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SWALLOWING DISORDERS (RE MARTIN, SECTION EDITOR)

A Systematic Review of Current Clinical and Instrumental Swallowing Assessment Methods

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Abstract Tests for dysphagia serve as either assessment or screening tools. To be clinically useful these tools must be reliable, validated with proper psychometric techniques, and feasible. In a previous systematic review, only two screening tools met these criteria from the studies in stroke patients. There are no such systematic reviews assessing the availability and methodological quality of bedside or instrumental diagnostic assessment tools for dysphagia. This systematic review of recent literature identified 13 articles that have targeted development of new dysphagia tools, seven of which related to screening, five to clinical assessment, and one to instrumental assessment. Across all articles, critical appraisal revealed that none of the recent articles addressing screening, clinical or instrumental assessment had sufficient methodological rigor, and therefore readiness, for implementation into clinical practice. To ensure the best in patient care, it is necessary to develop tools with methodological rigor for all patient groups with dysphagia, beyond just screening. Future studies of patients with dysphagia must use prospective controlled study designs and only available tools that are reliable, valid and feasible. The development and testing of any new tools must ensure that they are also reliable, valid and feasible.

Keywords Deglutition · Deglutition disorders · Stroke · Screening

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Introduction

A test can serve as a screening tool to identify the likelihood of an impairment in a group of patients otherwise not previously identified or as an assessment tool to diagnose the presence, location and severity of an impairment [1]. Diagnostic tests for dysphagia can be further subdivided into: clinical assessment tools administered at the bedside that capture dysphagia signs and symptoms; and instrumental assessment tools that utilize objective technology to measure dysphagia physiology.

Regardless of the purpose of the test, standards are now available to guide the proper psychometric development of screening and diagnostic tests [1, 2•, 3]. A recent systematic review by Schepp et al. [4••] published in 2012 used these guidelines in their review of the literature aimed at identifying existing dysphagia screening protocols for patients with stroke. Accordingly, they argued that screening tools need to be reliable, valid, and feasible. In their review, they identified and critically appraised 35 published screening protocols [4••], of which only two met

their aforementioned psychometric criteria with sufficient sample sizes [5, 6].

There are no such systematic reviews assessing the availability and methodological quality of bedside or instrumental diagnostic tools for dysphagia. Our goal for the current study was twofold: to conduct a systematic review of the literature aimed at identifying more recently published screening tools for dysphagia as an up-date to the previous review [4••], and to extend this review to also capture recently published tools that were using either bedside or instrumental technologies to target the assessment of dysphagia impairment in adult patients irrespective of their etiology.

Methods

Operational Definitions

Our search was guided by the following operational definitions, determined a priori: *dysphagia*, defined as any physiological impairment affecting the oral, pharyngeal and/or upper esophageal phases of swallowing; *validity*, defined as any statistical assessment of accuracy using either a criterion reference (i.e., sensitivity, specificity, ROC analysis) or correlation with another outcome; and *reliability*, defined as any statistical assessment of stability either between or within raters (i.e., percent agreement, Kappa, interclass correlation coefficient).

Search Methodology

We conducted electronic searches to identify relevant primary research articles published between January 1, 2012 and July 30, 2013 using the following databases: MEDLINE, Embase, CINAHL, PsycINFO, AMED, Cochrane Database of Systematic Reviews, and Cochrane Central Register of Controlled Trials (CCRCT). Main search terms included: *dysphagia* and *validity* or *reliability* (see Appendix for full search strategy).

Study Selection

Two independent raters reviewed all citations of the relevant primary research articles. Discrepant ratings were resolved by consensus with a third rater. Citations were *excluded* if they: had no abstract; included no human participants (animal study); were classified as a tutorial, educational report, or review; used a case series study design ($n < 10$); involved a population where >10 % of subjects were children (<18 years of age); made no mention of oropharyngeal dysphagia as an outcome measured via screening, clinical, and/or instrumental assessment; were primarily investigating an *intervention* for dysphagia; or, sought to determine the incidence/prevalence of dysphagia within a given population. All other abstracts were accepted and the cited articles brought to full review.

A full review of each article and conference proceeding was conducted by two independent raters. Discrepant ratings were resolved by consensus with a third rater. During the full article review, studies were *excluded* if they were deemed to be: a *physiology study* (i.e., any study investigating the underlying physiology of swallowing, which could be used to inform or create new dysphagia assessment tools); a *prediction study* (i.e., any study investigating how a given variable predicts dysphagia, or how dysphagia predicts a given variable, via relative risk, odds ratios, or likelihood ratios); an *assessment protocol* (i.e., any study investigating or seeking to *inform* or *change* current assessment protocols); a *tool utilization study* (i.e., any study looking at the *implementation* or *up-take* of a new assessment technique or tool); or a *tool effectiveness study* (i.e., any study looking at the *benefit* of a given assessment tool in reducing cost, adverse events, etc.). Conference proceedings were reviewed and excluded according to these same criteria.

