Correlation between Upper Extremity Strength and the Oral Health of Stroke Patients

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Objective: The objectives of this study were to evaluate the correlation between upper extremity strength and oral health in stroke patients, as well as to determine the need for improvement in oral health measures, including rehabilitation to enhance upper extremity strength, and education and training for patients and their guardians related to oral hygiene.

Methods: To evaluate the oral health of stroke patients, we performed an examination of oral health and survey of oral hygiene behavior. Using the Oral Health Assessment Tool, an examiner evaluated oral health using a dental mirror. The upper extremity muscle strength was also assessed using the Manual Muscle Testing (MMT) grading system.

Results: Patients with higher-grade upper extremity muscle strength had better oral health. Patients with higher MMT grades were more likely to brush their teeth independently, and more often, compared to those with lower grades.

Conclusion: The MMT grade of patients with chronic stroke was significantly related to the oral health. Therefore, to improve oral health, patients should receive oral hygiene education and rehabilitation to increase their MMT grade. Combined efforts by rehabilitation and dental departments are required to improve the oral health of chronic stroke patients.

Keywords: oral health, stroke, muscle strength

Introduction

The incidence of cerebrovascular diseases is increasing due to hypertension, diabetes, obesity, stress, lack of exercise, poor dietary habits, and smoking. According to the 2018 Stroke Fact Sheet in Korea, published by the Korean Stroke Society, the number of stroke patients in Korea in 2014 was 690,000 (males: 380,000, 55.1%; females: 310,000, 44.9%),

with an average annual increase of 105,000 patients. Additionally, the prevalence of stroke increased with advancing age; the prevalence rate in those aged over 75 years was 2-fold higher than for those aged 55-74 years and 13-fold higher than for those aged 19-55 years [1].

According to Health at a Glance 2017, published by the Organisation for Economic Co-operation and Development, the 30-day fatality rate among hospitalized patients with ischemic stroke over 45 years of age was 3.9%, which steadily decreased from 5.0% in 2008. The 30-day fatality rate for in-patients with hemorrhagic stroke also reduced from 19.8% to 17.1% during the same period [2]. The lifespan of stroke patients is increasing due to advances in medical technology; therefore, it is critical to improve the quality of life of these patients.

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Symptoms of stroke, such as paralysis, impaired consciousness, impaired communication, stiffness, and cognitive impairment impair the ability of patients to carry out oral hygiene tasks [3]. Aspiration pneumonia is a significant cause of death after stroke due to medical complications. The risk of aspiration pneumonia increases with poor oral hygiene [4,5]. However, the quantity of potential respiratory pathogens is reduced through proper oral care, and aspiration pneumonia is prevented by improving the swallowing reflex and cough sensitivity [6]. Therefore, professional oral care, including periodic dental treatment, tooth brushing after eating, and denture cleaning, reduce the risk of aspiration pneumonia [7].

Many activities of daily living depend on normal arm function, including tooth brushing. Muscle strength is essential for activities of daily living, and muscle weakness due to damaged upper motor neurons is common after stroke [8]. Manual muscle testing (MMT) is widely used to evaluate the arm and leg strength of stroke patients [9].

Although poor oral hygiene has been reported in stroke pa-

tients [3], few studies have examined the relationship between upper extremity movement and oral health. Therefore, we examined the arm strength of chronic stroke patients using the MMT, to determine the effects of upper extremity muscle weakness on oral health. In addition, we evaluated measures to improve the oral hygiene of chronic stroke patients.

Materials and Methods

1. Target population

This study included 60 patients (males: n=26, 43%; females: n=34, 57%; age range: 40-85 years; mean age: 62 years) with chronic stroke (6-12 months before the study) who were admitted to the Department of Rehabilitation Medicine of a general hospital in South Korea.

