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Research Article

ANALYSIS OF RANGE OF TONGUE MOTION AND PHARYNGEAL CONSTRICTION POST STROKE

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ABSTRACT

Neurological dysfunctions can affect the muscular activity of the tongue and pharynx and have repercussions on swallowing. Tongue mobility and pharyngeal constriction of 28 post-stroke patients were measured and compared to 19 individuals without dysphagia, and correlated with the presence and / or the degree of dysphagia in post-stroke patients. Tongue mobility, obtained by videofluoroscopic images via the ImageJ program, was determined by the common area obtained from the overlap of the tongue's traces during the production of the vowels /a/, /i/, and /u/, in relation to the total lingual area. Pharyngeal constriction presented as the ratio between the pharyngeal area filled with air and / or food residue during maximal constriction when swallowing 3 ml of thin liquid in relation to the pharyngeal area at rest. For tongue mobility, the total area was significantly larger in the control group than in the stroke group and, although with no statistical significance, the vowel intersection ratio was higher in the stroke group, suggesting that this group had a lower range of tongue movement. The pharyngeal area at maximal constriction and the pharyngeal constriction ratio were significantly higher in the stroke group, indicating more poor pharyngeal constriction. Also, a statistically significant correlation was observed between dysphagia severity and pharyngeal constriction, demonstrating that the greater the severity of dysphagia, the poorer the pharyngeal constriction. These results suggest that interventions aimed at improving pharyngeal constriction should be considered in the rehabilitation of post-stroke swallowing.

INTRODUCTION

Stroke is the leading cause of death in Brazil and one of the leading causes of long-term disability in adults [1-2]. Stroke is a public health concern because it is the largest acquired motor deficiency, responsible for up to 80% of disabilities [3]. In addition to motor disorders, post-stroke sequelae include speech or language disorders and swallowing disorders.

Neurogenic dysphagia is observed in about 50% of stroke patients, more evident in the first few days after the cerebrovascular accident [4-6]. Neurological dysfunctions can affect the muscular action of structures like the tongue and pharynx, and in the vast majority of cases of neurogenic dysphagia, feature changes at the oropharyngeal level [7-8]. The tongue is essentially a muscular organ that plays a key role in swallowing, as it actively participates in the processes of preparation, organization and bolus propulsion to the pharynx. Motor function impairment of the tongue, especially in regards to its coordination with other structures that participate in swallowing, causes a pressure reduction in bolus propulsion, resulting in changes in the pharyngeal phase of swallowing [9]. The main role of pharyngeal constriction is to propulse the bolus into the esophagus. Incomplete or inadequate bolus propulsion, in addition to slow bolus transition and food residue, can threaten the safety and efficiency of the swallowing process [10]. Pharyngeal clearance difficulties may be associated with both inefficient bolus propulsion and insufficient pharyngeal constriction [9, 11-12].

Pharyngeal constriction has been proposed as a parameter that can distinguish between a functional and a dysfunctional swallow [10, 13-16]. Although manometry is considered the gold standard for measuring strength of pharyngeal constriction, it is not readily available in many institutions. As an alternative to measuring pharyngeal constriction, Leonard and his colleagues developed the pharyngeal constriction ratio (PCR), a measure obtained by video fluoroscopic images of the

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swallow. PCR is the pharyngeal area (including the residual bolus material and/or air) as seen in the side view (PAmax) at the point of maximum pharyngeal constriction during swallowing, divided by the pharyngeal area with the bolus held in the oral cavity at rest (PAhold) [17]. Validation studies of PCR in young adults and healthy seniors [10, 18], as well as in individuals with dysphagia [13] showed that for younger individuals the PCR came to "0" (-0.04 0.03) and in elderly individuals the PCR was higher, at 0.10 -0.12 for 20 ml liquid bolus. Results indicated that an elevated PCR could suggest reduced pharyngeal constriction during the swallow and those measures higher than 0.25 suggest abnormal pharyngeal constriction in adults. Yip and his collaborators [15] investigated the relationship between PCR and aspiration and found that individuals with greater than 0.25 PCR were three times more likely to aspirate. Leonard *et al*. [10] assessed the correlation between PCR and pharyngeal pressure (PP) derived from the manometry measure and noted that when PP increased, PCR decreased. The results suggested the usefulness of PCR to evaluate pharyngeal strength when manometry was not available.