Data Extraction

Only full articles that met the inclusion criteria outlined above underwent data extraction. A single rater extracted the following data from each included article: sample size; study population (including etiology, age, and gender); the new assessment tool or technique being validated (index test); and the criterion reference test or correlational outcome used to validate the technique or tool. Data extraction was checked by a second rater and discrepancies were resolved by consensus.

Quality Assessment

The methodological quality of each included full article was assessed according to the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) [2•]. The QUADAS-2 is a valid and reliable tool used to evaluate the *quality* of diagnostic accuracy studies. It includes four domains: patient selection, index test, criterion reference test, and flow and timing.

Results

Literature Retrieval

We identified 716 citations pertaining to the development of tools targeting screening or assessment of oropharyngeal dysphagia. (Fig. 1). Removal of duplicates resulted in 493

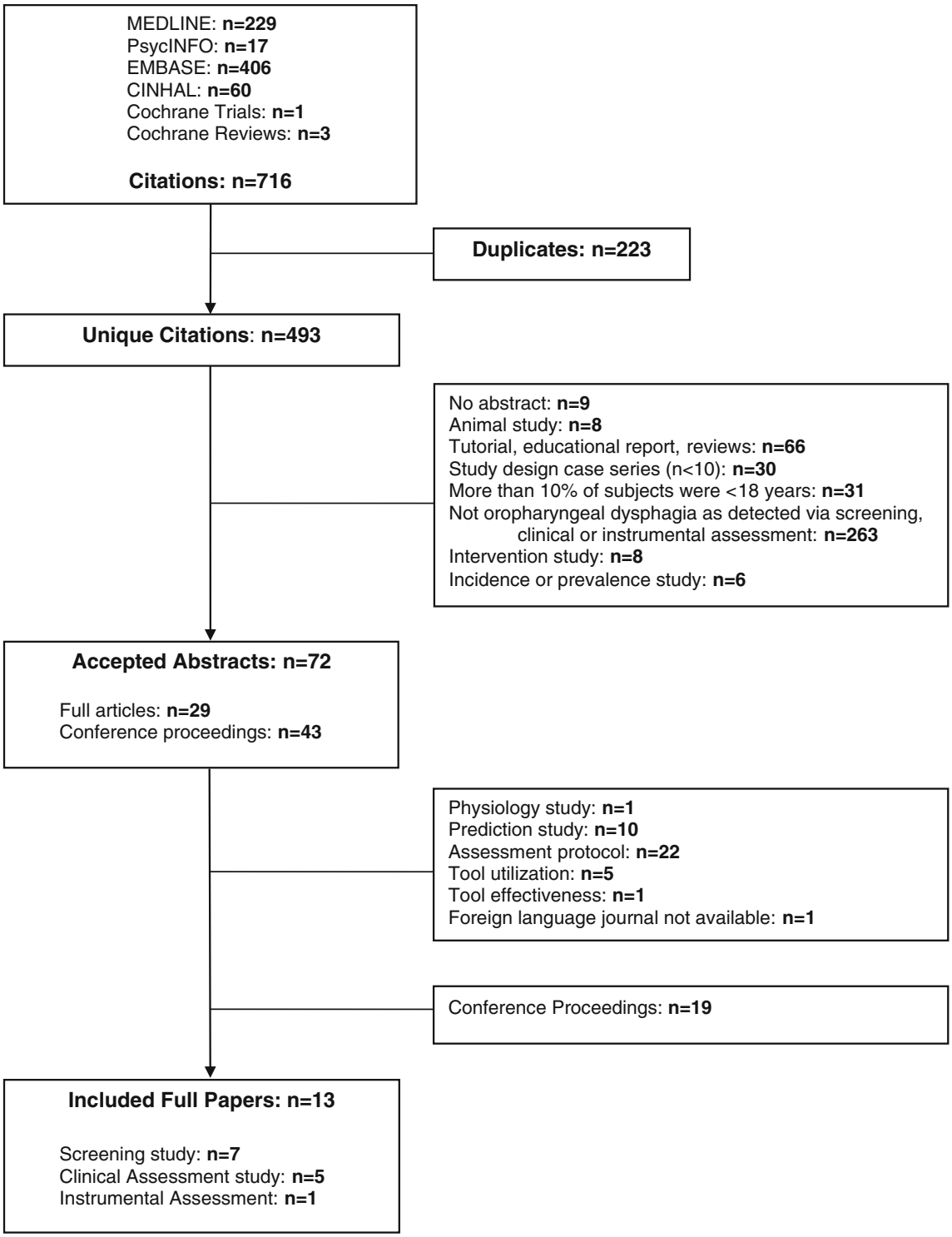

Fig. 1 Flow chart illustrating the abstracts and articles identified and reviewed

