ORIGINAL ARTICLE

Oral Health Status and Salivary Parameters in Stroke Patients at a Tertiary Hospital

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ABSTRACT

Introduction: Dental caries and impaired salivary function are very common but undertreated. The aim of this study was to investigate the oral health status and salivary parameters of stroke patients. **Methods:** A cross-sectional study was carried out on 54 stroke and 54 non-stroke patients attending rehabilitation treatment at Hospital Universiti Sains Malaysia. Decay, Missing and Filled Teeth (DMFT) index and plaque scores were used to evaluate patients' oral health. Salivary parameters such as salivary cortisol, salivary flow rate, pH and buffering capacity were measured. Salivary cortisol was analysed using Cobas E6000 automated immunoassay. **Results:** Among the 54 stroke patients, the majority were Malays 72.2% and 63.0% were male, with a mean age of 48.1 (14) years. There was a significant difference of dental caries between stroke patients, at 17.6 (4.26), compared to 15.7 (5.38) for non-stroke patients (p=0.042). Only 53.7% of stroke patients had good oral hygiene, compared to, 85.2% among non-stroke patients' (p-value= 0.001). Salivary parameters showed no significant differences (p>0.05). However salivary cortisol levels were higher in stroke patients 5.2(5.1) nmol/L) than in non-stroke patients 4.0 (3.6) nmol/L). There was no significant correlation between salivary parameters and DMFT index (P>0.05). **Conclusion:** Stroke patients had more dental caries and poor oral hygiene compared to non-stroke patients. Salivary parameters showed no significant difference between stroke and non-stroke patients.
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INTRODUCTION

Stroke, a cerebrovascular disease, is characterised by rapidly developing clinical symptoms and signs of focal—and often global—loss of cerebral function lasting more than 24 hours or leading to death with no apparent cause other than one of vascular origin (1). According to the World Health Organization (WHO), 15 million people worldwide have a stroke annually; five million die, and another five million are permanently disabled due to stroke complications (2). Based on data from the Ministry of Health of Malaysia, stroke was the third leading cause of death in Malaysia in 2021 (3).

Stroke survivors often experience post-stroke complications such as physical limitations, including impaired manual hand dexterity, which may hinder effective daily toothbrushing needed for dental plaque removal. Dental caries is caused by complex interactions over time between the cariogenic bacteria in dental plaque and fermentable dietary carbohydrates on tooth surface (4). Globally, it is estimated that two billion people suffer from caries of permanent teeth and 520 million children suffer from caries of primary teeth (5). In Malaysia, 90.7% of adult Malaysians report having a mean of 11.6 teeth affected by caries (6). In addition, facial paralysis in stroke patients contributes to food stagnation in the oral cavity, necessitating a longer time for saliva to cleanse the oral cavity naturally. This results in an abundant accumulation of dental plaque in the oral cavity. Most stroke survivors are on daily medication that causes xerostomia, as well as cariogenic nutritional supplements, which facilitate caries formation by providing an acidogenic environment within the oral cavity. Furthermore, patient dependence on the daily intake of starchy foods or liquid meal supplements for energy often introduces fermentable carbohydrates into the mouth, where the fermentable carbohydrates interact with cariogenic bacteria. As cariogenic bacteria act on these carbohydrates, the weak organic acid produced removes essential negatively charged ions from the enamel surface, resulting in demineralisation. As disturbances occur in the demineralisation–mineralisation balance, the tooth structure breaks down and eventually leads to dental caries.

Impaired salivary function would contribute to prolonging plaque retention and pH imbalance within the oral cavity, further exacerbating the development of caries. Furthermore, the regular use of endotracheal tubes and nasogastric tubes in bedridden stroke patients may produce dry mouth and may make oral hygiene maintenance difficult (7). Kim et al. (8) discovered that the mean and standard deviation values for tooth decay among stroke patients, at 0.8 (1.91), are significantly higher than among non-stroke patients, at 0.7 (1.54), ($p = 0.02$).

The fermentation phase of cariogenic bacterial activity alters the pH of saliva, creating an acidogenic oral environment at an essential pH of 5.5. During this crucial pH interval, the tooth structure degrades further, leading to dental caries, which lowers the saliva pH even more initiating a vicious cycle (9). Saliva plays a crucial role in preventing caries by buffering the acidic condition: neutralising the acid by-product and dissolving debris and microorganisms. However, the flushing capacity of saliva may be affected by changes in its consistency and flow rate (10).