The Institutional Review Board of Kwangju Christian hospital approved the study and signed (No. KCHIRB-D-2019-096), written informed consent forms were obtained. The partic-

Table 1. Oral Health Assessment Tool for dental screening

Category	0 = Healthy	1 = Changes*	2 = Unhealthy*	Category scores
Lips	Smooth, pink, moist	Dry, chapped, or red at corners	Swelling or lump, white/red/ulcerated patch; bleeding/ulcerated at corners	
Tongue	Normal, moist roughness, pink	Patchy, fissured, red, coated	Patch that is red and/or white, ulcerated, swollen	
Gums and tissues	Pink, moist, smooth, no bleeding	Dry, shiny, rough, red, swollen, one ulcer/sore spot under dentures	Swollen, bleeding, ulcers, white/red patches, generalized redness under dentures	
Saliva	Moist tissues, watery and free flowing saliva	Dry, sticky tissues, little saliva present, resident thinks they have a dry mouth	Tissues parched and red, very little/no saliva present, saliva is thick, resident thinks they have a dry mouth	
Natural teeth Yes/No	No decayed or broken teeth/roots	1-3 decayed or broken teeth/roots or very worn down teeth	4+ decayed or broken teeth/roots, or very worn down teeth, or less than 4 teeth	
Dentures Yes/No	No broken areas or teeth, dentures regularly worn, and named	1 broken area/tooth or dentures only worn for 1-2 hrs daily, or dentures not named, or loose	More than 1 broken area/tooth, denture missing or not worn, loose and needs denture adhesive, or not named	
Oral cleanliness	Clean and no food particles or tartar in mouth or dentures	Food particles/tartar/plaque in 1-2 areas of the mouth or on small area of dentures or halitosis (bad breath)	Food particles/tartar/plaque in most areas of the mouth or on most of dentures or severe halitosis (bad breath)	
Dental pain	No behavioural, verbal, or physical signs of dental pain	Are verbal &/or behavioural signs of pain such as pulling at face, chewing lips, not eating, aggression	Are physical pain signs (swelling of cheek or gum, broken teeth, ulcers), as well as verbal %/or behavioural signs (pulling at face, not eating, aggression)	
				Total score: 16

ipants were informed of the study purpose and procedures prior to enrollment.

2. Research methodology

We performed oral examinations and conducted a survey to evaluate oral condition and hygiene behavior, respectively. The survey responders were patients or their guardians. A single examiner performed the oral examination using the Oral Health Assessment Tool (OHAT) [10] and a dental mirror.

1) Oral health examination

Using the OHAT, eight categories of oral health were examined, including lips, tongue, periodontal region, saliva, teeth, denture, cleanliness, and pain. Each category was scored on 2-point scale (total score: 0-16). Higher scores correlated with worse oral health (Table 1).

2) Survey for oral hygiene behaviors

The survey asked participants whether they were able to brush their teeth by themselves, whether they used oral hygiene aids (such as floss, an interdental toothbrush, oral rinse, or an electric toothbrush), and the frequency of tooth brushing. The patients were also asked to specify the aspects that they considered significant when choosing or visiting a dental clinic.

3) Muscle strength evaluation

We used the MMT to evaluate the muscle strength of 60 chronic stroke patients based on upper extremity movements [11] (Table 2).

Table 2. Manual Muscle Testing grading system

Grade	Percentage	Description
5 (Normal)	100%	Complete range of motion against gravity with full resistance
4 (Good)	75%	Complete range of motion against gravity with some resistance
3 (Fair)	50%	Complete range of motion against gravity with no resistance
2 (Poor)	25%	Complete range of motion with gravity eliminated
1 (Trace)	10%	Evidence of slight contractility with no evidence of joint motion even with gravity eliminated
0 (No movement)	0%	No evidence of muscle contractility

Table 3. Age and sex distribution of chronic stroke patients

Sex	Age (y)					Total
	40-50	51-60	61-70	71-80	81-85	
Male	2 (3.3)	8 (13.3)	12 (20.0)	4 (6.7)	0 (0.0)	26 (43.3)
Female	5 (8.3)	10 (16.7)	5 (8.3)	10 (16.7)	4 (6.7)	34 (56.7)
Total	7 (11.6)	18 (30)	17 (28.3)	14 (23.4)	4 (6.7)	60 (100.0)

Values are presented as number (%).

4) Data analysis

We performed t-tests using SPSS software (version 12.0; SPSS Inc., Chicago, IL, USA) and evaluated the homogeneity of variance using Levene's test. Pearson correlation analysis was performed to evaluate the relationship between MMT grade and oral health.