remaining unique citations, of which 421 did not meet our inclusion criteria. Hence, we accepted 72 abstracts for full review. Of these, 29 were peer reviewed journal articles, while the remaining 43 were published abstracts from conference proceedings. Of accepted abstracts, 40 were excluded for reasons detailed in Fig. 1. An additional 19 conference proceedings were only available as abstracts and thus had insufficient details for data extraction or critical appraisal. Thirteen full articles were included in this review and detailed in Tables 1 and 2.

Table 1 Description of the articles included and the frequency of dysphagia reported according to index and criterion reference tests

Author, year	n	Age[a] Male, *n* (%)	Etiology	Index test details	Psychometric testing
Screening					
Hongama et al. [7]	53	24.6 ± 4.2 year 26 (49 %)	Group A: Young healthy dentate	Clinician testing using MISS[b] to measure number of repetitive laryngeal elevations in 30 s. Magnet is placed over thyroid cartilage and held in place with adhesive tape. Sensor to detect movement of magnet during saliva swallows is placed on sternum	Correlation with RSST[c] and digital laryngeal palpation: Correlation coefficient $R^2 = 0.82$, $p < 0.01$
	40	70.3 ± 11.6 year 20 (50 %)	Group B: Elderly edentulous		
Miles et al. [11]	181	VFS Cohort, *n* = 80 67 ± 19 year 48 (60 %) FEES Cohort, *n* = 101 78 ± 13 year 51 (50 %)	Mixed etiologies, patients referred for VFS or FEES with suspicion of dysphagia	Clinician testing, the CRT[d] administers increasing citric acid concentrations of 0.4 mol/l, 0.6 mol/l and 0.8 mol/l for 15 s each via a face mask nebulizer in 1-min intervals Testing repeated 3× for each concentration, 2+ cough responses during each administration indicated a positive response, 2+ positive responses per concentration indicated dysphagia Dysphagia, 0.4 mol/l, 98 (54 %) Dysphagia, 0.6 mol/l, 148 (82 %) Dysphagia, 0.8 mol/l, 159 (88 %)	Criterion Reference: VFS[e] Aspiration, 24 (30 %) FEES Aspiration, 63 (62 %)
Osawa et al. [8]	111	65.6 ± 13.4 year (20–98) 65 (59 %)	Mixed stroke, patients referred for VFS with suspicion of dysphagia	Clinician testing, the WST[f] administers increasing water boluses from 3, 5, 10, 30, to 60-ml Cough, gurgling voice or >2 % drop in SpO_2 for 1+ min indicated dysphagia Dysphagia frequency at patient level, not provided	Criterion Reference: VFS Aspiration with 5-ml, 17 (15 %) VFS Aspiration with 10-ml, 23 (21 %) VFS Aspiration with 30-ml, 35 (32 %) VFS Aspiration with 60-ml, 70 (63 %) VFS Aspiration with 3-ml MWST[g], 38 (34 %)
Paris et al. [9]	20	66 (±8) NR	ALS[h]	Clinician testing, the V-VST[i] administers increasing volumes (ex. 5-, 10- and 20-ml) of different textures (ex. Nectar, liquid and pudding) Testing continues until signs of laryngeal penetration or aspiration (i.e. cough, >3 % drop in SpO_2 or wet voice) or reduced efficiency (i.e. oral or pharyngeal residue, need for repeated swallowing or drooling) Any of these signs indicated dysphagia Dysphagia, 15/20 (75 %)	Criterion Reference: VFS Dysphagia, 5 (75 %)
Sato et al. [12]	141	71 ± 14 year (23–94) 92 (65 %)	Mixed etiologies, patients referred for FEES with suspicion of dysphagia	Clinician testing, the SCT[j] administers a mist of 1 % w/v citric acid-physiological saline via a portable nebulizer Cough ≤30 or ≤60 s post inhaled mist indicated dysphagia Dysphagia, cough <30 s, 35 (25 %) Dysphagia, cough <60 s, 66 (47 %)	Criterion Reference: FEES[k] Aspiration, 53 (38 %) FEES Silent Aspiration, 37 (26 %)

