Salivary diagnostics and its implementation in diagnosis of COVID19

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Abstract

The coronavirus disease (COVID-19), epidemic started in Wuhan, caused by a novel coronavirus (SARS-CoV-2), has become a major public challenge around the world. Here, saliva diagnostic testing for COVID-19 is essential to controlling the global pandemic. The use of saliva has various advantages compared to collection of Nasopharyngeal swabs. The close contacts involved in swab collection have a risk to healthcare workers, and collection of saliva may reduce this risk. Presently, rapid testing is enchanting with the help of nasopharyngeal, oropharyngeal swab, bronchoalveolar lavage, sputum, urine, and blood. Saliva is demonstrating to be a capable non-invasive sample variety for the diagnosis of COVID-19, thus helping to detect the infection and prevent it from further spreading by prompt isolation. The saliva biomarkers have a potential to be a vital guide in COVID-19 diagnosis, making possible the development of sampling procedures. Salivary biomarkers connected with the improvement and evolution of COVID-19 could allow a well distinction among asymptomatic, mild, moderate or advanced disease.

Keywords: Saliva, infections, COVID-19, sampling, antibodies

Introduction

The epidemic of coronavirus disease 2019 (COVID-19), instigated by a novel coronavirus (SARS-CoV-2), has become a major public health challenge around the world. In many cases, the rapid spread of infection transmission through person-to-person, either direct contact by sneeze, cough, or droplet inhalation, or contact transmission such as ocular contact or through mucous membranes of the eyes and nose and saliva, and the spread through droplets and aerosol particles [1].

Diagnostic testing for COVID-19 is essential to controlling the global pandemic. Inspite of increase in diagnostic testing capacity for SARS-CoV-2, in many countries, testing is still inadequate to slow the COVID-19 pandemic. Many people still do not have access to COVID-19 tests, and some that do still experience long delays in receiving results due to imbalance between supply and demand at large testing centres. The use of saliva has various advantages compared to collection of Nasopharyngeal swab.

The close contacts involved in swab collection have a risk to healthcare workers, and collection of saliva may reduce this risk. Presently, rapid testing is taking place with the help of nasopharyngeal, oropharyngeal swab, bronchoalveolar lavage, sputum, urine, and blood [2]. All these approaches are invasive or uncomfortable to the infected person. It is observed that salivary glands are hosting SARS-COV-2 because of angiotensin-converting enzyme and the detection of high viral loads in the saliva and is playing a major role in virus spread, especially from individuals showing absolutely no symptoms. Further, saliva collection does not require specialised equipment, causes less patient discomfort, and may be a useful sample for self-collection.. Saliva is proving to be a promising non-invasive sample specimen for the diagnosis of COVID-19, thus helping to detect the infection and prevent it from further spreading by prompt isolation.
Salivary Fluid as Possible Investigative Tool for Covid-19

Saliva is a distinctive body fluid secreted by the salivary glands. It has the purposes of lubricating oral mucosa, digesting food, cleaning and protecting the oral cavity, and is one of the most significant factors affecting homeostasis of the oral cavity. The major salivary glands parotid, submandibular and sublingual glands are the main sources of salivary exudation [3].

The development of the COVID-19 epidemic has emphasized the necessity for numerous diagnostic strategies to professionally estimate probable cases in order to deliver information on people exposure and immunity. These outfits presently include disease molecular analysis and quick host immune reaction assays. Saliva is a natural fluid in which SARS-CoV-2 can be established and for this purpose saliva has continued taken into consideration in the diagnosis of COVID-19 [6]. The investigative prospective of salivary was recognised by studies that shown that, like serum, saliva contains hormones, antibodies, growth factors, enzymes, microbes and their yields that can go into saliva through blood by passive diffusion, active transport or extracellular ultrafiltration. Hence, saliva can be a consistent liquid for observing the biological function of the body [3]. While the little concentration of certain substances in saliva linked with the blood formerly revealed challenging, the creation of extremely complex molecular approaches and nanotechnology have to a great opportunity avoided this restriction.

