Research Article

Characterizing dysphagia after spinal surgery

Anna Miles ¹, Gabi Jamieson¹, Lara Shasha¹, Kelly Davis²

¹Speech Science, University of Auckland, Auckland, New Zealand, ²Allied Health, Counties Manukau Health, Auckland, New Zealand

Context/Objective: Dysphagia after spinal surgery is well recognised. Characteristics of post-operative dysphagia are not well defined. This study explored severity, longevity, and physiological characteristics of dysphagia.

Design: Prospective, observational study.

Setting: Tertiary urban hospital.

Participants: Two-hundred fifty patients consecutively receiving spinal surgery.

Interventions: Demographic and clinical information were collected. Flexible endoscopic evaluation of swallowing (FEES) and videofluoroscopic study of swallowing (VFSS) recordings were analyzed.

Outcomes Measures: FEES recordings were analyzed using three validated symptom scales. VFSS recordings were analyzed using 10 objective digital measures of timing, displacement and symptoms.

Results: Of 250 patients, 75 were referred for swallowing assessment. Sixty-two received FEES and 11 VFSS. Patients with anterior approach surgery for cervical level injuries represented 85% of referrals ($n = 64$). Secretion accumulation, aspiration and residue scores decreased significantly within 2 months for most patients. For those with persisting dysphagia, objective VFSS measures demonstrated significant impairments in pharyngeal constriction, hyoid displacement and pharyngoesophageal segment opening with corresponding residue and aspiration scores. By 6 months, all patients had returned to a regular diet except three patients following anterior cervical discectomy and fusion (ACDF) who remained nil by mouth with severe physiological impairments.

Conclusions: A quarter of patients following spinal surgery present with dysphagia. For most, symptoms decrease significantly by 2 months and patients return to normal diets. Early screening of dysphagia is critical to avoid secondary complications and prolonged hospitalizations. For some, significant pharyngeal impairments persist and high-quality case series exploring efficacy of rehabilitation programmes are needed.

Keywords: Dysphagia, Deglutition, Spinal cord, ACDF, Aspiration

Introduction

Dysphagia (swallowing difficulties) is well-recognized as a complication of spinal surgery following spinal cord injury (SCI) and is the most common complaint after anterior cervical discectomy and fusion (ACDF).¹ Large cohort studies and a number of systematic reviews have documented incidence and explored risk factors for developing dysphagia over the last 20 years. Incidence of dysphagia following SCI varies from 2 to 81% depending on assessment method and cohort studied.^{1,2} In the largest published study, of 1,649,871 US patients following ACDF, only 2% had dysphagia

reported in their medical records.³ Yet, many large observational studies have reported higher numbers. In the UK, of 600 patients following SCI, 40% received input for dysphagia.⁴ Published rates of swallowing difficulties in patients with cervical SCI include: 7,⁵ 8,⁶ and 33%.⁷ Published rates of swallowing difficulties after ACDF include: 2,³ 11,⁸ and 13%.⁹

Risk factors for developing dysphagia have also been explored with common factors including: increased age,^{1,3,5,6,8,10,11} increased operative time,^{1,2,10,12} multiple level surgeries and revision surgeries,^{1,3,8,12} cervical level injuries/surgeries (particularly C1–4),^{1,4,5,8,11,12,13} ACDF⁹ and tracheostomy placement.^{5,6,10}

Fortunately, dysphagia is transient for most patients suggesting superficial post-operative injuries rather than permanent neural damage.¹ However, aspiration pneumonia is the highest cause of mortality in patients

Correspondence to: Anna Miles, Speech Science, School of Psychology, The University of Auckland, Tamaki Campus, Private Bag 92019, Auckland, New Zealand; Ph: +64 9 923 8177. Email: a.miles@auckland.ac.nz