Results

1. Participant characteristics

The study participants were 60 chronic stroke patients (males: n=26, 43%; females: n=34, 57%) aged 40-85 years (40-50 years: n=7, 11.6%; 51-60 years: n=18, 30%; 61-70 years: n=17, 28.3%; 71-80 years: n=14, 23.3%; 81-85 years: n=4, 6.8%). Patients aged 51-70 years (n=35, 58.3%) accounted for more than half of the hospitalized patients (Table 3).

Table 4. Oral health assessment in chronic stroke patients

Category	0 = Healthy	1 = Changes	2 = Unhealthy
Lips	20 (33.3)	35 (58.3)	5 (8.4)
Tongue	34 (56.7)	21 (35.0)	5 (8.3)
Gums and surrounding tissues	27 (45.0)	29 (48.3)	4 (6.7)
Saliva	48 (80.0)	12 (20.0)	0 (0.0)
Natural teeth	32 (53.3)	20 (33.3)	8 (13.4)
Denture	0 (0.0)	0 (0.0)	5 (100.0)
Oral cleanliness	25 (41.7)	21 (35.0)	14 (23.3)
Dental pain	60 (100)	0 (0.0)	0 (0.0)

Values are presented as number (%).

2. Oral health

We scored the eight categories of oral health as 0 (healthy), 1 (changes), or 2 (unhealthy) (Table 4).

Slight changes in the lips were seen in 35 patients (58.3%) due to dryness, scored as 1, and 5 patients (8.4%) had a score of 2 for inflammation and ulceration in the corners of the lips. For the tongue, 21 patients (35.0%) had a score of 1 due to a cracked or red-colored back of the tongue, and 5 (8.3%) had a score of 2 due to white tongue lesions. For the periodontal region (gums and tissues), 29 patients (48.3%) had a score of 1 due to red and swollen gums, and 4 (6.7%) had a score of 2 due to loose teeth and swollen gums around more than seven teeth. Twelve patients (20.0%) had a score of 1 for saliva due to oral dryness. For the natural teeth, 20 patients (33.3%) had a score of 1 due to three or fewer dental caries, and 8 (13.4%) had a score of 2 due to four or more dental caries and significantly worn teeth. No patients were completely edentulous. Five patients used dentures before stroke surgery, and all used partial dentures. Three patients had ill-fitting dentures due to tooth extraction for tracheal intubation before the stroke surgery. Two patients could not wear dentures due to periodontal changes (because the dentures had not been worn for a long time). For oral cleanliness, 21 patients (35.0%) had a score of 1 due to food debris stuck between teeth or tartar in 1-2 teeth, and 14 (23.3%) had a score of 2 due to plaque and calculus on the teeth. All 60 patients scored 0 for dental pain (i.e., had no verbal or physical signs of pain).

Table 5. OHAT score and MMT grade by sex

Sex	Value	OHAT Score (0-16)	Upper extremity MMT grade (0-5)
Male	26 (43.0)	3.5 ± 2.25	3.46 ± 1.23
Female	34 (57.0)	3.79 ± 2.16	3.05 ± 1.17
Total	60 (100.0)	3.67 ± 2.18	3.23 ± 1.39

Values are presented as number (%) or mean ± standard deviation. OHAT: oral health assessment tool, MMT: manual muscle testing.

Table 6. Correlation between OHAT score and MMT grade

		OHAT score	Upper extremity MMT grade
OHAT score	Correlation coefficient	1	-0.547
	p-value		0.000
	n	60	60

OHAT: Oral Health Assessment Tool, MMT: manual muscle testing.

3. OHAT scores and upper extremity muscle strength by sex

No significant difference was observed in the average OHAT scores of 26 male and 34 female patients (3.5 and 3.79, respectively; $p > 0.05$). The average OHAT score for all patients was 3.67 (Table 5).

The average MMT grades for male and female patients were 3.46 and 3.05, respectively, with a combined average grade of 3.23.

4. Correlation between upper extremity muscle strength and oral health

Upper extremity muscle strength grade and oral health showed a significant moderate correlation ($r = -0.547$). Higher upper extremity muscle strength grades were associated with lower OHAT scores and better oral health (Table 6).