Gonçalves and Leonard [19] proposed the use of image analysis software to carry out measures such as the area of the pharynx at rest and at maximum constriction, and mobility of the tongue, achieved through articulation movements during speaking tasks.

Since tongue mobility and pharyngeal constriction may interfere with oral and/or pharyngeal phase of deglutition, the more information obtained on the dynamics of these structures, the greater the chance of understanding the pathophysiology of these phases in post-stroke patients, and the greater the possibilities of expanding therapeutic approaches and targeting specific treatment options for post-stroke oropharyngeal dysphagia.

The purpose of this study was twosome: a. to analyze and compare tongue mobility and pharyngeal constriction of post-stroke patients to individuals without dysphagia through videofluoroscopic swallow studies; b. to correlate tongue mobility and pharyngeal constriction with the presence and/or degree of oropharyngeal dysphagia in post-stroke patients.

METHODS

Population

This was a descriptive, transversal, and retrospective study where videofluoroscopic swallowing tests were analyzed of adults (19 to 59 years) and elderly (60 years or more) with medical diagnosis of stroke, referred to the Functional Swallowing Rehabilitation Division sector of the Department of Speech-Language Pathology of the Federal University of São Paulo-UNIFESP/EPM. Videofluoroscopy exams were performed in the Diagnostic Imaging Department sector of UNIFESP/EPM from January 04, 2008 to December 13, 2013. This study was approved by the Research Ethics Committee of the Federal University of São Paulo-UNIFESP/Hospital of São Paulo under the protocol number 842.135/14. Sixty-two stroke patient exams were identified. Exclusion criteria included exams with poor image and sound quality, patients with other neurological disorders associated with dysphagia; patients who had head and neck surgery, patients who were unable to reproduce the vowels /a/, /i/, and /u/, and/or patients who were not tested with 3ml of thin liquid. According to such criteria, 34 exams were excluded. In addition to the post-stroke patients, within the exams carried out in the same period, 19 individuals were also selected as a control group, who were seen for a videofluoroscopic exam due to some complaints, but with no diagnosis of oropharyngeal dysphagia and with no associated neurological diseases, with age and gender compatible to the stroke group patients.

Procedure for the videofluoroscopic examinations

All videofluoroscopic swallowing exams were performed by a speech-language pathologist, preceded by anamnesis and clinical swallow evaluation, and adopting the Dynamic Swallowing Study Protocol by Image (Estudo Dinâmico da Deglutição por Imagem - EDDI), described by Gonçalves and colleagues (2004) [20].

The subjects were evaluated in the left lateral and frontal orthostatic positions, head straight, and identified by the initials of their first and last name, written at the beginning of the examination along with the date. Prior to the first take, a metallic marker (Brazilian Real penny) was set on the patient with tape in the region of the mastoid process of the temporal bone for calibration and subsequent measurements on the image analysis program ImageJ [19], which will be described later.

The initial step in the EDDI protocol was to record a baseline side view image. Afterwards, individuals were prompted to swallow foods and water of different volumes and consistencies mixed with barium sulfate x-ray contrast. After the bolus samples, individuals were asked to perform some speech tasks, such as producing the vowels /a/, /i/, and/u/. These images were also recorded.

Procedure for the selection of the images

Five pictures were selected for each patient in lateral view: three to analyze tongue mobility images of the vocal tract during the production of the vowels /a/, /i/, and /u/; and 2 to analyze pharyngeal constriction, one during physiological rest (breathing) in order to calculate the pharyngeal area, and another swallowing 3 ml of thin liquid.The images selected in the videofluoroscopy were digitized and edited using the Cyberlink Power DVD9 program, which analyzed the video frame by frame and enabled the capture of the paused images. The captured images did not identify to which group the subject belonged to.