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after SCI¹⁴ and there is merit in advocating for early dysphagia screening for patients.² In recent years, attention has been placed on surgical and medical techniques to reduce the risk of dysphagia and its secondary complications.¹² This recent systematic review provides multiple avenues for risk reduction including limiting operative time, where possible, using small/smooth plates, using anchored spacers instead of plates, steroid applications to wound closures and reducing tracheostomy cuff pressure.¹²

Dysphagia after SCI and spinal surgery is not surprising in view of the proximity of the injury, surgery, and permanent plating to vital cranial nerves and muscles involved in swallowing. The cause of dysphagia is likely multifactorial: neuronal, muscular and mucosal¹ as well as more generic contributors such as level of consciousness, pharmacological effects, intubation/ventilation effects, cognition, positioning and psychological effects (anxiety and mood). To date, little attention has been given to the physiological impairments leading to swallowing difficulties after SCI. Without an understanding of physiology, individualized rehabilitation programmes for those with persisting dysphagia are not possible. This study explored severity, longevity, and physiological characteristics of dysphagia after spinal surgery. The authors answered the following questions: How many patients receive input from a speech-language pathologist (SLP) for dysphagia assessment after SCI? What are the demographic characteristics of those referred compared with those who are not referred? How long do swallowing difficulties last? What are the common symptoms of dysphagia? What are the common physiological impairments?

Method

This prospective observational cohort gained appropriate local ethical approval (UAHPEC 9263). The study was designed and recorded according to the STROBE statement for observational studies.¹⁵

Participants

Two hundred and fifty patients received spinal surgery at one tertiary urban hospital in New Zealand between June 2014 and July 2017 [72% male; mean age 48 years (range 14–87, SD 19)].

Service pathway at the research site

There is a clinical pathway for patients at the research site following SCI and/or spinal surgery with suspected dysphagia (Figure 1). Differences in protocol across wards, SCI level, and surgical approach means that this cohort includes two referral types: (i) anticipatory referrals –

patients who have a cervical spine injury and are admitted to the Intensive Care Unit (ICU), and (ii) reactive referrals – patients who have a spine injury (at any level) and are admitted directly to the ward and are referred due to presenting symptoms of dysphagia and/or suspicion of dysphagia determined by medical team. All patients receive a standardized clinical swallowing evaluation (CSE) [case history, medical notes review, cranial nerve examination, cough reflex test (if not tracheostomized), oral trials]. Following CSE, the treating SLP determines need for Flexible endoscopic evaluation of swallowing (FEES) based on CSE findings. Typical reasons for FEES referral include: failed cough reflex test, dysphonia, signs of dysphagia (e.g. coughing, wet voice). FEES are conducted at a patient's bedside and repeat FEES were clinically driven. Videofluoroscopic study of swallowing (VFSS) is also clinically driven. Typically VFSS referrals are made if a patient continues to show signs of dysphagia during FEES beyond the acute phase and investigation of physiological impairments are required to guide rehabilitation.

There are standardized FEES and VFSS protocols at the research site. For FEES, a trained SLP conducts all procedures and no anesthesia was used. Patients are given 3× tspn Level 0: water, 3× sip Level 0: water, 50 ml continuous drinking of Level 0: water, 3× tspn Level 1: Mildly Thick water, 3× sips Level 1: Mildly Thick water, 50 ml continuous drinking of Level 1: Mildly Thick, 3× Level 4: Extremely Thick Drinks, followed by Level 7: biscuit or bread (iddsi.org). For VFSS, studies are recorded at 30 frames per second. A 2.2 cm diameter radio-opaque ring is taped to the patient's chin (in the lateral plane) to allow calibration for displacement measures. A Medical Radiation Technician (MRT) and a SLP are present at all procedures. Patients are screened in the lateral plane. Patients are given 1, 3, then 20 ml of Level 0: Regular Drink barium (E-Z Paque 100% w/v) followed by half a cup of Level 0: Regular Drink barium through a straw. Patients are then given 3 ml of barium paste (E-Z-paste 60% w/w). All procedures are truncated if required, for patient safety.