Table 1 continued

Author, year	n	Age[a] Male, *n* (%)	Etiology	Index test details	Psychometric testing
Steele et al. [13]	40	67.0 ± 14 year (37–90) 20 (50 %)	Unknown etiologies, patients referred for VFS with suspicion of dysphagia	Clinician testing, accelerometer sensor placed against anterior cricoid and held in midline with adhesive tape during 3 × 5-cc and 1× cup sip barium water swallows Signal level to indicate dysphagia not provided Dysphagia frequency at patient level, not provided	Criterion Reference: VFS (n = 37) PAS score ≥3, 13 (35 %)
Yamamoto et al. [10]	61	67.0 ± 9.2 year 40 (66 %)	Parkinson's disease	Patient self-administered questionnaire, Japanese version of SDQ[l] Total score ≥11 indicated dysphagia Dysphagia, 15 (25 %)	Criterion reference: VFS aspiration, 9 (15 %)
Clinical assessment					
Archer et al. [14]	12	24.8 ± 3.1 year 12 (100 %)	Group 3: Healthy volunteers	Patient self-administered questionnaire, SSQ[n]—speech-language pathologists assisted with VAS[o] scoring Total score 0–1,700, higher score worse symptoms	Discriminative validity: Total score for Groups 3 versus 2 versus 1 each statistically different
	6	21.0 ± 3.0 year 6 (100 %)	Group 2: Patients with DMD[m] but no dysphagia		
	9	21.7 ± 4.2 year 9 (100 %)	Group 1: Patients with DMD and with known dysphagia		
Govender et al. [15]	20	63.0 year (44–83) 10 (50 %)	Group A: Healthy volunteers	Patient self-administered questionnaire, SOAL[p] Total score 0–35, higher score worse symptoms	Face validity: Achieved with patients (n = 10) and clinicians (n = 35) Internal consistency: Cronbach's alpha >0.91 for Group B Discriminative validity: Total score for Groups A versus B versus C each statistically different Correlation with VFS: Pearson $r = 0.50$, $p = 0.03$ for Group C
	19	66.0 year (48–80) 10 (53 %)	Group B: HNC following total laryngectomy with unknown dysphagia		
	19	61 year (41–92) 11 (58 %)	Group C: HNC following radiotherapy with known dysphagia		
Shem et al. [16]	39	41.6 ± 16.6 year 30 (77 %)	Acute cervical spine injury with tetraplegia	Clinician testing at bedside looking for signs of aspiration or dysphagia (i.e. coughing, choking, bolus around excreted tracheotomy tube, or wet voice after drinking) Dysphagia, 15/39 (38 %)	Criterion Reference, n = 26: VFS Dysphagia, 11 (42 %)

Table 1 continued

Author, year	n	Age[a] Male, *n* (%)	Etiology	Index test details	Psychometric testing
Skeppholm et al. [17]	45 111	64.8 ± 10.4 year 23 (51 %) 46.0 ± 6.7 year 55 (49 %)	Mixed etiologies post ACSS[q] with known dysphagia	Patient self-administered questionnaire, DSQ Dysphagia Short Questionnaire[r] Total score 0–18, higher score worse symptoms DSQ mean score 6.3 ± 2.7 (2–13)	Face validity: Achieved with patients (n = 10) and ear-nose-and-throat specialists (n = 4) Intra-rater reliability, n = 40: Cronbach's alpha >0.82 Correlation with MDADI,[s] n = 40: Pearson $r = 0.59$, $p < 0.01$ Sensitivity to change over time, n = 111: Preop DSQ mean score 1.4 ± 1.9 4 weeks Postop DSQ mean score 3.2 ± 2.5 3 mos Postop DSQ mean score 1.7 ± 2.0 1 year Postop DSQ mean score 1.2 ± 1.7
Ward et al. [18]	40	66 year (25–94) 23 (35 %)	Mixed etiologies with known dysphagia; various etiologies	Clinician testing via tele-swallowing exam (T-SE), as relayed by video from bedside CSE Dysphagia, 40/40 (100 %)	Intra-rater reliability, tele-exam: Percent exact agreement, most items >0.80 Intra-rater reliability, live-exam: Percent exact agreement, most items >0.80 Inter-rater reliability, tele-exam: Percent exact agreement, most items >0.80 Inter-rater reliability, live-exam: Percent exact agreement, most items >0.80 Correlation with Live Exam: Percent exact agreement, all items >0.75 Kappa, most items >0.63

Table 1 continued

Author, year	n	Age[a] Male, *n* (%)	Etiology	Index test details	Psychometric testing
Instrumental assessment					
Hsiao et al. [19]	40 30	n/a n/a	Group A: Healthy volunteers Group B: Mixed stroke with no dysphagia on oral intake Group C: Mixed stroke with known dysphagia on tube feedings	Instrumental testing using curvilinear ultrasound transducer placed submentally to measure tongue thickness changes during swallows of 5-ml water	Criterion reference, $n = 60$: FOIS[t] (score 4–7), 30 (50 %) Discriminative validity (tongue thickness mean change): Group A, 1.1 ± 0.2 cm Group B, 1.0 ± 0.2 cm Group C, 0.9 ± 0.3 cm