Procedure for obtaining and analyzing measures

Tongue mobility and pharyngeal constriction measurements, that were analyzed in the present study, were obtained using the ImageJ (National Institute of Health) computer program. Prior to performing measurements of the area to be studied, calibration was performed in the program, using the diameter of the metal marker (Brazilian Real penny) placed on the mastoid process of the patient's temporal bone as a reference measure (= 1.6 cm).

Tongue mobility

Prior to beginning the tracing of the tongue, a straight line was drawn along the floor of the nasal cavity until the anterior tubercle of the atlas vertebra. This line intersected with another straight line, which projected inferiorly to the tubercle forming a 90° angle [19]. The purpose was for the line to serve as a reference in the overlay of the tongue images during vowel production. The tracing of the tongue producing each vowel was performed by bypassing the tongue anteriorly from its insertion in the floor of the mouth, to the vallecula posteriorly (figure 1).

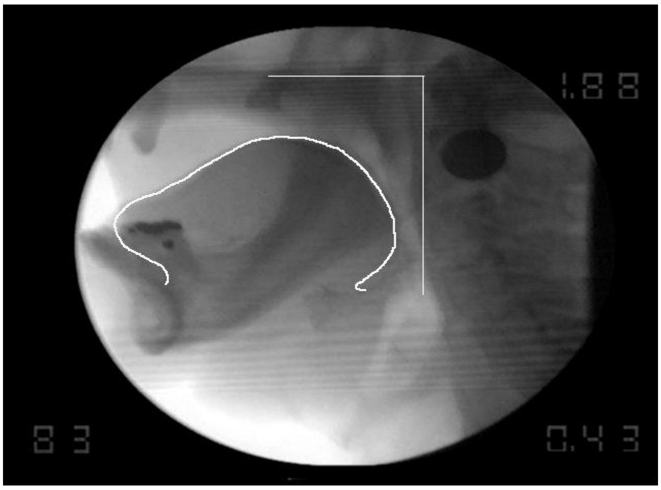

Figure 1 Image of the tracing of the tongue of an elderly man from the control group during the production of the vowel / a /, with the reference lines for vowel overlap.

Then the tracings of the two other vowels and part of the reference lines were copied (Figure 2), and pasted into the image of the first vowel (figure 3).

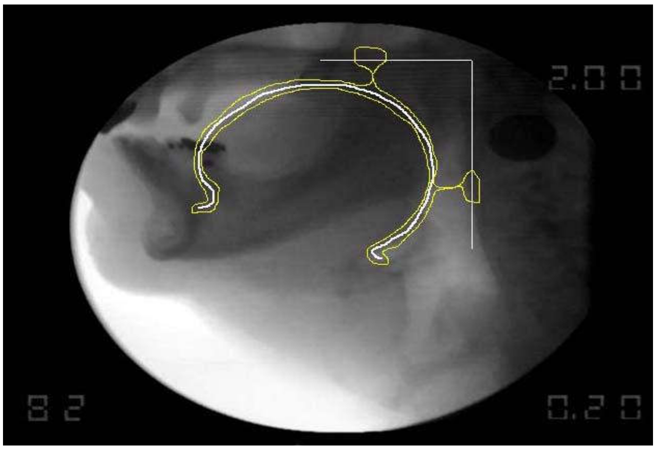

Figure 2 Contour image of the tracing of the vowel / u / and part of the reference lines to overlap.