Patients with stroke are also vulnerable to stress. Restricted movement and inability to perform activities of daily living, as well as intangible factors such as reduced participation in leisure activities and limitations to significant life roles (11), constitute major causes of stress for stroke survivors. Moreover, dental procedures and chronic pain resulting from caries may be linked to an increase in chronic stress load (12). Salivary cortisol level is a reliable stress biomarker because the autonomic nervous system (ANS) and the hypothalamus-pituitary-adrenal axis (HPA) gradually become dysregulated with chronic stress exposure, causing alterations in salivary gland activity, which affects the concentration and flow rate of salivary proteins. Mirzaee et al. (13) reports that stroke patients have a significantly higher mean (SD) salivary cortisol level of 43.5 (28) nmol/L than the 19.2 (13) nmol/L observed in healthy participants ($p = 0.012$). There is limited information available in Malaysia on the oral health status and salivary biomarkers of stroke patients. Furthermore, the oral health status of stroke patients has not been properly monitored. Therefore, we aim to assess the oral health status of stroke patients in relation to salivary parameters. The findings of this study will provide information on the relationship between caries and stroke, facilitating prognosis and early referral to appropriate treatment for high-risk individuals. This will minimise complications, reduce the financial burden of stroke and improve the quality of life of stroke survivors.

MATERIALS AND METHODS

A cross-sectional study was conducted at the rehabilitation medicine unit of the Hospital Universiti Sains Malaysia (HUSM). The study participants were recruited based on a set of inclusion and exclusion criteria. The inclusion criteria for participating stroke patients were as follows: patients aged 18 years and above who experienced their first stroke at least six months prior, with a Modified Rankin Scale (mRS) score of 3–4; not involved in other ongoing research; has at least eight remaining teeth; is not on nasogastric tube feeding. The comparison group included non-stroke patients aged 18 years and above who had undergone general rehabilitation therapy for sport-related injury at the rehabilitation medicine unit without evidence of neurological deficit upon neurological examination and had at least eight teeth. All patients participating in the study were evaluated by the same rehabilitation medicine specialist to reduce inter-rater and intra-rater bias on evaluation of mRS and patients' selection.

We excluded medically unstable patients (i.e., unable to complete the exercise prescription given during the therapy and patients who had comorbidities in the upper or lower limbs such as spasticity and contractures). We also excluded conditions including hyperpituitarism (overactive pituitary gland), benign pituitary tumors including adenomas, cancerous pituitary tumors, benign, and malignant adrenal gland tumors and Cushing syndrome that might raise salivary cortisol levels . Patients who were using long term, and high dose of corticosteroids to treat asthma, arthritis and certain cancers, were also excluded from all groups since these may influence the cortisol levels. Patients who met the following criteria were also excluded from the study: depression; conditions that can affect saliva function, such as Sjögren syndrome, rheumatoid arthritis, and cancer; patients who were on chemotherapy or radiation of the head and neck region; patients who were pregnant or lactating.

The sample size, calculated using Power and Sample Size (PS) software 3.1.2, is based on comparing two dichotomous categorical variables: the prevalence of poor oral hygiene among stroke and non-stroke patients—at 34.4% and 10.1%, respectively (14). The results of the calculation indicated that a total of 45 patients were needed for each group (stroke patients and non-stroke patients) to achieve a power of 80%. Anticipating that approximately 20% of the qualified participants might not agree to participate in the study, a total of 54 participants per group were invited to participate. Stroke patients were selected using simple random sampling. Participants were given an appointment date determined by their rehabilitation follow-up appointments.

Data Collection

Prior to data collection, a phone call was made one day before the appointment date to explain the study protocol. Participants were not allowed to brush or floss their teeth on the day of the appointment, and they were instructed not to consume caffeine, food, nicotine, or alcohol for at least two hours prior to saliva collection. This was to ensure that no confounding factors affected the measured saliva parameters (15).

Saliva was collected in the early morning between 8:30 am and 10:30 am and at the same time every day to minimise the effects of circadian variations (16). Each participant received an explanation of the purpose of the study and the study procedure, after which the participants gave their informed consent. Sociodemographic profiles and relevant medical histories were obtained using a proforma that included demographic details such as age, gender, race and other comorbidities. All participants were assigned a code, and only the researchers had access to their data. The participants then underwent a saliva collection procedure to measure saliva parameters, followed by a clinical intraoral examination.