[a] Mean ± standard deviation (range) unless otherwise specified

[b] Magneto-impedance Sensor-aided Screening System

[c] Repetitive Saliva Swallowing Test

[d] Cough Reflex Test

[e] Videofluoroscopic assessment of swallowing

[f] Water Swallowing Test

[g] Modified Water Swallow Test

[h] Amyotrophic lateral sclerosis

[i] Volume Viscosity Swallowing Test

[j] Simplified Cough Test

[k] Fiberoptic Endoscopic Evaluation of Swallowing

[l] Swallowing Disturbance Questionnaire

[m] Duchenne Muscular Dystrophy

[n] Sydney Swallow Questionnaire

[o] Visual analogue scale

[p] Swallowing Outcome after Total Laryngectomy

[q] Anterior cervical spine surgery

[r] Dysphagia Short Questionnaire

[s] M.D. Anderson Dysphagia Inventory

[t] Functional Oral Intake Scale

Table 2 Summary of methodological quality

	Archer et al. [14]	Hongama et al. [7]	Hsiao et al. [19]	Miles et al. [11]	Osawa et al. [8]	Govender et al. [15]	Paris et al. [9]
Patient selection							
1. Was the entire spectrum of disease severity represented?	?	−	+	?	?	?	+
2. Were the selection criteria clearly described?	+	−	+	+	+	+	+
3. Was a consecutive or random sample of patients enrolled?	−	−	?	−	−	+	+
(Screening/clinical Ax/instrumental) index test							
1. Was the protocol described well enough to be reproducible?	+	+	+	+	+	+	+
2. Were results interpreted without knowledge of criterion reference findings?	+	−	−	+	+	?	?
3. Was an impairment threshold used and was it pre-specified?	−	−	−	+	+	−	+
4. Was inter-rater reliability assessed?	−	−	−	+	−	−	−
Criterion reference test							
1. Was the protocol described well enough to be reproducible?	n/a	+	+	+	−	+	+
2. Were results interpreted without knowledge of index test findings?	n/a	?	?	+	−	+	−
3. Was an impairment threshold used and was it pre-specified?	n/a	−	+	+	+	−	+
4. Was inter-rater reliability assessed?	n/a	−	−	+	?	+	−
Flow and timing							
1. Was there an appropriate interval between screening and criterion tests?	n/a	+	?	+	+	?	+
2. Did all patients receive a criterion reference test?	n/a	+	+	+	+	−	+
3. Did all patients receive the same criterion reference test?	n/a	+	+	−	+	−	+
4. Were all patients included in the analysis?	n/a	+	+	+	?	−	+
5. Were all patients assessed in the same medical state for index and reference test?	n/a	+	?	?	+	+	+

	Sato et al. [12]	Shem et al. [16]	Skeppholm et al. [17]	Steele et al. [13]	Ward et al. [18]	Yamamoto et al. [10]
Patient selection						
1. Was the entire spectrum of disease severity represented?	?	?	?	?	?	+
2. Was the selection criteria clearly described?	+	+	+	+	+	+
3. Was a consecutive or random sample of patients enrolled?	−	+	−	−	−	?
(Screening/clinical Ax/Instrumental) index test						
1. Was the protocol described well enough to be reproducible?	+	+	+	+	+	−
2. Were results interpreted without knowledge of criterion reference findings?	?	−	?	−	?	?
3. Was an impairment threshold used and was it pre-specified?	+	+	−	−	−	+
4. Was inter-rater reliability assessed?	−	−	+	−	+	−
Criterion Reference Test						
1. Was the protocol described well enough to be reproducible?	+	+	+	+	+	+
2. Were results interpreted without knowledge of index findings?	?	−	?	+	?	?

Table 2 continued

	Sato et al. [12]	Shem et al. [16]	Skeppholm et al. [17]	Steele et al. [13]	Ward et al. [18]	Yamamoto et al. [10]
3. Was an impairment threshold used and was it pre-specified?	+	+	–	+	–	+
4. Was inter-rater reliability assessed?	–	–	–	+	+	+
Flow and Timing						
1. Was there an appropriate interval between screening and criterion tests?	?	?	?	+	+	?
2. Did all patients receive a criterion reference test?	+	–	–	+	+	+
3. Did all patients receive the same criterion reference test?	+	+	+	+	+	+
4. Were all patients included in the analysis?	+	–	–	–	+	+
5. Were all patients assessed in the same medical state for index and reference test?	?	?	?	+	+	+

Yes (+), No (–), Unclear (?), not applicable (n/a)

Study Characteristics

The 13 full articles were grouped according to the authors' stated objective to develop dysphagia-specific tools that involved either screening for the presence of dysphagia ($n = 7$), clinical bedside assessments for symptoms or signs related to swallow physiology ($n = 5$), or instrumental assessments of the safety and/or efficiency of swallow physiology ($n = 1$) (Table 1).