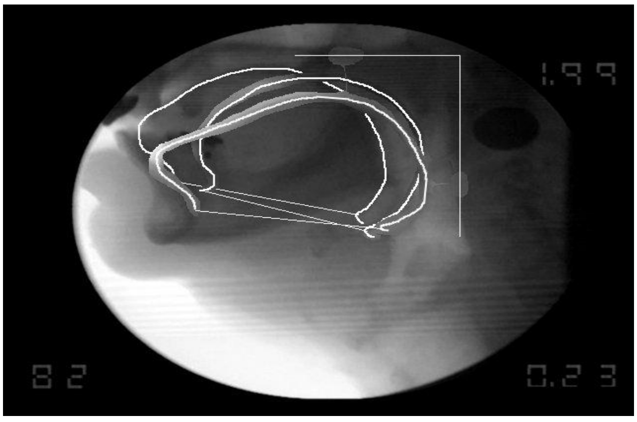

Figure 3 Image of the overlapping of the contours of the tongue traces during vowel emission.

Tongue mobility measurement was estimated by the area obtained in the overlapping of the tongue traces during the production of the three vowels, defined as total area, compared to the area of intersection of the same, defined as common area. From the image made up by vowel overlays, the total and common areas were outlined and calculated by the program and tongue mobility presented as a ratio between the common area and the total area of the vowels, called the vowel intersection ratio.

Although normative data have not been described in the literature, it is assumed that the higher the intersection rate of vowels, the lower the mobility of the tongue.

Pharyngeal Constriction

The measurement of the pharyngeal area at rest (PAhold) was obtained by tracing the posterior pharyngeal wall, from the middle portion of the anterior tubercle of the atlas vertebra, to the corresponding level in height from the top (colliculus) of the arytenoid cartilage.

Then the inferior contour was transported anteriorly onto the arytenoid cartilages to delineate the epiglottic cartilage, vallecula and base of tongue to the point where the soft palate comes into contact with the base of the tongue. The soft palate was then traced until it reached the posterior nasal spine of the horizontal blade of the palatine bone. The upper border became a straight line between the posterior nasal spine and the middle portion of the anterior tubercle of the atlas vertebra (Figure 4). The delineated pharyngeal area was then automatically calculated using the ImageJ program.

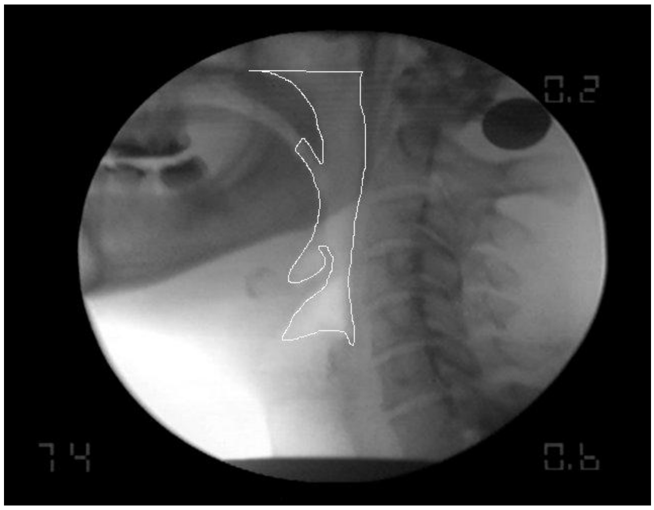

Figure 4 Contour image of the pharynx area at rest of an adult in the control group under videofluoroscopy in the lateral view

The maximum pharyngeal constriction during swallowing of 3 ml of thin liquid was defined by the tracing of the pharyngeal area occupied by air and /or food residue, or completely obliterated (zero) (Figures 5A and 5B). The time of maximum pharyngeal constriction during swallowing was designated as (PAmax) and the delineated area was calculated automatically by the ImageJ program.