Saliva as a Possible Source for Spread of Virus

Human saliva is abundant of biologically active components, such as proline-rich proteins, mucins MG1 and MG2, and gp340 [6]. These components intermingle with pathogens and cause multiple influences on their biological performance. The interface between viruses and saliva is a multifaceted biological process. Coronavirus is a group of enclosed single-stranded RNA viruses belonging to the order Nidovirales, the coronavirus family, and the coronavirus subfamily [5]. It has 26 known species and can be dispersed into four classes (α, β, γ, and δ). Merely the α and β genus are human pathogenic strains. SARS-CoV, SARS-CoV-2 and the Middle East respiratory syndrome coronavirus (MERS-CoV) all belong to the β subdivision. Studies have revealed that early target cells for SARS-CoV infection comprise ACE2-positive cells/keratin epithelial cells in the salivary gland duct and other cells in the lungs, such as ACE2-positive cells/keratin alveolar epithelial cells, which recommended the salivary gland epithelial cells may be infected in vivo after entry of the virus (Liu et al., 2011) [6]. Hence, the saliva produced by the infected salivary glands could be a significant source of virus, predominantly in early infection (Liu et al., 2011) [6]. At present, RT-PCR detection results of throat wash and saliva indicated that the content of SARS-CoV RNA in saliva was comparatively higher than that in throat wash, which maintained the possibility of oral droplet transmission of SARS-CoV (Wang et al., 2004) [7]. The quantity, distance, and size of saliva droplets vary between individuals, signifying that the infectious intensity and transmission route of saliva droplets differ when the same pathogen is reduced. Each cough can produce about 3000 saliva droplets nuclei, which is almost equivalent to the quantity generated during a 5-min conversation. Each sneeze can create roughly 40,000 droplets of saliva covering several meters in the air. A regular exhalation can create saliva droplets that go beyond one meter in the air. Enormous saliva droplets with increased naturally fall to the ground and small saliva droplets flutter by airflow like a cloud over longer distances. Henceforth, the virus has the likely to initiate disease through both short-distance and long-distance aerosol spread. There is increased risk of infection in people who have direct and unprotected contact with SARS patients (Tuan et al., 2007) [8]. Therefore, dental clinicians in near contact with patients, salivary aerosols and plasma need to be highly endangered to condense the risk of infection, mostly during the epidemic period of COVID-19.

Role of Saliva in Molecular Detection

The nature and clinical features linked with this virus are relatively distinctive including fever, non-productive cough mostly, malaise, dyspnoea and pneumonia. While sputum production, haemoptysis, headache and gastrointestinal symptoms such as diarrhoea, nausea and vomiting are less frequently presented symptoms [9]. Patients infected with COVID-19 show increased number of leukocytes, greater levels of plasma pro-inflammatory cytokines and abnormal respiratory findings. Swabs from the nasopharynx and oropharynx are the recommended upper respiratory tract specimen types for making diagnosis of COVID-19 the collection of swab requires close contact between healthcare workers and patients that not only increase the risk of transmission of the virus among healthcare workers but also causes discomfort resulting in bleeding, especially in condition like thrombocytopenia [9]. To overcome this problem, saliva has been found as an alternate source for making the diagnosis. It can be used for detecting respiratory viruses, including Coronavirus because of high consistency > 90% with nasopharyngeal specimens.

