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Dysphagia

Teaching Speech Pathology Students the Interpretation of Videofluoroscopic Swallowing Studies

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Abstract. This article examines a teaching package that was designed to cover the progression of skills agreed to by clinicians and educators as being pertinent to interpreting Videofluoroscopy Swallowing Studies (VFSSs). Sessions taught included knowledge of anatomy and physiology of swallowing, examination and identification of structures and landmarks from radiographs, and the use of an assessment scale such as the Bethlehem Assessment Scale (BAS) to interpret VFSSs. The ability to interpret eight VFSSs using the BAS was used as the final assessment. ANOVA for repeated measures and post hoc tests using Tukey's HSD statistic revealed that there was a statistically significant correlation between students' knowledge of anatomy and physiology and their knowledge of radiographic anatomy. There was a statistically significant correlation between their knowledge of radiographic anatomy and their ability to interpret videofluoroscopic examinations, as assessed using the BAS. There was also a statistically significant correlation between their knowledge of anatomy and physiology and their ability to interpret videofluoroscopic examinations using the BAS.

Key words: Student teaching — Dysphagia — Fluoroscopy — Deglutition — Deglutition disorders.

Videofluoroscopy Swallowing Studies (VFSSs) are widely used in clinical settings to determine the nature and extent of swallowing problems. Little data are available to inform what leads to good inter- and intrarater reliability when interpreting results of this technique [1]. Kuhlemeier et al. [2] indicated that, even when using experienced clinicians, inter- and intrarater reliability in VFSSs was adequate only for evaluating oral stage, laryngeal penetration and aspiration, and pharyngeal retention, but it was questionable for the evaluation of functional components. This article examines methods of achieving reliability when interpreting VFSSs and ways of teaching this skill to student speech pathologists.

In Australia, dysphagia is seen as part of a standard university undergraduate course in speech pathology. However, there are still many differences in teaching students the interpretation of videofluoroscopic examinations. These differences include the number of hours spent on teaching dysphagia and videofluoroscopy and the year level at which these subjects are introduced to the students (Table 1).

In 1994, the Australian Association of Speech and Hearing (AASH) established Competency-Based Occupational Standards (C-BOS). This document outlined the relevant minimal professional standards required of a newly qualified speech pathologist in the assessment and management of various speech, language, and swallowing disorders [3]. In the area of dysphagia assessment and management, these standards include the following: clinicians need to examine the nature of the client's difficulty using a variety of methods including case history, observational techniques, and investigative techniques; clinicians should be involved in the decision to investigate dysphagia further, using radiographic and other techniques; and clinicians should be aware of the use and interpretation of videofluoroscopic investigation (with reference to a senior or supervising speech pathologist for assistance when appropriate).

Currently there is no agreed on structured method for teaching the interpretation of videofluoroscopic examinations. There is a need to teach this technique because of its wide use in varied clinical settings. Accuracy and clinical rigor in interpreting VFSSs are vital in clinical diagnosis. This project sought to examine the optimal

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Table 1. Summary of the differences in teaching dysphagia and the interpretation of videofluoroscopic examinations in Australian universities

	Universities				
	La Trobe	Sydney	Flinder's	Curtin	Queensland
Number of hours on dysphagia	20	28 to 30	40	24	18 20
Year level at which dysphagia is taught	2nd	3rd	3rd	3rd	3rd 4th
Number of hours on videofluoroscopy	2–40	approx. 4	maximum 3	approx. 4	approx. 6
Year level at which videofluoroscopy is taught	2nd	3rd	3rd	3rd	3rd and 4th
Methods of teaching dysphagia					
Lectures	√	√	√	√	√
Tutorials	—	—	—	√	√
Self-directed study	√	√	√	√	√
Materials used to teach videofluoroscopy					
Textbooks	√	√	√	√	√
Journal articles	—	√	√	√	√
CDROM: The Dynamic Swallow	√	√	√	√	√
Examples of videofluoroscopic examinations	√	√	√	√	√
Attendance at videofluoroscopy clinic	Elective	Compulsory	Elective	Elective	Compulsory
Number of teachers or tutors					
Lectures	1	1	1	1	1
Tutorials	—	—	—	1	1
Size of class (students)					
Lectures	75	80	30	34	55
Tutorials	—	—	—	34	55

way of teaching students to interpret videofluoroscopic examinations accurately. This problem is not unique to Australia. As Jarchow [4] indicated in her survey of graduates in the United States, many graduates were being certified for a position when they may not have had courses in an area which constituted 40%–50% of their caseload.