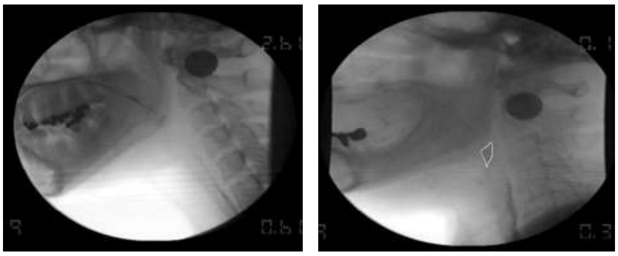

Figure 5 Images of maximum pharyngeal constriction during swallowing of 3 ml of thin liquid of an adult in the control group (A) and of an adult in the stroke group (B)

Pharyngeal constriction data were presented as a ratio between the air- and/or food residue-filled area at the time of greatest pharyngeal constriction during swallowing (PAmax) over the pharyngeal area at rest in the lateral view (PAhold). This ratio is termed Pharyngeal Constriction Ratio (PCR).

RESULTS

The study sample consisted of 47 individuals, 28 of whom were post-stroke, with ages ranging from 27 to 86 years (mean of 63.3 years). Of these, 17 (60.7%) were male (between 35 and 80 years) and 11 (39.3%) female (between 27 and 86 years), and 19 individuals without oropharyngeal dysphagia to compose the control group, with ages varying between 24 and 87 years (mean of 61.8 years), 8 (42.1%) males (between 38 and 83 years) and 11 (57.9%) of the females (between 24 and 87 years).

The complaints that led the individuals in the control group to perform the swallowing videofluoroscopy examination were:

Table 1 Vowel areas between stroke and control groups

	Vowels	Average	Medium	SD	CV	Min	Max	N	IC	P-value
Total vowel area	Stroke	0.224	0.224	0.030	14%	0.166	0.283	28	0.011	<0,001*
	Control	0.266	0.256	0.038	14%	0.198	0.348	19	0.017	
Common area of the vowels	Stroke	0.105	0.104	0.020	19%	0.073	0.146	28	0.007	0,112
	Control	0.117	0.118	0.027	24%	0.062	0.172	19	0.012	
Reason for vowel intersextion	Stroke	0.471	0.476	0.065	14%	0.366	0.598	28	0.024	0,108
	Control	0.437	0.436	0.073	17%	0.276	0.576	19	0.033	

Table 2 Pharyngeal areas between stroke and control group

Pharynx		Average	Medium	SD	CV	Min	Max	N	IC	P-value
Pharyngeal area at rest	Stroke	9.42	8.81	2.45	26%	5.20	15.49	28	0.91	0,894
	Control	9.33	8.85	1.65	18%	7.19	12.17	19	0.74	
Pharyngeal area at maximum constriction	Stroke	0.95	0.70	0.84	88%	0.00	3.24	28	0.31	0,001*
	Control	0.25	0.15	0.31	123%	0.00	1.03	19	0.14	
Pharyngeal constriction ratio (PCR)	Stroke	0.098	0.085	0.074	75%	0.000	0.274	28	0.027	<0,001*
	Control	0.026	0.019	0.031	120%	0.000	0.114	19	0.014	

The values found in the study by Leonard *et al.* [17] were the reference values adopted in the present study for 3 cc (3 ml) of thin liquid. The values are as follows: mean PCR =0.03 ± 0.02; 0.021 ± 0.02 for females and 0.035 ± 0.03 for males.

Swallowing classification of post-stroke patients

Swallowing of individuals with stroke was classified according to O'Neil's Dysphagia Outcome Severity Scale (DOSS) [21]. The DOSS classifies deglutition into 7 levels according to severity, independence and nutritional aspects, as follows: Level 7 - Normal; Level 6 - Within functional limits / independence modified; Level 5 - Mild dysphagia; Level 4 - Mild / moderate dysphagia; Level 3 - Moderate dysphagia; Level 2 - Moderately severe Dysphagia; Level 1 - Severe dysphagia.

To analyze the data, swallowing / dysphagia levels were grouped according to the efficiency of airway protection mechanism. High levels (levels 5, 6 and 7) were considered those that presented greater efficiency of airway protection mechanism; low levels (levels 1, 2, 3 and 4) those that presented less efficiency of airway protection mechanism.