Salivary Fluid as Biomarkers for Covid-19 Diagnosis and Detection

Coronaviruses, such as SARS-CoV and Central East breathing syndrome (MERS)-CoV, have established methods to reduction or delay the production of interferon (IFN), triggering exuberant inflammatory responses leading to severe pulmonary conditions [10]. Salivary biomarkers and their role in point-of-care application have underlined the progress of the practice of more advanced technologies such as micro/Nano electro-mechanical systems, paper-based skill, fluorescent biosensors, photometric and electrochemical approaches, RNA-sequencing, liquid biopsy, electric field-induced release and measurement technique [11]. Markers of the inflammatory progression, such as cytokines and chemokine, can be measured in saliva. Such statistics has been recommended to be useful for the identification and prognosis of both oral cavity and systemic diseases. Hence, it is possible to create an inflammatory outline of COVID-19 by studying inflammation-related biomarkers in saliva. Interestingly, some of the known biomarkers in these studies such as C reactive protein, malic acid, guanosine monophosphate, lactate dehydrogenase, and proteins related with macrophage, platelet degranulation and complement pathway are visible to be present in saliva [12]. These results support the possible use of saliva-based metabolic/protein/lipid biomarkers as a non-invasive approach for patient stratification in COVID-19 disease. Metabolomics is a method used in the study of small molecules from the metabolic profile of cells, tissues or fluids, which help in the classification of a phenotype. These molecules termed biomarkers, are essential in clinical practice for defining the state of a disease [13]. Thus, metabolomics has helped to recognise biomarkers with investigative potential.
Salivary Antibodies against Covid-19
Viral antibodies have been spotted in saliva and the vaccination status of measles, rubella, mumps and hepatitis can be tested by analysing IgG, IgM and IgA in oral fluids [18]. In addition to RT-PCR based RNA detection of SARS-CoV-2, initially studies have been reported, capable results for the finding of IgM and IgG against SARS-CoV-2 in serum/plasma samples of patients with SARS-CoV-2. Regarding SARS-CoV-2, only a study procedure aimed to analyse IgG, IgM and IgA in changed biological fluids including self-collected saliva for rapid SARS-CoV-2 diagnosis has been published [20]. Viral antibodies have been noticed in saliva and the immunisation status of measles, rubella, mumps and hepatitis can be confirmed by analysing IgG, IgM and IgA in oral fluids [18]. Though, there are so far no outcomes describing the presence of antibodies against SARS-CoV-2 in human saliva. This clearly permits future studies on the potential use of salivary immunoglobulins for COVID-19 in diagnostics, disease progression and immunisation monitoring.

Methods of Salivary Testing For Sars-CoV-2
Salivaomics is the study of salivary “omics” methodologies including the genome, the epigenome, the transcriptome, the proteome, the microbiome, and the metabolome [21]. The ability to assemble a model in a non-invasive, safe, and total effective method, with the profits of advanced patient ease and compliance makes the adoption of saliva for each of these “omics” techniques an attractive proposition for all parties concerned (patients, researchers, and clinicians) here are many properties of human saliva that attract clinicians or researchers to adopt the use of saliva specimens and reinforce the use of this non-invasive fluid in diagnostic algorithms [22]. Some of these are highlighted below: Non-invasive, Simple collection protocols, Non-infectious sample, Easily disposal, Effortlessly portable, economic, Not subject to cultural and religious, Safe and effective, Advanced patient acquiescence. The actual principal occurrence of a method for saliva assemblage from a patient was in the initial 19th period (1934) by Wainwright for the investigation of salivary calcium (Ca2+). In Wainwright’s method, the patient’s head was angled forward with the opening indicating vertically downwards and saliva was permitted to drip from the mouth into a filter funnel [23]. Specific young adults yield around 0.5 to 1.5 litres of saliva per day (or nearly 0.5 mL/min) but in various systemic diseases, and in pathological and biological conditions, there may be a considerable (negative) impact on the salivary flow rate. [24] [Table 1]
Two companies from the United States, namely Epitope, Inc, were two of the early pioneers in the area; each developed commercially viable saliva collection devices in the 1990s, and each of these has been used in proteomic analysis and other areas of research and clinical practice [31]. The Ora Sure Device from Epitope/Ora Sure was the first saliva collection device to be linked to a clinical test for the human immunodeficiency virus (HIV) and the company was successful in gaining Food and Drug Administration (FDA) approval for the device in conjunction with a laboratory enzyme-linked immunosorbent assay (ELISA) test for the HIV virus. Saliva [10]. These early procedures prompted new improvements in saliva collection method equipment instigating in devices that yield “domestic” specimens, thus permitting clinicians to analyse saliva more easily than before. Other devices that have been used historically include the Salivate device from S Salimetrics Oral Swab (SOS). Fresher devices on the marketplace “paradigm” whole saliva pool using passive drool. These devices, which includes the (A) Salivette® (Sarstedt); (B) Quantisal® (Immunoanalysis); (C) SCS® (Greiner-BioOne), Super+SAL™ (Figure D) and Versi+SAL® (Figure E) technologies. These devices (Figure D,E) have been used successfully to collect hormones [31], proteins, and biomarkers potentially useful in the diagnosis of Parkinson’s disease [31] as well as infectious agents including the Ebola virus and Lassa fever. The serious entity is that the modern group of strategies provide a standardized trial of saliva, characteristic of complete mouth saliva.