The Bethlehem Assessment Scale (BAS)

The Bethlehem Assessment Scale (BAS), developed by Scott [1] for evaluating dysphagia in motor neuron disease subjects, involves interpreting dynamic VFSSs guided by a 4-point rating scale, with clear verbal descriptors and printed radiological examples of the scalar points. Developed from the Charing Cross profile [5], the BAS has established validity and reliability data from studies of experienced clinicians' use of the scale. Specific parameters allow the evaluation of individual functions that contribute to the dynamic process of swallowing. These parameters include: labial function, lingual function, jaw function, velar function, swallow reflex, hyoid elevation, pooling in valleculae, pooling in pyriform sinuses, aspiration, pharyngeal wall function, and cricopharyngeal function [6].

In using the BAS for assessing students' skills, this article examines teaching and learning paradigms in the interpretation of videofluoroscopic examinations. We hypothesized that there would be a relationship between the students' knowledge of the anatomy and physiology of swallowing, their knowledge of radiographic landmarking, and their competence in the interpretation of videofluoroscopic examinations using the BAS. This would be demonstrated by their ability to obtain a 75% agreement on (i) anatomy and physiology assessment and (ii) radiographic landmarking assessment, and by examining kappa coefficients for agreement using the BAS.

We further hypothesized that there would be a relationship between the interpretation of structure (as ascertained by identification of landmarks on "still" radiographic images) and function (interpretation of videofluoroscopic examinations using the BAS).

Materials and Method

Subjects

Female subjects (38) were recruited in 1998 from the third year of the four-year speech pathology undergraduate course at La Trobe University. They had no previous specific training in the interpretation of videofluoroscopic examinations and had no known hearing or visual impairment. The rationale for using only female participants was to eliminate the confounding factor that gender might have on the results. In addition, the speech pathology course is very much female-dominated and it would have been difficult to obtain an equal number of male participants.

Materials

The five structured teaching sessions were as follows:

Session 1 covered materials relating to the normal anatomy and physiology of swallowing. This included the normal process of swallowing, the anatomical structures and muscles involved in swallowing, and the innervation of these muscles. Teaching was didactic with quality overheads and handouts provided to augment the session. Following this session, all subjects were required to complete and submit a worksheet to assess knowledge gained.

Session 2 was to teach radiographic anatomy and landmarking. Subjects were taught by the researcher how to identify structures and landmarks on "still" radiographic images. Following this teaching session, subjects were required to complete and submit a worksheet relating to the topic covered. The worksheet consisted of radiographs with arrows labeling structures to be identified. Students were required to identify and correctly label by writing the names alongside the anatomical areas outlined.

Sessions 3 and 4 taught subjects how to interpret and rate the parameters in the oral and the pharyngeal phase of the swallow in VFSSs using the BAS. Parameters in the oral phase were labial function, lingual function, and jaw function; parameters in the pharyngeal phase were velar elevation, swallow reflex, hyoid elevation, residue in the valleculae, residue in the pyriform sinuses, aspiration, pharyngeal wall function, and cricopharyngeal function. Subjects were provided with visual examples of normal and abnormal swallows (in the form of VFSSs). Subjects were also taught what viewing mode (i.e., normal play mode, pause mode, or frame-by-frame mode) to use when rating each of the parameters and the levels of function for each parameter using the BAS descriptors (which included visual examples of each of the four points on the scale).

In session 5, subjects were given the opportunity to practice (as a group) using the BAS for interpreting differing videofluoroscopic examinations in class.

Procedure

Five hours of carefully structured teaching was developed. In order to assess knowledge gained, worksheets were given after each specific skill had been covered in the training sessions (namely, the anatomy and physiology of swallowing, radiographic anatomy of the swallowing mechanism, and interpretation of dynamic videofluoroscopic examinations using the BAS), and all subjects agreed to complete the final assessment.

The teaching package was designed in this way for a number of reasons. First, it was agreed that students would need an understanding of "normal" anatomy and physiology before they could understand abnormalities in the swallowing process. Second, swallowing, being a complex and integrated process, needed to be divided into its component phases so that students could gain a fuller understanding of the different aspects. In addition, the BAS divides the areas to be interpreted into the oral phase and pharyngeal phase. Therefore, it was essential that students learn where each phase began and ended so that they could use the BAS reliably. Finally, it was necessary to teach the students to interpret radiographs so that they could identify structures and spaces that are in the swallowing process. The BAS refers to a number of structures and spaces in the ratings of some specified parameters. It was also assumed that this would follow the progression of skills that are necessary in the interpretation of dynamic VFSSs.