Estimation of Saliva Flow Rate

Saliva collection for the measurement of saliva flow rate, saliva pH and saliva buffering capacity were performed according to the protocol provided by the manufacturer of the Saliva-Check Buffer kit. To facilitate saliva collection, the participants were instructed to sit upright with their heads slightly bent forward. They were then instructed to expectorate for five minutes into a special cup provided with the Saliva-Check Buffer kit, after allowing the saliva to accumulate for one minute. The volume of saliva collected was measured using a level indicator on the cup. Froth formation was excluded from the saliva level measurements. The unstimulated saliva flow rate per minute was calculated by dividing the total saliva volume by five and is expressed in millilitres per min (mL/min).

Analysis of Saliva pH

The same saliva samples used to measure saliva flow rate were used to measure saliva pH using a pH test strip. The pH test strip was dipped into the saliva sample for 1–2 seconds. It was then taken out of the saliva sample and set aside for 15 seconds. The colour of the pH test strip was compared to a colour chart provided on the bottle label by the manufacturer of the pH test strip. The pH reading is the corresponding number of the colour on the pH chart that matches the colour of the pH test strip. The pH reading of each participant was recorded in the case proforma.

Analysis of Saliva Buffer Capacity

A sufficient amount of saliva from the same saliva sample was obtained using a disposable pipette provided with the Saliva-Check Buffer kit. One drop of saliva was placed on each test pad of the saliva buffering test strip, which was then placed on absorbent tissue. Following that, the test strip was immediately tilted 90 degrees to prevent swelling of the test pad and to allow excess saliva to soak into the absorbent tissue. Consequent colour changes on the test pads were observed after two minutes and compared to a colour chart provided by the manufacturer to determine the value of the reading for each pad. The values for each test pad were then added to obtain the final value of the saliva buffering capacity in grams per decilitre (g/dL). The final value for each participant was recorded.

Salivary Cortisol Collection and Analysis

All study participants were instructed not to consume caffeine, food, nicotine, or alcohol two hours before cortisol sampling. The saliva samples were collected by trained research assistants. Following a ten-minute relaxation period, during which the participants were instructed to sit quietly and relax, each participant chewed on a Salivette swab (Sarstedt, Rommelsdorf, Germany) for two minutes until the Salivette swab was saturated. All participants were able to orally manipulate the Salivette swabs and then return them into the Salivette tubes safely. The Salivette tubes were immediately placed in a cold storage box and delivered to the Chemical Pathology Laboratory of HUSM. When the samples arrived at the laboratory, they were centrifuged for 2 min at 1,000 g and stored in a refrigerator at -80 °C until needed for further analysis. The samples were tested using commercially prepared kits manufactured by Roche Diagnostics, along with the Cobas E6000 automated immunoassay analyser.

Assessment of Oral Hygiene Status and Dental Caries Experience

Upon completing the saliva sample collection, a clinical oral examination was performed by a single examiner using disposable mouth mirrors and periodontal probes, with the patients seated upright on a portable dental chair under good lighting. The examiner had been calibrated for caries assessment by a senior specialist. The inter- and intra-examiner results show that approximately 90% of the measurements reproduced within ±1.0 mm. Measurement of oral hygiene status was based on the Silness-Löe plaque index (1964) (17). Both soft debris and mineralised deposits on the six specific teeth (tooth 16, 12, 24, 36, 32 and 44) and on all four sides of each tooth (the buccal, palatal, mesial and distal) were examined. Missing teeth were not substituted. The teeth were first examined visually; a periodontal probe was then passed over the cervical third of the tooth to test for the presence of plaque. Each tooth side was given a score between 0 and 3. The score for each tooth was determined based on the Plaque Index Scoring System.

Score	Criteria
0	The tooth surface is clean.
1	The tooth surface appears clean but dental plaque can be removed from the gingival third with the periodontal probe.
2	Moderate accumulation of plaque on the tooth is visible along the gingival margin.
3	The tooth surface is covered with abundant plaque.