Statistical analysis

The parametric ANOVA statistical test was used for the analysis of the results, with a significance level of 0.05 (5%). In the data presentation, values marked with an asterisk (*) were considered statistically significant at the level of significance adopted.

food stasis sensation (52.6%); gagging (42.1%); difficulty with solid foods (26.3%); regurgitation of food (10.5%); difficulty swallowing tablets (10.5%); popping sensation in the facial bones (5.3%); sensation of food stagnant in the stomach (5.3%).

In comparing stroke and control groups in terms of vowel areas, there was no significant difference between the groups regarding the mobility of the tongue represented by the ratio between the common and total vowel areas (p = 0.108); But in relation to the total area of the vowels, one of the parameters, also used to estimate tongue mobility, was significantly higher in the control group than in the stroke group (p <0.001) (table 1).

In regards to the pharyngeal areas, the stroke group presented with greater PCR as compared to the control group (p<0.001), as well as greater maximum pharyngeal area (p=0.001) (Table 2).

Swallowing of individuals with stroke was classified according to the Dysphagia Outcome Severity Scale (DOSS) [21]. An incidence of 78.5% of some degree of dysphagia was observed in this group (table 3).

When comparing tongue mobility and pharyngeal constriction to the presence and / or degree of dysphagia in post-stroke patients, there was no significant correlation between dysphagia levels and tongue mobility (table 4); however, there was a statistically significant difference between dysphagia levels and pharyngeal constriction (p = 0.002) (table 5).

Table 3 Swallowing classification of stroke patients according to the Dysphagia Outcome Severity Scale (DOSS)

Classification according to the level of dysphagia	N	%
Level 1 – Severe dysphagia	2	7.1%
Level 2 – Moderately severe dysphagia	3	10.7%
Level 3 – Moderate dysphagia	9	32.1%
Level 4 – Mild-to-moderate dysphagia	5	17.9%
Level 5 – Mild dysphagia	3	10.7%
Level 6 – Functional swallowing	5	17.9%
Level 7 – Normal swallowing	1	3.6%

Levels that showed higher efficiency of airway protection mechanisms were grouped as high levels (levels 5, 6 and 7), while those with lower efficiency were grouped as low levels (levels 1, 2, 3 and 4).

Table 4 Comparison between swallowing / dysphagia levels (DOSS scale) grouped according to the efficiency of the airway protection mechanisms and the intersection ratio of the vowels of the AVE group.

Reason for vowel intersection	Low Levels	High Levels
Average	0.480	0.451
Medium	0.481	0.432
SD	0.060	0.074
N	19	9
IC	0.027	0,048
P-value	0.277	

Table 5 Comparison between swallowing / dysphagia levels (DOSS scale) grouped according to the efficiency of the airway protection mechanisms and the average PCR of the stroke group.

Pharyngeal constriction ratio (PCR)	Low Levels	High Levels
Average	0.126	0.039
Medium	0.110	0.035
SD	0.073	0.025
N	19	9
IC	0.033	0.016
P-value	0.002*	

DISCUSSION

The present study investigated tongue mobility and pharyngeal constriction after stroke, as several studies described alterations of these functions under certain neurological conditions [22-26]. However, no studies in the literature measured tongue mobility and pharyngeal constriction from images extracted from videofluoroscopy of swallowing in this population.

The methodology used in the present study was based on the few works studies in the literature involving the analysis of measurements of videofluoroscopic images [10, 13-15, 17-19]. The vowels /a/, /i/ and /u/ were chosen to evaluate tongue mobility because of the position variation that the tongue assumes in each of their production. In comparing tongue mobility results (table 1), although the vowel intersection ratio was higher in the stroke group (0.471) than in the control group (0.447), no significant difference was observed between the groups, and there are no normative values in the literature using such methodology for other comparisons. A statistically significant difference between the two groups was found in relation to the total area of the vowels, with a mean of 0.224 for the group with stroke and of 0.266 for the control group. These findings suggested that the individuals in the control group presented a greater amplitude of tongue language movement in the emission of the three vowels.