Seven articles presented screening tools to identify the increased risk of dysphagia presence. Etiologies included edentulous elderly [7], stroke [8], ALS [9], Parkinson's disease [10], mixed etiologies [11, 12], and unknown etiologies [13]. Screening methods utilized either clinician testing [7–9, 11–13] or patient self-report [10]. Of the screening methods utilizing clinician testing, two articles [11, 12] used the cough reflex and the remaining articles used one of the following screening methods: laryngeal movement captured by a magnetic sensor [7], water swallows of varying amounts per mouthful [8], varying oral intake of food and liquid textures [9] and capture of an acoustic swallow signal using an accelerometer [13].

Six other articles presented tools for dysphagia assessment either at the bedside [14–18] or using a technical instrument [19]. Of the five articles targeting bedside assessment, etiologies included spinal abnormalities [16, 17], head and neck cancer [15], Duchenne muscular dystrophy [14] and mixed etiologies [18]. Clinical assessment methods utilized patient self-report [14, 15, 17] or clinician testing of oral, oromotor and laryngeal function at the bedside [16, 18]. One article in this review targeted instrumental assessment in patients who had suffered a stroke utilizing an ultrasound device designed to measure tongue thickness [19].

Across all 13 accepted articles, confirmation of dysphagia involved a variety of criterion references: namely, combined repetitive saliva swallowing and digital laryngeal palpation [7], abnormal swallow physiology captured on videofluoroscopy [9, 15, 16], aspiration captured on videofluoroscopy [8, 10, 13], aspiration captured on endoscopy [12], aspiration captured on either videofluoroscopy or endoscopy [11], a live clinical exam [18], functional oral intake [19], and dysphagia related quality of life [17]. However, instead of using a criterion reference, one article [14] presented discriminative validity of self-report captured with the SSQ [20] in patients known to have or not have dysphagia.

Methodological Appraisal

Methodological critical appraisal of the included articles was conducted according to the QUADAS-2 criteria [2] and depicted in Table 2. Of the 13 accepted articles, only

three [9, 10, 16] declared the use of consecutive enrolment and did not conduct prior screening for dysphagia. One other article [7] failed to specify the nature of subject recruitment, and the remaining nine introduced serious bias by selecting patients with either suspicion of [8, 11–13] or confirmed dysphagia [14, 15, 17–19].

All accepted articles, except for one [10], described their index testing protocol with enough detail to ensure reproducibility. However, only three articles [11, 17, 18] assessed the inter-rater reliability of the index test. In addition, all but one article [8] described their protocol for criterion reference testing with sufficient detail to ensure reproducibility; yet, only five [10, 11, 13, 15, 18] assessed the inter-rater reliability of the criterion reference. Of these five articles, three [10, 11, 13] defined dysphagia according to airway safety alone (i.e., aspiration) without taking into account swallow efficiency. In general, blinding was not commonly used. In fact, only four articles clearly declared the use of rater blinding in some capacity—three related to their index tests [8, 11, 14] and one related to its criterion reference test [13]—and no article consistently to both tests.

Discussion

This systematic review of recent literature identified 13 articles that targeted development of new dysphagia tools. Of these, seven related to screening, only five to clinical assessment and one to instrumental assessment. Screening protocols identified in this systematic review captured the presence or absence of dysphagia using: (1) devices mounted on the thyroid lamina to record laryngeal elevation [7] or an acoustic swallow signal [13]; (2) concentrations of citric acid introduced into the oropharynx to trigger a cough response [11, 12]; (3) water swallow intake [8] or both water and solid food intake [9] to elicit a cough response and/or oxygen desaturation; and, (4) patient self report to identify problems with oral intake [10]. Similar to the screening protocols, three clinical assessment protocols used either patient self-report [14, 15, 17] or cough response following water intake [16]; however, in contrast to the screening tools, the stated purpose of the assessment protocols was to augment the clinical swallowing assessment. The remaining clinical assessment protocol compared findings from a live versus televised comprehensive exam of the same patients being assessed in both modes simultaneously [18]. The only instrumental assessment protocol that was included in this review used ultrasound measures in the oropharynx to verify dysphagia impairment [19].

Across all articles, critical appraisal identified serious methodological violations regarding: patient selection based on prior knowledge of swallowing status [7, 8, 11–14, 17, 18]; failure to use rater blinding during administration of the index test [7, 13, 16, 19] and/or criterion reference test [8, 9, 16]; and, failure to assess inter-rater reliability for the index [7–10, 12–16, 19] and/or criterion reference [7, 9, 12, 16, 17, 19] tests.