Subjects agreed to attend all 5 teaching sessions and complete and return all assessments. The subjects were given one week to complete and submit each worksheet example (see Appendix 1) and another week to complete and submit the final assessment which consisted of 8 VFSSs recorded on videocassette for subjects to take home and complete, using the BAS. In order to discount any practice effect, the sequence of the 8 VFSSs was randomized so that the order of the swallows was different from tape to tape. The 8 VFSSs chosen had no identifying information on them which minimized the possibility that subjects would compare their responses among themselves.

Results and Analysis

Normal Anatomy and Physiology of Swallowing

Using worksheet 1 (see Appendix 2), all participants got at least 75% of the answers correct. The mean score was 87.5% and the range of scores was between 79% and 100%. The results for worksheet 1 are summarized in Tables 2 and 3. These results are categorized into question topics examining knowledge of *structures* and question topics examining knowledge of *functions*. The tables are also ranked according to scores in terms of percentage correct. The questions that did not reach the 75% correct criterion are in italics. Of the 40 individual aspects that were covered in worksheet 1, there were 9 aspects that did not achieve the 75% correct criterion. The overall of mean correct answers was 83.3%, the standard deviation was 19%, and the range was between 31.6% and 100% of students' correctly answering individual aspects. The individual aspects where subjects were unable to attain the required 75% correct score were complex concepts involving several structures; a series of diagrams might have aided subjects to understand better. It may have been that subjects did not understand these concepts or the wording of the question.

Radiographic Anatomy

In worksheet 2, subjects were required to label 8 diagrams of radiographic still images with a total of 71 structures (Figs. 1 and 2). The subjects scored in the range of 94.4%–100% correct for this worksheet. The mean score was 98.6% with a standard deviation of 1.6. Table 4 summarizes the results of worksheet 2, with individual aspects ranked in terms of scores. The table shows that all structures that were to be labeled were done so correctly, with all above 75% correct. The range of accurate labeling was between 90.4% and 100%. Teeth, vallecula, and the first cervical vertebrae were labeled accurately 100% of the time. The following items had relatively low frequencies of occurrence (i.e., the number of times that students were requested to label structures): teeth (frequency = 2), laryngeal opening (frequency = 3), trachea (frequency = 3), vallecula (frequency = 4), tongue (frequency = 4), and first cervical vertebra (frequency = 2). Therefore, further testing may be required to validate the results pertaining to these

Table 2. Results: knowledge of structures

Question topic (structures)	Answers	% Correct
First phase of the swallow	Tongue	100
	Jaw	100
Second phase of the swallow	Cheeks	100
	Tongue	100
	Jaw	100
Bolus formation	Tongue	100
Second phase of the swallow	Lips	97.4
Third phase of the swallow	Soft palate	97.4
	Epiglottis	97.4
	Larynx	94.7
	Hyoid bone	94.7
	Pharynx	92.1
	Arytenoid cartilages	92.1
	Cricopharyngeus	79.0
Bolus formation	Cheeks	73.7
	Tongue forms a groove shape	68.4
	Lips	60.5
	Soft palate	55.3
	Jaw	31.6

Table 3. Results: knowledge of functions

Question topic (functions)	Answers	% Correct
Number of phases in a swallow	Four	100
Name the phases of a swallow	Oral preparatory, oral, pharyngeal, oesophageal	100
First phase in swallow	Bolus preparation	100
Airway protection	Laryngeal elevation	100
Soft palate	Soft palate elevates	100
Cricopharyngeal opening	Laryngeal elevation	100
Airway protection	Epiglottis down tilt	97.4
	Laryngeal forward tilt	97.4
Soft palate	Soft palate meets back of tongue	97.4
First phase in swallow	Chewing	94.7
Airway protection	Back of tongue movement	94.7
Soft palate	Oral and nasal cavities separated	94.7
Airway protection	Vocal fold closure	92.1
First phase in swallow	Taste	89.5
Cricopharyngeal opening	Causes traction	86.8
	Opens via passive movement	79.0
	Remains closed at rest	76.3
Soft palate	Maintains negative pressure	73.7
Airway protection	Posterior pharyngeal wall movement	71.0
Cricopharyngeal opening	Laryngeal forward tilt	42.1
Airway protection	Breathing ceases	31.6

areas. The lowest percentages of correct labeling were for the position of the laryngeal opening (93.0%) and the position of the trachea (90.4%). These structures are close to each other which may explain the results. The frequency for these two items was low which may indicate that further testing for these two items is required. The reproduction of the diagrams used was not ideal because of the inferior quality of photocopied images. However, the cost and time involved in printing the worksheet on a printer would have been far greater than just photocopying the images.