PCR Detection in Sars-CoV-2 with Salivary Fluid Testing For Sars-CoV2
At Present, RT-PCR is the most universally used diagnostic test for the exposure of SARS-CoV-2 RNA in the biological samples. For comprehensive testing as in the case of SARS-CoV-2, accurate collection of the type and the site of biological specimen collection is crucial for obtaining unfailing test results [32]. Biological samples from the upper tract such as nasopharyngeal swabs, oropharyngeal swabs, throat swabs, nasal swabs and lower tract such as bronchoalveolar lavage respiratory tract scan and tracheal aspirates can be used for the detection of SARS-CoV-2 with varying degree of test sensitivity [33]. Presently, nasopharyngeal/oropharyngeal swabs where virus samples are collected by separately rubbing the nasopharyngeal wall and

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the posterior pharynx/tonsillar areas through mini tip swabs, are regularly used for SARS-CoV-2 detection. Despite the extensive use, the collection of nasopharyngeal/oropharyngeal swabs has a number of restrictions. The assembly of these washes is less reasonable to patients as associated with non-invasive approaches like saliva collection, as it tends to cause patient discomfort and even bleeding. Likewise, the risk for disease transmission to the healthcare workers when collecting these samples is high, as it needs active participation of the test taker. Also collection of these samples stresses the use of personal protective and healthcare resources, both of which tend to be in little source in a pandemic like COVID-19 [30].

Advantages and Disadvantages of Salivary Sampling
Saliva has been studied comprehensively as a possible diagnostic tool and it is likely to become a auxiliary for other biological fluids such as serum or urine in disease analysis [18]. Compared with other investigative fluids, saliva sampling has both advantages and disadvantage in use for the diagnosis of COVID-19. (Table 2)

**Future of Salivary Sampling in SARS-COV-2**
Saliva collection is relatively stress-free for patients as well as being easy, inexpensive, and non-invasive with minimal equipment required. It should also minimize the nosocomial transmission of COVID-19 to healthcare workers. The usage of saliva-based SARS-CoV-2 testing deals several clinical benefits and is scientifically well created. Saliva-based testing can be an substitute to the more extensively used nasopharyngeal and oropharyngeal washes for COVID-19 diagnosis and disease monitoring. The beneficial role of saliva as a quick, non-invasive diagnostic modality and the various possibilities it presents with, for investigation, during the course of the disease process, prognosis or presence of any antibodies to the novel COVID-19 virus, needs further exploration. Additionally, the involvement of any other receptors or cellular proteases which may throw more light on the pandemic disease pathogenesis may pave way to targeted drug therapies.