Each of these methodological violations places a study at substantial risk for bias. For example, enrolling patients with known dysphagia and/or a control group without dysphagia may over-estimate the diagnostic accuracy estimate of the new index test [2•], and thereby introduce a bias in its favor [3]. Also, the potential for bias in articles without blinding of both their index and criterion reference tests relates to the subjectivity of interpreting their findings, hence a likely opportunity to exaggerate the diagnostic accuracy [2•]. Furthermore, three articles [10, 11, 13] defined dysphagia narrowly according to airway safety alone without consideration of swallow efficiency. By restricting dysphagia to the absence of safety, milder and more 'difficult-to-diagnose' levels of dysphagia may be missed resulting in an overestimation of diagnostic accuracy [2•]. In sum, unfortunately none of the included 13 articles in this review addressing screening, clinical or instrumental assessment had sufficient methodological rigor, and therefore readiness, to justify immediate clinical implementation.

This study serves as an up-date to the systematic review by Schepp [4••]. Given that we identified no new recently published screening tools for dysphagia with adequate psychometric validation, we recommend continued uptake of the findings from Schepp et al. [4••]. According to their review, two available dysphagia screening tools with sufficient sample sizes and sound methodological and psychometric properties are available for clinical use today—the Toronto Bedside Swallowing Screening Test (TOR-BSST©) [5] and the Barnes Jewish Hospital Stroke Dysphagia Screen [6].

Recent published work [22] has postulated that no single dysphagia screening tool for patients post-stroke had reached consensus and was ready for clinical implementation. However, from the review by Schepp et al. [4••], two psychometrically tested screening tools do exist. These two screening tools were only published recently, 2009 and 2011, and it is likely too soon to expect high clinical uptake of either tool even though both were supported by high quality evidence. That is, the implementation of evidence is fraught with barriers not necessarily related to its quality; hence, the impetus for future research and funding bodies is to mandate knowledge translation objectives as part of clinical science proposals. [23, 24] Specific to implementation of dysphagia screening, identified barriers have resulted at the level of the institution (willingness to change existing protocols) and of the clinician screener (confidence in being able to execute screening properly). [25]

Despite these known barriers to implementation of a dysphagia screening tool, the TOR-BSST© for example is already being utilized by hundreds of speech-language pathologists, in 13 countries and the screening test has been incorporated as part of the Canadian guidelines for stroke care. [21, 26] That is, there is at least one psychometrically sound tool that is emerging with clinical impact on a national (and even global) level. Hopefully the value of the more recent Barnes screening tool will similarly be assessed in the clinical realm.

To ensure the best in patient care, it is critical that we continue to advance science. Our goals should now be to develop tools with the same methodological rigor for all patient groups with dysphagia, and beyond just screening. Although well validated clinical [27] and instrumental [28] assessment tools do exist, this study of the recent literature identified no new additions to this short list. Development of these assessment tools needs to be a future focus among our researchers. For stroke patients there already exist two well validated screening tools for dysphagia [4••] and we identified no recent additions for patients with stroke or other disorders.

Conclusion

In future studies of patients with dysphagia, it is essential to use prospective controlled study designs and only tools that are reliable, valid and feasible. Likewise, the development and testing of any new tools must ensure that they are reliable, valid and feasible.

Acknowledgments R Martino and NE Diamant are developers of the TOR-BSST© and R Martino offers a course focused on the TOR-BSST© for which she does not profit personally.

Compliance with Ethics Guidelines

Conflict of Interest R Martino has received research grants from Amgen and a speaker honorarium from Nestle. HL Flowers declares no conflicts of interest; SM Shaw declares no conflicts of interest; NE Diamant declares no conflicts of interest.

Human and Animal Rights and Informed Consent All studies by R Martino involving human subjects were performed after approval by the appropriate Institutional Review Boards. Written informed consent was obtained from all participants.

Appendix

See Table 3.