Interpretation of Videofluoroscopic Examinations Using the BAS

Kappa coefficients were calculated for each of the 11 parameters in the BAS. This analysis showed that poor-to-good interrater reliability was obtained. The range of the kappa coefficient K ranged from 0.2 to 0.55. Using the kappa coefficients, obtained *z* values and their corresponding *p* values were calculated. Table 5 summarizes the parameters ranked in terms of their obtained *z* values. All the *z* scores were above that which would be expected from ?? for all 11 parameters tested.

An analysis of variance (ANOVA) for repeated measures was performed to allow the comparion of the scores in the knowledge of the anatomy and physiology of swallowing (worksheet 1), the ability to identify structures and landmarks in still radiographic images (worksheet 2), and the 8 trials at interpreting dynamic videofluoroscopic examinations using the BAS (final assessment). Table 6 summarizes the ANOVA for repeated measures. It shows that the obtained value of F is 40.11. From the F distribution, $F(\text{critical}) = 4.90$, $df = 2$ and 74 ($\alpha = 0.01$). The obtained value of F (40.11) exceeds the critical value of F (4.90) at the decision level of $\alpha = 0.01$. There is a demonstrated correlation between the knowledge of the anatomy and physiology of swallowing (worksheet 1), the ability to identify structures and landmarks in still radiographic images (worksheet 2), and the 8 trials at interpreting dynamic videofluoroscopic examinations using the BAS (final assessment).

Since the obtained F ratio is significant, post hoc testing using Tukey's HSD enabled the determination of which factors in the progression of skills required to interpret videofluoroscopic examinations were more important. Table 7 illustrates the statistical comparison between the knowledge of the anatomy and physiology of swallowing (worksheet 1), the ability to identify structures and landmarks in still radiographic images (worksheet 2), and the 8 trials at interpreting dynamic video-

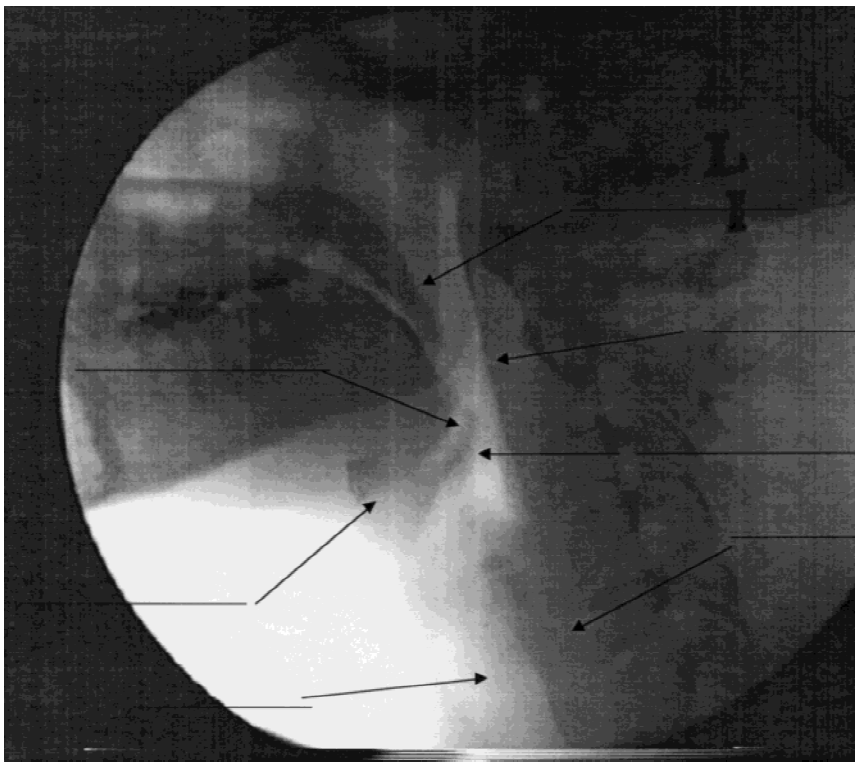

Fig. 1. Radiograph for labeling structures.

fluoroscopic examinations using the BAS (final assessment). In this case, S2(residual) = 90.33 and n (the number of subjects) = 38. The value of q for df(residual) = 74 and k (the number of test conditions) = 3. For $\alpha = 0.01$, $q = 3.391$. Thus, it can be demonstrated that there was a correlation between the knowledge of the anatomy and physiology of swallowing and competence in interpreting videofluoroscopic examinations (as demonstrated by the ability to obtain a 75% agreement on specified parameters in the BAS).