We investigated the correlations between OHAT categories and upper extremity muscle strength (Table 7). A significant negative correlation was observed between upper extremity muscle strength grade and category of oral cleanliness ($r = -0.605$). Oral cleanliness was evaluated on the basis of food debris, plaque, and tartar. Higher upper extremity muscle strength grades were associated with lower oral cleanliness scores, indicating good oral condition (Table 8).

Table 7. p-value for the scores on the Oral Health Assessment Tool categories

Category	p-value
Lips	0.071
Tongue	0.057
Gums and surrounding tissues	0.052
Saliva	0.068
Natural teeth	0.062
Denture	0.069
Oral cleanliness	0.000*
Dental pain	0.067

Table 8. Correlation between oral cleanliness and upper extremity MMT grade

		Oral cleanliness	Upper extremity MMT grade
Oral cleanliness	Correlation coefficient	1	-0.605
	p-value		0.000
	n	60	60

MMT: manual muscle testing.

5. Oral health behavior analysis

1) Tooth brushing behavior by upper extremity muscle strength grade

The survey revealed that 33 patients (55%) brushed their teeth independently, while 27 (45%) were assisted by their guardians; there was a significant difference in muscle strength grade between these groups (3.76 and 2.59, respectively) (Table 9).

2) Frequency of tooth brushing

The survey revealed that the number of participants who brushed their teeth daily, twice a day, three times a day, and after every meal was 18 (30%), 14 (23.3%), 18 (30%), and 10 (16.7%), respectively (Table 10).

3) Correlation between OHAT scores and frequency of tooth brushing

There was a significant negative correlation between OHAT scores and frequency of tooth brushing. Patients who brushed their teeth more frequently had lower OHAT scores (Table 11). The results showed that tooth brushing had a significant correlation with OHAT scores ($r = -0.754$).

Table 9. Upper extremity MMT grade by tooth brushing ability

Toothbrush ability	Value	Upper extremity MMT grade
Independent	33 (55.0)	3.76 ± 1.03
Dependent	27 (45.0)	2.59 ± 1.53

Values are presented as number (%) or mean ± standard deviation. MMT: manual muscle testing.

Table 10. Tooth brushing frequency in chronic stroke patients

Tooth brushing frequency	n (%)
Once a day	18 (30.0)
Twice a day	14 (23.3)
Three times a day	18 (30.0)
After every meal	10 (16.7)

Table 11. Correlation between OHAT scores and tooth brushing frequency

		OHAT score	Tooth brushing frequency
OHAT score	Correlation coefficient	1	-0.754
	p-value		0.000
	n	60	60

OHAT: Oral Health Assessment Tool.

4) Correlation between upper extremity muscle strength grade and frequency of tooth brushing

A significant correlation was observed between the upper extremity muscle strength grade and frequency of tooth brushing (Table 12). Higher upper extremity muscle strength grades were associated with more frequent tooth brushing ($r = 0.742$).

6. Analysis of dental clinic visits

The dental clinic most frequently visited by the stroke patients was the one closest to the hospital where they were hospitalized (51.7%), followed by university dental hospitals (26.7%) (Table 13).

The major factor in clinic choice was distance (65%), followed by availability of necessary devices and equipment (21.7%). However, some patients selected university dental hospitals because they were not accepted by the local dental clinic (Table 14).

Table 12. Correlation between upper extremity MMT and tooth brushing frequency

		Upper extremity MMT grade	Tooth brushing frequency
Upper extremity MMT grade	Correlation coefficient	1	0.742
	p-value		0.000
	n	60	60

MMT: manual muscle testing.

Table 13. Dental care utilization by stroke patients

Dental care utilization	n (%)
Close to the hospital	31 (51.7)
Previously visited	13 (21.7)
University dental hospital	16 (26.7)
Total	60 (100.0)

Table 14. Reasons cited by stroke patients for dental clinic choice

Reasons	n (%)
Quality of dental care	5 (8.3)
Distance	39 (65.0)
Modern and up-to-date equipment	13 (21.7)
Referral	3 (5.0)
Total	60 (100.0)

Discussion

The oral cavity, as the primary digestive system, is extremely important for health. Diseases of the oral cavity can be systemic, and there is a significant correlation of the incidence of cardiovascular diseases with periodontitis and tooth loss [12].