When analyzing these results, it is important to point out the fact that the sample of this study selected excluded post-stroke individuals with expressive language communication deficits that would have made it difficult to emit the three vowels necessary for obtaining the tongue area measurements. As post-stroke patients with speech or language disorders were excluded from the study, the sample was further restricted and, perhaps among the individuals who were excluded, there were individuals with even lower tongue mobility.

Also, when observing still images to estimate speech mobility using speech tasks, range of motion could be estimated, but muscle strength could not. Although mobility may have an impact on the degree of pharyngeal constriction, tongue strength required for oral food efficacy is not necessarily tied to mobility, and poor speech performance may correlate but not necessarily imply swallowing deficits.

Another point to be considered is that studies that assess tongue mobility in stroke patients are highly controversial [9,11,28,29], perhaps because of different methodologies used for evaluation or also because of the difficulty in measuring it.

To evaluate pharyngeal constriction, the present study selected swallowing images of 3 ml of thin liquid because a greater number of individuals had this consistency tested, and because it was one of the volumes tested in the study used as reference for this measurement [17].

The baseline imaging to calculate the pharyngeal area was performed with the subject in the lateral position, without food in the oral cavity as seen in the reference studies [17, 19]; the subject held 1 ml of thin liquid offered without swallowing, with the bolus in the “hold” position before any posterior movement (PAhold).

The present study showed that individuals with neurological impairment often do not have an adequate oral control and premature fluid leakage occurs before effectively triggering the swallow. The procedure of having patients hold the bolus in the oral cavity before swallowing in order to evaluate oral control and premature spillage is part of the EDDI routine. As such, most subjects´ image at rest was with 1ml LF in the oral cavity before swallowing. The calculation of the area of these images was performed and compared to the area at rest adopted in this research, and no significant difference that could interfere with the interpretation of the data was observed between the area of these images to the images at rest adopted in this study. The outline of the pharyngeal area at rest was based on the methodology of the works used as references of the present study [10,17,19]. However, here are some considerations about the anatomical nomenclature adopted for the pharyngeal area. The first is that the language used in radiological anatomy sometimes differs from topographic anatomy. The pharynx has been a controversial area among radiologists due to the complexity of its anatomy and the difficulty of adequate recording due to the difficulty of keeping it distended with the use of means of contrast.

The second consideration concerns what has been termed as the "pharyngeal area", which did not correspond effectively to the total area in anatomical terms. As the pharynx is an organ with great complacency that can assume various degrees of distension according to the amount of food ingested, the tracing of this area was functional and clinical rather than anatomical (i.e., the design of the pharyngeal area basically bypassed the oral and laryngeal portions of the pharynx). The "pharyngeal area" was essentially the area of the organ through which the food passed and the air spaces filled up during the pharyngeal phase of swallowing.

In comparing results related to pharyngeal areas between the stroke and control groups (Table 2), the present study found significant differences for PCR between the two groups. This result was expected and was in line with the study conducted by Leonard *et al*. [14] who looked at a heterogeneous population of twenty individuals, four with stroke, and demonstrated increased PCR values for these individuals, as found in the present study.

A significant difference was also found between the stroke and control groups for maximum pharyngeal constriction in swallowing 3 ml of LF (Table 2), showing a higher presence of food and / or air in the stroke group and suggesting that individuals in this group present a decrease of the strength and / or clearing ability of the pharynx at maximum constriction during swallowing, in agreement with studies by Sellars *et al*. [30] and Martino *et al*. [31].

Leonard *et al*. [17, 18] defined that the area of the pharynx at maximum constriction should approach zero, and that significant deviations from this parameter are likely to be associated with problems in propulsion of the bolus during swallowing.