There was also a relationship between the interpretation of structures (as ascertained by identification of structures and landmarks on still radiographic images) and functions (interpretation of VFSSs using the BAS). This confirms the link between knowledge of anatomy, radiological landmarking, and success at interpreting VFSSs.

Discussion

In worksheet 1 (normal anatomy and physiology of swallowing), all participants got at least 75% of the answers correct. One cannot discount that pre-existing knowledge probably contributed to this good result since all students study general anatomy in year 1 of their course.

Of the 40 individual aspects that were covered in worksheet 1, the criterion of 75% correct was not obtained in 10 aspects. This may have been a result of the way the questions were worded or the required number of points per question was not included as a cue in the worksheet to remind the students of the extent of the answer required. Alternatively, these aspects may have been taught inadequately. The use of serial diagrams and models could have aided subjects to better understand these aspects. It may also have been the researcher's inexperience at teaching that contributed to the poor result in these areas.

In assessing radiographic anatomy and landmarking, all subjects scored in the range of 94.4%–100% for this worksheet. The mean score was 98.6%. This result was particularly high. Further testing is needed to determine the subjects' true ability to identify structures and landmarks in radiographs, perhaps in the absence of any guided instruction.

Some areas (i.e., the position of the laryngeal opening and the position of the trachea) were relatively more difficult for the subjects to label accurately as reflected by the poorer results in these areas. These structures are close to each other and the position of the label line may have been misleading or ambiguous. This may have contributed to the poor results. The diagrams in the

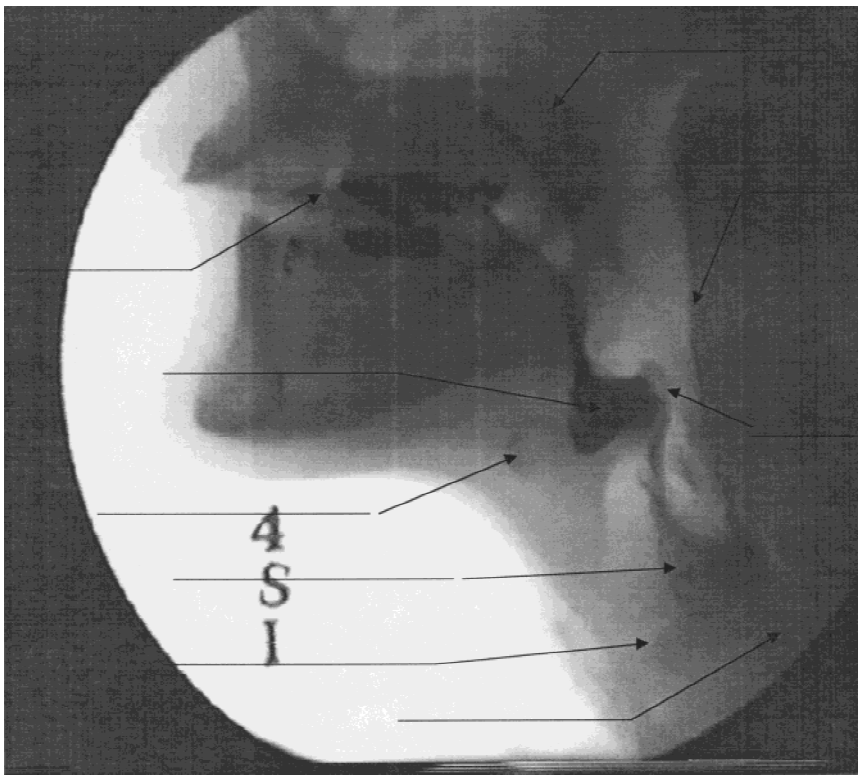

Fig. 2. Radiograph for labeling structures.