For each tooth, the score for all four surfaces were added and then divided by four to obtain the index for that tooth. The scores were categorised as excellent (a score of 0), good (a score of 0.1–0.9), fair (a score of 1.0–1.9) or poor (a score of 2.0–3.0).

The caries experience of the patients were charted based on the index of Decayed, Missing and Filled Teeth (DMFT) (Klein et al., 1938). During the intraoral examination, the number of teeth that had caries lesions (D), teeth that had been extracted or were missing due to caries (M), and teeth that had fillings or crowns (F) were counted and recorded on a designated dental form.

Statistical Analysis

The data were inputted into and analysed in the Statistical Package for Social Science (SPSS) version 26.0. The descriptive statistics were calculated, including mean and standard deviation (SD) or median and interquartile range (IQR) for continuous variables (i.e., age, DMFT, saliva flow rate, saliva pH, salivary cortisol level, and saliva buffer capacity), and frequency and percentage for categorical variables (i.e., gender, race, marital status, comorbidity, education status, employment status, smoking status, and oral health status). A comparison of the mean DMFT and each of its components (i.e., D, M, and F) between the stroke and non-stroke patients was performed using an independent T-test. Because of the nonnormal distribution of the data, comparison of saliva flow, saliva pH and salivary cortisol level was performed using the Mann–Whitney U test. The Pearson correlation test was used to determine the correlation between the saliva parameters and the presence of caries. The $p < 0.05$.

Ethical statement

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the approved by the Human Research Ethics Committee of USM (Reference number: USM/JEPeM/ 19010031)

RESULTS

A total of 108 participants were successfully recruited for this study. Table I presents the sociodemographic profiles of the stroke and non-stroke patients. Among the 54 stroke patients, the majority were Malays (n = 39, 72.2%), 34 (63.0%) were male, and the mean age was 48.1 (SD = 14) years. Thirty-nine (72.2%) of the 54 stroke patients were married, and 26 (48.1%) received secondary-level education. The majority were unemployed (n = 35, 64.8%) and non-smokers (n = 38, 70.4%), while 13 (24.1%) were ex-smokers. The main underlying comorbidities were cardiovascular disease (n = 31, 57.4%), followed by hyperlipidaemia (n = 23, 42.6%), traumatic brain injury (n = 21, 38.9%) and diabetes mellitus (n = 20, 37.0%) (Figure 1). In contrast, among the 54 non-stroke patients, the majority were Malays (n = 49, 90.7%) and female (n = 31, 57.4%), and the mean age was 40.4 (SD = 16) years. Most of the non-stroke participants were married (n = 38, 70.4%) and had received secondary education (n = 28, 51.9%);

Table I: Sociodemographic profile of stroke and non-stroke patients

Variables	Frequency (%)	
	Stroke (n=54)	Non-stroke (n=54)
Age[a]	48.1 (14)	40.4 (16)
Gender		
Male	34 (63)	23 (43)
Female	20 (37)	31 (57)
Race		
Malay	39 (72)	49 (90)
Chinese	11 (20)	2 (4)
Indian	1 (2)	1 (2)
Others	3 (6)	2 (4)
Marital Status		
Single	15 (28)	13 (24)
Married	39 (72)	38 (70)
Divorcee	0 (0)	1 (2)
Widowed	0 (0)	2 (4)
Education Level		
None	1 (2)	1 (2)
Primary	5 (10)	3 (6)
Secondary	26 (48)	28 (52)
Tertiary	22 (40)	22 (40)
Employment Status		
Working	19 (35)	25 (46)
Not working	35 (65)	29 (54)
Smoking Status		
Current smoker	3 (6)	5 (10)
Never smoke	38 (70)	38 (70)
Ex-smoker	13 (24)	11 (20)

[a] mean (SD)

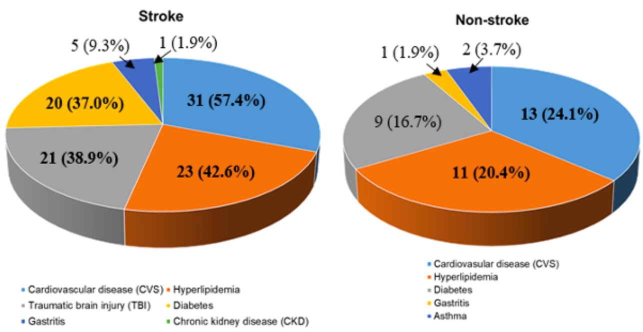

Figure 1: Comorbidity of stroke (n-54) and non-stroke patients (n=54)

twenty-nine (n = 53.7) were unemployed and 38 (70.4%) were non-smokers.