The incidence of stroke is gradually increasing. Stroke may lead to serious physical, mental, and social problems, making oral care more difficult and thus compromising oral health [13]. Given the longer life expectancy of chronic stroke patients as a result of advances in medical technology, it is necessary to focus on the oral health of these patients.

We examined the oral health of patients using the OHAT, which evaluates oral health in eight domains, including lips, tongue, periodontal region, saliva, teeth, denture use, oral cleanliness, and pain. The OHAT allows rapid evaluation of oral health, even among patients with cognitive impairment. Assessment of oral care using the OHAT, at hospital admission and discharge, can guide oral healthcare plans. Considering these factors, we examined the oral health of patients using the OHAT.

The mean OHAT score of our 60 participants was 3.67 ± 2.18 (0: good; 1-5: oral care intervention necessary). A total score of ≥ 6 , or a score of ≥ 1 in the categories of “gums and surrounding tissues”, “natural teeth”, or “toothache”, warrant a dental check-up [10]. Therefore, most chronic stroke patients need oral care. The most significant changes in oral care were dry and cracked lips, red swollen gums, dry mouth, food debris in the mouth, and dental plaque. It is necessary to identify changes in oral health based on OHAT scores, and to take action as appropriate. Scores of 1 and 2 in any category require advice from the dentist and a dental check-up, respectively.

Patients who have difficulty in tooth brushing due to wounds or dental appliances should be managed via oral hygiene intervention and mouthwash. The use of chlorhexidine gluconate is required for prosthetic inflammation, candida infection, and gingivitis. Cognitively impaired patients may benefit from a demonstration of a simplified tooth brushing process or the hand-over-hand technique, in which teaching tooth brushing is achieved by holding their hands, rather than through verbal instructions.

The MMT is a highly reliable method for testing the muscle strength of stroke patients [9]. Muscle strength is graded on the basis of the degree of resistance overcome by the muscle. Muscle strength is scored from 0 to 5 based on three factors: gravity, resistance, and range of joint movement. The MMT does not require any particular tools, and can be used by examiners with the requisite education and knowledge. Therefore, the MMT can be used to evaluate muscle strength in a large

volume of patients [10]. Notably, the MMT cannot detect subtle changes in muscle strength, which is a significant limitation [14]. In this study, the average upper extremity muscle strength grade for the stroke patients was 3.23 ± 1.39 (i.e., upper extremity can be lifted without any external resistance).

The average upper extremity muscle strength grades were 3.76 ± 1.03 and 2.59 ± 1.53 for patients who brushed their teeth independently and those who were dependent on their guardians for tooth brushing, respectively.

Upper extremity muscle strength grades of 4 and 5 indicate that patients are able to independently brush their teeth. Grades of ≤ 2 indicate that the patient requires assistance for tooth brushing. Some of our grade 3 patients were able to independently brush their teeth, whereas others were not. Therefore, an upper extremity muscle strength grade of ≥ 3 may predict independent tooth brushing. Additionally, there was a significant correlation between oral health and upper extremity muscle strength grade, where higher grades were associated with better oral health.

No significant correlation was observed between the upper extremity muscle strength grade and OHAT category of “natural teeth”, which evaluates dental caries, residual tooth root, and the number of teeth (cutoff of <4). Because we only included patients who suffered a stroke within the past 6-12 months, an inadequate amount of time had passed to assess the effects of poor tooth brushing on oral health. Therefore, longer follow-up is required in future studies.

A significant correlation was observed between the upper extremity muscle strength grade and oral cleanliness. The OHAT category of “oral cleanliness” evaluates food debris, dental plaque, and tartar. Plaque buildup leads to periodontal disease [15]. Prevention and alleviation of chronic inflammatory periodontal disease relies on effective daily plaque removal from the tooth surface [16]. Therefore, plaque and residual food debris should be removed using various dental aids, such as manual or electric toothbrushes [17]. Independent tooth brushing is possible only with a high degree of upper extremity muscle strength. It is likely that more frequent tooth brushing improves oral cleanliness.