Table 4. Results of worksheet: radiographic anatomy

Structures labeled	% Correct
Teeth	100
Vallecula	100
First cervical vertebrae	100
Soft palate	99.7
Hyoid bone	99.6
Pyriform sinus	99.6
Jaw	99.3
Posterior pharyngeal wall	99.1
Tongue	98.7
Hard palate	98.7
Epiglottis	98.0
Laryngeal opening	93.0
Trachea	90.4

Table 5. Obtained *z* values for the final assessment—rating videofluoroscopic examinations using the BAS

Parameters	Kappa coefficient	Obtained *z* values
Cricopharyngeal function	0.20	2.97
Aspiration	0.38	3.93
Lingual function	0.37	7.30
Velar function	0.28	9.81
Labial function	0.44	10.14
Hyoid elevation	0.46	14.97
Pooling in pyriform sinuses	0.50	16.67
Jaw function	0.47	19.35
Swallow reflex	0.41	21.21
Pharyngeal wall function	0.53	24.32
Pooling in valleculae	0.55	40.01

worksheets were photocopied resulting in poorer quality images. Reproduction of these images using a digital printer or having subjects label these images on the computer may aid the performance of subjects in this area.

Interpretation of Videofluoroscopic Examinations Using the BAS

In worksheet 2 (radiographic anatomy), subjects were not required to label the cricopharyngeus. This lack of practice at a lower skill level may have caused the identification of this parameter to be worse compared with that for other parameters on the BAS. Alternatively, the first author's teaching of this function may have been inadequate.

Finally, 11 subjects who first volunteered did not return the final assessment to the researcher, which negated their contribution to the study. This may have been because the final assessment was too difficult. In our study, those who returned the final assessment were self-selected, i.e., they were able to interpret videofluoroscopic examinations using the BAS. Since we cannot

Table 6. ANOVA for repeated measures. Knowledge of anatomy/physiology of swallowing; ability to identify radiographic landmarks and interpretation of VFSSs using the BAS

Source	SS	*df*	S2	*F*
Subjects	34.47	37	0.93	—
Between groups	97.88	2	48.94	40.11
Residual	90.33	74	1.22	—
Total	222.69	113	—	—

$\alpha = 0.01$

Table 7. Comparisons using Tukey's HSD statistic

Test conditions	Mean percentage scores	Comparisons	
Final assessment	75.90		
Anatomy and physiology	87.58	11.68	
Radiographic anatomy	98.59	22.69	11.01
Final assessment			q
Anatomy and physiology		6.525	
Radiographic anatomy		12.676	6.151

force the subjects to return the final assessment, the possibility of the missing assessments affecting the results cannot be excluded.

Clinical Implications

The results of this research reinforce the necessity of Australian clinicians adhering to C-BOS. C-BOS states that "Clinicians should be aware of the use and interpretation of videofluoroscopic investigation *with reference to a senior or supervising speech pathologist for assistance when appropriate*" (our italics). With the current level of teaching of the interpretation of videofluoroscopic examinations, we cannot assume new graduates can interpret videofluoroscopic examinations as reliably as might be desired [7]. Our work also reinforces the belief that accredited postgraduate training should be made available for new graduates to improve and refine their skills at interpreting videofluoroscopic examinations and hence achieve more accurate assessment in dysphagia.

Conclusions

Recent literature has shown that dysphagia assessment and management forms a significant part of a speech pathologist's caseload. The issues raised by our study highlight that we may not be providing adequate knowlege, skill, and practice as part of the undergraduate training program. There is a need for educators to meet the needs of the profession. As such, universities must reflect on the design and delivery of their training courses and help their graduates meet accredited standards. Ideally, professional standards such as C-BOS should outline the universally acceptable skill performance level for new graduates, and university courses need to reflect how these skills should be demonstrated. Until these issues are addressed, it may be necessary for accredited postgraduate training to be made available for new graduates to improve and refine their skills at interpreting VFSSs. Formal mentoring activities should also be made accessible to all new graduates.

Appendix 1: Example of Worksheet 1 for Students' Assessment

Worksheet 1 Group: _____ Number: _____

Please complete this worksheet and hand it in at the next training session. Responses in point form are acceptable.

1. How many phases are there in the process of swallowing?

2. Name the phases of swallowing.

3. What are the functions of the first phase of swallowing?

4. What structures are involved in the first phase of swallowing?

5. Name the structures involved in the second phase of swallowing.

6. Describe what structures are involved in collecting and containing the bolus in a cohesive form in the second phase of swallowing.

7. Name the structures involved in the third phase of swallowing.

8. Describe how complete airway protection is achieved in the third phase of the swallow.

9. Describe the postures, movements, and functions of the soft palate in the second and third phases of the swallow.

10. Describe the process by which the cricopharyngeus opens to allow the transit of the bolus from the pharynx into the oesophagus.

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