Presence of Dental Caries

There was a significant difference in the mean (SD) for dental caries experience among stroke patients, at 17.6 (4.26), compared to 15.7 (5.38) for non-stroke patients (p = 0.042), as seen in Table II.

Oral Hygiene Status

Figure II presents a comparison of the oral hygiene status of stroke and non-stroke patients. Of the stroke patients, 53.7% had good oral hygiene, 42.6% had fair oral hygiene, and 3.7% had poor oral hygiene. In contrast, among the non-stroke patients, 85.2% had good oral hygiene, and 15.5% had fair oral hygiene. An analysis using the Chi-square (x2) test showed there is a significant difference between the oral hygiene status of stroke and non-stroke patients; x2 test (df) = 13.1 (2) and p-value = 0.001.

Table II: Comparison between presence of caries in stroke and non-stroke patients

Compo-nent	Stroke	Non-stroke	Mean difference (95% CI)	t-stats (df)	p-value
	Mean (SD)	Mean (SD)			
DMFT	17.6 (4.26)	15.7 (5.38)	- 1.9 (-3.78,- 0.7)	-2.062 (106)	0.042
D	9.1 (5.40)	6.7 (3.38)	-2.4 (-4.13, -0.69)	-2.778 (89.0)	0.010
M	5.2 (5.29)	5.7 (5.89)	0.5 (-1.692, 2.581)	0.27 (106)	0.070
F	3.2 (3.46)	3.2 (3.59)	0.01 (-1.328, 1.365)	0.412 (1.06)	0.749

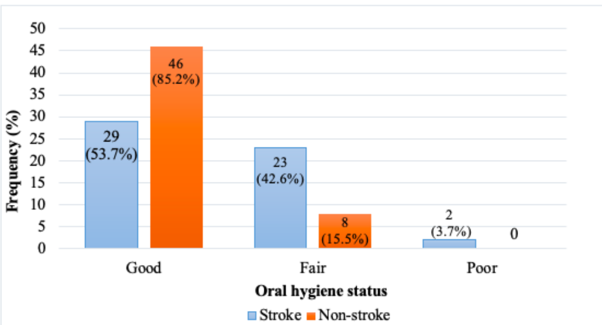

Figure 2: Comparison of oral hyiene status between stroke (n-54) and non-stroke patients (n=54)

Saliva Parameters

The median (IQR) saliva flow rate was similar for both groups at 0.4 (0.4) mL/min (p = 0.845), and the saliva pH values were similar at 6.6 (0.5) for stroke patients and 6.6 (0.4) for non-stroke patients, p = 0.435 (Table III). The salivary cortisol level among the non-stroke patients, 4.0 (3.6) nmol/L, was not significantly lower than that of the stroke patients, 5.2 (5.1) nmol/L (p = 0.178). Table IV presents a comparison of the salivary buffering capacity of stroke and non-stroke patients. The mean (SD) of the salivary buffering capacity among the non-stroke patients, 5.4 (2.4), was not significantly lower than that of the stroke patients, 6.1 (2.8); p = 0.207. No significant correlation was observed between the saliva parameters and DMFT (p > 0.05), as seen in Table V.

Table III: Comparison of salivary flow rate, salivary pH and salivary cortisol between stroke and non-stroke patients

Variables	n	Stroke n=54	Non-stroke n=54	p-value [a]
		Median (IQR)	Median (IQR)	
Salivary flow rate (ml/ min)	54	0.4 (0.4)	0.4 (0.4)	0.845
Salivary pH	54	6.6 (0.5)	6.6 (0.4)	0.435
Salivary cortisol (nmol/L)	54	5.9 (5.10)	4.8 (3.62)	0.178

[a] Mann-Whitney test

Table IV: Comparison of salivary buffering capacity between stroke patients and non-stroke patients

Group	n	Salivary buffering capacity Mean (SD)	Mean difference (95% CI)	t-stats (df)	p-value[a]
Stroke	54	6.1(2.83)	- 0.7 (-1.66, 0.364)	-1.270 (106)	0.207
Non-stroke	54	5.4(2.45)			

DISCUSSION

To the best of the authors' knowledge, this is the first study on the Malaysian population to evaluate saliva parameters in stroke patients. According to the Malaysian National Burden of Diseases Study, stroke is the leading cause of death in Malaysia and the third leading cause of total burden in Malaysia (18). Stroke has become a global issue and is a cause of major concern because of its significant mortality and morbidity, as well as post-stroke complications. Neglected oral care, impaired manual dexterity, impaired salivary function, and oral musculature paralysis are major contributors to the high prevalence of caries among stroke patients (19).