**Table 1:** Table represents the group of mouth liquid and collection method of salivary sampling

<table>
<thead>
<tr>
<th>Group of Complete Mouth Liquid</th>
<th>Method of Collection and Type of Collection Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Saliva (WS)</td>
<td>Patients should refrain from eating, drinking, and oral hygiene actions for at minimum 1 h before saliva collection. (Optimal collection time is 8–10 a.m.). Once collection implements a 1 min oral rinse by distilled water and then after 5 min collects ~5 mL of saliva. Collected sample must be processed in the laboratory within 1 h. [25]</td>
</tr>
<tr>
<td>Un-stimulated Full Saliva</td>
<td>Passive drooling: In this method limit oral movement and drain saliva from the lower lip into a plastic vial. Spitting technique: Teach subject to spit into a collection vial. In this method 14 times more bacterial contamination is introduced into the sample [26].</td>
</tr>
<tr>
<td>Stimulated Whole Saliva</td>
<td>For the stimulation of glands, chewing unlike things like natural gum, a piece of paraffin wax, citric acids, and powdered drink crystals have been used. [27]</td>
</tr>
<tr>
<td>Parotid Gland</td>
<td>Method introduced by Carlson and Crittenden (1910). In this process a dual chambered copper beaker with two opening tubes is used. One termination grasps the cup in place using vacuum suction. The following half acts as a gathering vehicle for saliva. Sample collection can be boosted by spreading citric acid (10%; 1 mL) on the dorsum of tongue every 30 s. Remove the first 1.5 mL of saliva prior to trial collection. [28]</td>
</tr>
<tr>
<td>Submandibular and Sublingual Gland</td>
<td>Truelove, Bixler, and Merrit (1967) castoff a “V”-shaped accumulator. This method is similar to that for parotid gland collection, but in this case the initial 2 mL is discarded [29].</td>
</tr>
</tbody>
</table>

Versi SAL®, (E) Super SAL by Oasis Diagnostics® Corporation

**Fig A:** (A) Salivette® (Sarstedt); (B) Quantisal® (Immunalysis); (C) SCS® (Greiner-BioOne) [9, 10]
Minor Glands

Kutscher et al. (1967) used capillary tubes for accumulating saliva from minor glands situated at the everted surface of the lower lips.¹⁰

### Table 2: Table represents the most common advantages and disadvantages of saliva sampling method in diagnosis of covid19

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
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<tbody>
<tr>
<td>Safer collection for health professionals than other biological trials such as nasopharyngeal swabs and blood. Non-invasive method for diagnosis of the disease</td>
<td>Not at all times reliable for measurement of certain markers</td>
</tr>
<tr>
<td>No patient discomfort and anxiety for sampling. Easy collection and applicable in isolated areas. Comparatively cheap technology. Economical</td>
<td>Substances of saliva can be predisposed by the method of collection, degree of stimulation of salivary flow, inter individual dissimilarity and oral hygiene status. Serum indicators can reach whole saliva in an unpredictable way. Medications may upset salivary gland function and subsequently the quantity and composition of saliva.</td>
</tr>
<tr>
<td>Suitable for children, anxious, disabled and elderly patients. Potential multisampling. Easy to handle. No need for expensive equipment or instruments. Simply needs a sterile container</td>
<td>Possibility for degradation of salivary proteins due to occurrence of proteolytic enzymes.</td>
</tr>
</tbody>
</table>

### Conclusion

The examination for salivary biomarkers linked with the improvement and evolution of COVID-19 could allow a better distinction between asymptomatic, mild, moderate or advanced disease. Saliva biomarkers have a prospective to be an essential guide in COVID-19 prognosis, making possible the development of sampling procedures. Knowledge of this kind might lead to the development of point-of-care devices, which can be extremely useful for understanding of the evolution of contagions and immunological responses in population studies. Right now, in this uncontrollable pandemic situation, all research centers, health agencies, and health care providers must explore the diagnostics opportunity and rapidly develop automated molecular point-of-care assays. This write-up will help epidemiologists, virologists, and clinicians to understand the importance of saliva in diagnostic testing as well as the transmission of the disease.

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