Table 3 Electronic search strategies

Database	Search strategy
Ovid MEDLINE (R) 1946—week 3 2013	1. exp deglutition disorders/
	2. deglut*.mp.
	3. swallow*.mp.
	4. dysphag*.mp.
	5. VSS.mp.
	6. VFS*.mp.
	7. FEES.mp.
	8. FEEST.mp.
	9. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
	10. exp Mass Screening/
	11. screen*.tw.
	12. assess*.tw.
	13. (swallow* adj2 test*).tw.
	14. (identification or identify or diagnos*).tw.
	15. or/10–14
	16. validit*.tw.
	17. validat*.tw.
	18. "gold standard".tw.
	19. ROC.tw.
	20. "receiver operator curve".tw.
	21. reliability.tw.
	22. sensitivity.tw.
	23. specificity.tw.
	24. or/16–23
	25. 9 and 15 and 24
	26. limit 25 to year = "2012—current"
PsycINFO 2002 to July Week 3 2013	1. dysphagia/
	2. swallowing/
	3. deglut*.mp.
	4. dysphag*.mp.
	5. VSS.mp.
	6. VFS*.mp.
	7. FEES.mp.
	8. FEEST.mp.
	9. or/1–8
	10. screening tests/
	11. screening/
	12. exp health screening/
	13. exp assessment/
	14. (screen* or assess* or identify or identification or diagnos* or (swallow* adj2 test*)).tw.
	15. or/10–14
	16. (validit* or validat* or "gold standard" or ROC or "receiver operator curve" or reliability or sensitivity or specificity).tw.
	17. 9 and 15 and 16
	18. limit 17 to year = "2012—current"

Table 3 continued

Database	Search strategy
EMBASE 1980–2013 week 30	1. exp dysphagia/
	2 deglut*.mp.
	3. swallow*.mp.
	4. dysphag*.mp.
	5. VSS.mp.
	6. VFS*.mp.
	7. FEES.mp.
	8. FEEST.mp.
	9. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
	10. exp screening/
	11. screen*.tw.
	12. assess*.tw.
	13. (identification or identify or evaluat* or diagnos*).tw.
	14. (swallow* adj2 test*).tw.
	15. or/10–14
	16. exp validity/
	17. validit*.tw.
	18. validat*.tw.
	19. "gold standard".tw.
	20. ROC.tw.
	21. "receiver operator curve".tw.
	22. reliability.tw.
	23. sensitivity.tw.
	24. specificity.tw.
	25. or/16–24
	26. 9 and 15 and 25
	27. limit 26 to year = "2012—current"
	28. exp dysphagia/
	29. deglut*.mp.
	30. swallow*.mp.
	31. dysphag*.mp.
	32. VSS.mp.
	33. VFS*.mp.
	34. FEES.mp.
	35. FEEST.mp.
	36. 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35
	37. exp screening/
	38. screen*.tw.
	39. assess*.tw.
	40. z.z(identification or identify or diagnos*).tw.
	41. (swallow* adj2 test*).tw.
	42. or/37–41
	43. exp validity/
	44. validit*.tw.
	45. validat*.tw.
	46. "gold standard".tw.
	47. ROC.tw.
	48. "receiver operator curve".tw.
	49. reliability.tw.
	50. sensitivity.tw.
	51. specificity.tw.
	52. or/43–51
	53. 36 and 42 and 52
	54. limit 53 to year = "2012—current"
CINAHL 1982—July 30 2013	1. TX FEEST
	2. TX FEES
	3. TX VFS*
	4. TX VSS OR TX dysphag* OR TX deglut*
	5. TX VSS
	6. (MH "Deglutition") OR (MH "Swallowing Therapy") OR (MH "Swallowing Therapy (Iowa NIC)") OR (MH "Swallowing Impairment (Saba CCC)") OR (MH "Impaired Swallowing (NANDA)") OR (MH "Deglutition Disorders")
	7. S1 or s2 or s3 or s4 or s5 or s6
	8. TX swallow* N2 test*
	9. TX assess* OR TX screen* OR (MH "Health Screening + ") OR identification OR identify OR diagnos*
	10. 8 or 9
	11. 7 AND 10
	12. TX validity OR TX validit* OR TX validat* OR TX "gold standard" OR TX
	ROC OR TX "receiver operator curve" OR (MH "Reliability") OR TX
	Reliability OR (MH "Validity") OR TX sensitivity OR TX specificity
	13. 11 AND 12
	14. 11 AND 12 Limiters—Published date: 20120101–20130631
EBM Reviews—Cochrane Central Register of Controlled Trials 2012 to July 2013	1. deglut* or swallow* or dysphag* or VSS or VFS* or FEES or FEEST:kw
	2. screen* or assess* or (swallow* adj2 test*) or identification or identify or diagnos*
	3. validity:kw
	4. validit* or validat* or "gold standard" or ROC or "receiver operator curve" or reliability or sensitivity or specificity
	5. 3 or 4
	6. 1 and 2 and 5
EBM Reviews—Cochrane Database of Systematic Reviews 2012 To July 2013	1. deglut* or swallow* or dysphag* or VSS or VFS* or FEES or FEEST:kw
	2. screen* or assess* or (swallow* adj2 test*) or identification or identify or diagnos*
	3. validity:ti,ab,kw
	4. validit* or validat* or "gold standard" or ROC or "receiver operator curve" or reliability or sensitivity or specificity
	5. 3 OR 4
	6. 1 AND 2 AND 5

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