Most of the stroke patients in our study were unemployed, indicating that stroke had significantly impacted their physical abilities. Our results are supported by a hospital-based cohort study among the Dutch population, which—after eight years of follow-up—reported that stroke patients have a two to three times higher probability of unemployment than their

Table V: Correlation between salivary parameter and presence of caries among stroke patients.

	Variables	r	p-value
1.	Salivary flow rate (mL/min)	-0.073	0.452
2.	Salivary pH	-0.083	0.393
3.	Salivary cortisol (nmol/L)	-0.116	0.232
4.	Salivary buffering capacity (g/dL)	-0.094	0.335

peers (20). Because of the preponderance of stroke patients suffering from physical disabilities after a stroke, it is essential for them to receive effective rehabilitation therapy to facilitate recovery from their physical disability and return to performing daily activities, thus restrengthening their self-dependency.

Cigarette smoking is widely recognised as being associated with an increased risk of cardiovascular disease (21). In our study, most of the participants in both groups were non-smokers (n = 38, 70.4%). However, 13 (24.1%) and 11 (20.4%) stroke and non-stroke patients, respectively, were ex-smokers. One possible explanation for this finding is that, in our study, other risk factors (e.g., comorbidities) are more apparent in stroke patients.

Most of the stroke patients in our studies had underlying medical issues, such as cardiovascular disease, hyperlipidaemia, traumatic brain injury, and diabetes mellitus. This finding is consistent with the findings reported by Norsa'adah et al. (22). Burke et al. observed that traumatic brain injury is a risk factor for stroke and that it is independently associated with subsequent ischaemic stroke (23). According to Kowalski et al., untreated traumatic brain injury that disrupts or induces occlusion of normal cerebrovascular circulation can cause ischaemia in affected cerebral territories, which may lead to irreversible acute ischaemic stroke (24).

In our study, caries was significantly more prevalent among stroke patients than among non-stroke patients. This result is comparable to another cross-sectional analysis performed in a study by Budin et al. (14). We also discovered that the highest DMFT was from the caries-induced decay (D) component, which was significantly higher among stroke patients than among non-stroke patients. However, Budin et al. observed that missing teeth due to caries (M) was the highest component contributing to DMFT in stroke patients as compared to non-stroke patients in their study (14). As evidenced by the decay component of DMFT, stroke patients in our study had more lesions caused by new caries than stroke patients in the Budin et al. study. Conversely, according to another study conducted in the United States, the prevalence of dental caries was not significantly different between study participants with stroke and participants without stroke (25). Regarding the results on the DMFT components in our study, the D component was the highest, and the F component was the lowest. A high D denotes the effect of prolonged neglect of oral care, which eventually leads to tooth decay. Meanwhile, a low F component indicates neglecting to seek oral health treatment for the decayed tooth due to the patient's reliance on caregivers for access to healthcare facilities. Our findings highlight the impact of poor oral hygiene care among stroke patients due to their physical limitations, which leads to neglected dental care and ultimately contributes to the high prevalence of caries. One possible explanation for this observation is that most stroke patients are physically disabled, which their manual hand dexterity. Furthermore, oral care for these individuals is a particularly challenging task for caregivers and stroke nurses during rehabilitation. Another single-centre study conducted at a tertiary stroke centre revealed that only one-third of nurses' report conducting or assisting with the daily oral hygiene clinical practice of their stroke patients (26). We found that half of the stroke patients had good oral hygiene. Our finding is higher than that of Budin et al. (14), who reported that only 5.7% of the stroke patients in their study had good oral hygiene. Our study is supported by a systemic review of 27 studies that concluded that stroke patients have poorer plaque scores compared to control groups (27).