Previous studies showed that dental plaque causes caries and gingival inflammation [18-20]. Plaque forms on the tooth surface due to a bacterial film consisting of saliva and glycoprotein. The bacteria on the tooth surface may form a colony. Dental plaques alter the bacterial flora and chemical composition of the tooth surface [21,22]. Moreover, if oral hygiene measures (i.e., tooth brushing) are discontinued, partial gingivitis forms within 4-11 days, and spreads to the entire gum within 2-3 weeks. However, resumption of oral hygiene measures profoundly improves the gingival condition [22]. Although

the optimal frequency of plaque removal necessary to maintain gingival health is controversial, evidence from the current and previous studies suggests that plaque formation is reduced with increased frequency of application of oral hygiene measures, such as tooth brushing [23]. Therefore, rehabilitation, which improves the upper extremity muscle strength of chronic stroke patients, is crucial for preventing plaque formation, improving independence in activities of daily living, and maintaining healthy gingiva and teeth.

The survey results revealed that the number of participants who brushed their teeth daily, twice a day, three times a day, and after every meal was 18 (30%), 14 (23.3%), 18 (30%), and 10 (16.7%), respectively.

None of the patients used oral hygiene products, such as floss, an interdental toothbrush, mouthwash, or an electric toothbrush, except for manual toothbrushes. A significant correlation was observed between the OHAT scores and frequency of tooth brushing, with more frequent tooth brushing corresponding to better oral health.

The dental clinic most frequently visited by the stroke patients was the one closest to the hospital where they were hospitalized (51.7%), followed by university dental hospitals (26.7%). The distance to the dental clinic was the most important factor in the choice of dental clinic (65%).

Patients who visited university dental hospitals made their choice based on the availability of appropriate medical equipment, or were referred by other clinics. To improve the access of chronic stroke patients to dental care at nearby clinics, it is essential to provide continuous professional education and training to dentists working in these clinics regarding the diagnosis and treatment of such patients. Additionally, patients being treated at university dental hospitals may benefit from a systematic policy of patient transfers and referrals.

Our study results demonstrated that chronic stroke patients with high-grade upper extremity muscle strength had better oral health, probably because such patients could independently brush their teeth.

A strong correlation was observed between upper extremity muscle strength grade and oral cleanliness, where tooth brushing is critical for preventing tartar buildup and removing food debris and plaque. Therefore, the upper extremity muscle strength of chronic stroke patients significantly influences their oral health. For patients with an upper extremity muscle strength grade of ≤ 2 , guardians should be educated regarding tooth brushing. This education should extend to grade 3 patients and their guardians, as well as to patients of $\geq$ grade 4. Well-designed systems and policies are required to help chronic stroke patients and their guardians to improve their oral hygiene.

Conclusion

The purpose of this study was to investigate the correlation between oral health and upper extremity muscle strength grade in 60 chronic stroke patients hospitalized at the Department of Rehabilitation Medicine of a general hospital in South Korea. Based on the MMT grade and OHAT scores, we drew several conclusions. First, there was no significant correlation between sex and oral health. The OHAT score for all patients was 3.67 ± 2.18 , and the most frequent changes included dry and cracked lips, dry mouth, food debris in the mouth, mild plaque, gingivitis, and dental caries in less than three teeth. Second, the average upper extremity muscle strength grade was 3.23 ± 1.39 . Higher grades correlated with better oral health. Third, the average upper extremity muscle strength grades were 3.76 ± 1.03 and 2.59 ± 1.53 for patients who independently brushed their teeth and those who were dependent on their guardians, respectively. Patients with higher grades were more likely to brush their teeth independently, and more frequently. Finally, the dental clinic most frequently visited by the stroke patients was the one closest to the hospital where they were hospitalized (51.7%), followed by university dental hospitals (26.7%). The distance to the dental clinic was the most important factor in selecting the clinic (65%).

In conclusion, the upper extremity muscle strength grade of chronic stroke patients significantly influenced their oral health. Rehabilitation and oral hygiene training are necessary for chronic stroke patients to improve their MMT grade and oral hygiene.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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