streptococci and also, to some degree, subsequent caries activity experience are often correlated with the mother's salivary levels of mutans streptococci (Li and Caufield, 1995). Once mutans streptococci become established, they are considered difficult to eliminate, and the caries process is made possible.

The current concepts of dental caries focus on the fermentation of carbohydrates by cariogenic-bacteria-producing organic acids. Plaque bacteria produce a variety of end-products that may differ depending on the diet. When fermentable carbohydrates are present, the main organic acids produced are lactic, formic, and acetic acids (Geddes, 1975, 1981). These acids coincide with a pH drop in plaque, resulting in demineralization of the tooth (Loesche, 1986; Nyvad and Fejerskov, 1996) and creating an environment which is advantageous for further growth of *Streptococcus mutans* (Bradshaw *et al.*, 1989; Dashper and Reynolds, 2000). In addition to acid production, mutans streptococci express a wide range of virulence factors that are responsible for the cariogenicity of the dental plaque. However, saliva provides the main host defense systems against these virulence factors, and the balance between de- and remineralization is continuously affected by the interaction of bacterial virulence factors and host defense.

The final result, "caries to be or not to be", is a complex phenomenon (Fig. 1) involving internal defense factors, such as saliva, tooth surface morphology, general health, and nutritional and hormonal status, and a number of external factors-for example, diet, the microbial flora colonizing the teeth, oral hygiene, and fluoride availability. In this article, our aim is to focus on the effects of saliva and salivary constituents on cariogenic bacteria and the subsequent development of dental caries.

Salivary Flow Rate, Buffer Effect, and Dental Caries

Probably the most important caries-preventive functions of saliva are the flushing and neutralizing effects, commonly referred to as "salivary clearance" or "oral clearance capacity" (Lagerlöf and Oliveby, 1994). In general, the higher the flow rate, the faster the clearance (Miura *et al.*, 1991) and the higher the buffer capacity (Birkhed and Heintze, 1989).

Reduced salivary flow rate and the concomitant reduction of oral defense systems may cause severe caries and mucosal inflammations (Daniels *et al.*, 1975; Van der Reijden *et al.*, 1996). Dental caries is probably the most common consequence of hyposalivation (Brown *et al.*, 1978; Scully, 1986). Caries lesions develop rapidly and also on tooth surfaces that are

Key Words

Saliva, dental caries, buffer effect, adhesion, aggregation, antimicrobial agents.

Presented at the 16th International Conference on Oral Biology (ICOB), "Saliva in Health and Disease", held in Chantilly, Virginia, USA, April 9-12, 2000, sponsored by the International Association for Dental Research and supported by Unilever Dental Research