In our study, there was no significant difference in saliva flow rates between stroke and non-stroke patients. In contrast, Kawasaka et al. (28) found that saliva flow was significantly lower in stroke patients than in non-stroke patients. The lack of agreement between our results and those of Kawasaka et al. is most likely due to all stroke patients in our study being first-time stroke survivors who participated in the study within 6–24 months of their stroke. We excluded severe cases of stroke because of a few limitations we had to consider during the selection of the study sample, as severe stroke cases are challenging to handle, and saliva collection might be impossible in the manner prescribed by the study protocol.

No significant difference was observed in the saliva pH comparison. Furthermore, there was no significant difference in saliva buffering capacity between stroke patients and non-stroke patients, indicating that saliva has a good buffering effect. Our findings indicate that saliva pH and salivary buffering capacity are not the sole factors contributing to the development of caries. In addition, the pathogenesis of dental caries is multifactorial. Aside from aetiological factors, the following also contribute to caries: modifying factors such as medical disease, which increases the risk of developing caries; conditions that complicate dental treatment; frequency of sugary and acidic food intake; and protective factors such as fluoride exposure (29).

Regarding salivary cortisol, our findings reveal no statistically significant differences between stroke and non-stroke patients. In contrast, a Tel Aviv study discovered that post-stroke cognitively impaired participants had significantly higher cortisol levels than participants who were cognitively intact on admission (30). Another study conducted in Saudi Arabia reported that stroke patients had higher mean salivary cortisol levels than control participants (31). However, for most stroke patients, the incidence and the risk of stroke aftereffects—such as dysphagia, hypoesthesia, apraxia, decreased muscle tone, and thus reduced control of mouth and tongue movements—were much higher, making them feel uncomfortable (32). This, in turn, produces anxiety, depression, and deterioration in quality of life (33). However, our results contradict these observations. This is most likely because all the stroke patients in our study were in the early subacute stages of stroke. In addition, the majority of the stroke patients at our rehabilitation centre had a spouse or child who was waiting for them at the end of the session. Some participants even had their sessions with their spouses, as they both had the same medical condition, so they could better understand each other and communicate their emotional distress more effectively. This may have contributed to our respondents being less depressed than the participants in the studies referenced earlier. The tenderness, affection, and care that our stroke patients received may have contributed to their ability to cope with their condition despite all the post-stroke aftereffects.

Analysis of saliva parameters and the presence of caries revealed no correlation between saliva parameters and DMFT. Although the correlation is not statistically significant, the findings show a negative correlation: the better the salivary characteristics (i.e., pH, flow rate, cortisol, and buffer capacity), the fewer caries were detected. Our findings are consistent with a scoping review of four studies that reported a positive association between saliva cortisol levels and caries, with a weak to moderate association; however, two other studies found no association. Therefore, we can conclude that there is insufficient evidence supporting an association between stress-related changes in saliva and dental caries (12). This finding strengthens the fact that dental caries has a complex aetiology. Apart from susceptible host factors, factors such as general risk factors (including age, sex, race, geographic location, and social class) and the entire social-cultural environment of the community in which the individual lives may influence the development of dental caries (34). Therefore, it is recommended that future research on these factors be conducted with a larger number of participants.

There are some limitations to this research. For instance, the study was conducted at a single centre and thus generated limited data. Although we generated small data sets, the sample size is large enough to identify statistically significant differences between the study groups. Additional multicentred studies employing large samples are required to augment our findings. Furthermore, because periodontitis contributes to the overall host inflammatory burden, future studies may benefit from using outcome measures to examine periodontal status such as gingival index, plaque index, periodontal probing depth, and clinical attachment loss. Nevertheless, despite these limitations, we understand that the results are noteworthy, as there is little literature on oral health status and saliva parameters in stroke patient populations.

CONCLUSION

Our study demonstrates that stroke patients have more dental caries and poorer oral hygiene than non-stroke patients, with the most significant oral hygiene component being decay (D) due to caries. Saliva parameters, on the other hand, revealed no significant differences between stroke and non-stroke patients. Because oral health is severely impacted in stroke patients, improving the oral health knowledge of caregivers is thus crucial in preparing them to adapt to and be motivated by the challenging task of maintaining the oral health of stroke patients. Future studies with a multicentre design and larger sample sizes are needed to explore the magnitude of this problem.

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