No difference was observed in the pharyngeal area at rest between the stroke and control groups, since the individuals of these groups had similar ages and genders, and because no specific function was being evaluated when calculating this area.

In the present study, there was an incidence of 78.5% of some degree of dysphagia in the stroke group (Table 3) and the literature suggests that the incidence may vary between 43% and 86% of the cases [32,33], with an incidence between 22% and 65% [34] being influenced by the evaluation methods used. Xerez and colleagues [9] performed a clinical and videofluoroscopic swallowing evaluation of 26 patients after subacute stroke and identified dysphagia in 73% of the patients.

Post-stroke swallowing / dysphagia was classified according to the DOSS scale and for statistical analysis purposes, as a criterion, the levels were grouped according to the efficiency of the airway protection mechanisms. When swallowing / dysphagia levels were compared with tongue mobility in the stroke group (Table 4), no significant difference was observed between the groups. This result may be due to the fact that in order for swallowing to occur efficiently and safely, several oropharyngeal structures need to work simultaneously in an integrated manner, such as laryngeal elevation, epiglottis movement, and opening of the pharyngoesophageal sphincter. Therefore, an isolated event such as tongue mobility does not have a huge impact on dysphagia.

When the swallowing / dysphagia levels were compared with the pharyngeal constriction (table 5), a significant difference was observed between the groups. Logemann [35] and Leonard *et al*. [10] emphasize that the main role of pharyngeal constriction is to propel the bolus into the esophagus, and if incomplete or inadequate this may threaten swallowing safety and efficacy. Sellars and colleagues [30] performed a study with 23 patients with acute stroke (mean age 72 years) and 15 healthy controls (mean age 76 years), and identified that voluntary pharyngeal motor activity was impaired in the stroke group in comparison with the control group, as well as observed delayed initiation of swallow.

Onofri *et al*. [36] evaluated 91 post-stroke individuals with a mean age of 68.1 years, with oropharyngeal dysphagia. The study concluded that sensory changes in the laryngeal and pharyngeal mucosa associated with altered motor activity may lead to laryngeal penetration and aspiration in post-stroke individuals.

Kendall and Leonard [13] evaluated the pharyngeal constriction of 70 elderly patients, with dysphagia of unknown etiology, comparing the results with a control group with no dysphagia of 23 elderly and 60 young individuals. The authors reported that 73% of the patient population presented incomplete pharyngeal constriction compared to the control group. Moreover, a poor pharyngeal constriction, suggestive of pharyngeal weakness, contributes to 75% of cases of aspiration.

Exercises for increasing amplitude of tongue mobility, for both speech and swallowing purposes should be considered as patients post stroke showed a decrease in amplitude in relation to the control group.

Other methods of evaluation to estimate tongue mobility may also be applied concomitantly to videofluoroscopic used here, to observe agreement between methods and / or aggregate information.

These findings may also be correlated with the amount and conservation of teeth, presence of dental prostheses, type and route of feeding, amount of saliva, use of drugs that cause xerostomia, and age, since with aging the tongue is subject to hypertrophic changes due to connective tissue growth and fat deposition, which may lead to reduced tongue mobility.

CONCLUSIONS

In light of our results, future research is warranted, involving the measurement of tongue mobility by means of videofluoroscopy in normal individuals, for it to serve as reference in providing values for new studies.

Moreover, the method used in this research to assess tongue mobility is only a proposed type of measurement. It provides us with isolated information, but allows us to evaluate the patient pre- and post-dysphagia therapy, and to correlate this information with that obtained in the clinical evaluation and observed in its course.

Patients as well as a correlation with dysphagia severity, it is also suggested that this measure be observed in videofluoroscopy swallowing studies. These results further led to consider these aspects within the clinical evaluation of post-stroke patients, since not everyone may be appropriate or at times have access to the objective examination of swallowing, and suggest that interventions aimed at improving pharyngeal constriction have the potential to be effective in the rehabilitation of post-stroke swallowing.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

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