Data collection

Demographic, perioperative and postoperative variables were collected from the hospital's Spinal Injury Database and electronic clinical records by experienced clinicians. Clinical outcomes [including length of stay, oral intake, spinal cord injury, surgery, presence of pneumonia during the hospital admission (established using the NSHN (2005) "Criteria for Defining Nosocomial Pneumonia")] were recorded. FEES and

Figure 1 Examples of permanent spinal plating in four patients receiving a VFSS for persisting dysphagia.

VFSS recordings were collected and rated by clinicians trained and experienced in instrumental assessment interpretation. All FEES and VFSS were double blind marked by another author for reliability. The 7-point Functional Oral Intake Scale (FOIS) was selected as a validated and reliable tool to code food and drink recommendations.¹⁶

Measures and reliability testing

FEES recordings were evaluated in real-time and frame-by-frame viewing (QuickTime Media Player; Apple, Cupertino, California, USA) using three validated interval symptom scales: the 8-point New Zealand Secretion Scale (NZSS),¹⁷ the 8-point Penetration-Aspiration Scale (PAS),¹⁸ and the 5-point Yale Residue Scale (Yale).¹⁹ Agreement was excellent for NZSS (ICC = 96.5, C.I. 95.8–98.5), PAS (ICC = 97.80, C.I. 97.3–97.9) and Yale (ICC = 94.78, C.I. 93.4–96.5).

VFSS was analyzed using real-time and frame-by-frame viewing (QuickTime Media Player; Apple, Cupertino, California, USA). Swallowing parameters gathered by the researchers have been reported in detail previously.²⁰ This included four continuous

timing measures (seconds): Airway Closure Duration (Airway = AeCl–AeSt), Total Pharyngeal Transit Time (TPT = BP1–B1), Hyoid Maximum Displacement Duration (Hdur = H3–H2), Pharyngoesophageal Segment Maximum Opening Duration (PESdur = PC1–Pop); 4 continuous displacement measures (cm): Maximum Hyoid Displacement (Hm) and Hyoid-Larynx Approximation (HL), Pharyngoesophageal Segment Maximum Opening (PESMax), Pharyngeal Constriction Ratio (PCR) (cm²); one anatomical measure: Pharyngeal Wall Thickness (PWT) (cm); as well as two symptom measures: the 8-point Penetration-Aspiration Scale (PAS)¹⁸ and the Bolus Clearance Ratio (BCR) (cm²).²¹ All measures were taken from the 20 ml Level 0: Thin fluid bolus (iddsi.org) and were measured by two experienced researchers using Swallowtail software (Belldev Medical LLC, IL, USA). Agreement was excellent across all measures (ICC = 99.00, C.I. 98.2–99.5).

Statistical analysis

Data were inputted into Excel (Microsoft; Redmond, Washington, USA) and explored using descriptive

Table 1 Patient demographics (n = 250).

Variable		All patients (n = 250)	Patients referred to SLT (n = 75)
Age (Mean, range, SD)		48 years, 14–87, 19	50 years, 17–87, 20
Sex		Male 181 (72%)	Male 60 (80%)
Ethnicity	New Zealand European	90 (36%)	33 (44%)
	New Zealand Maori	59 (23.6%)	22 (29.3%)
	Pacific Islander	49 (19.6%)	10 (13.3%)
	European	14 (5.6%)	4 (5.4%)
	Asian	17 (6.8%)	4 (5.4%)
	Other	21 (8.4%)	2 (2.6%)
Cause of spinal injury	Traumatic	198 (79.2%)	69 (92%)
	Non-traumatic	52 (20.8%)	6 (8%)
Spinal injury level	Cervical	123 (49%)	64 (85%)
	Multi-level – Cervical/thoracic	16 (6%)	4 (5%)
	Thoracic	51 (20%)	4 (5%)
	Multi-level – Thoracic/lumbar	9 (4%)	–
	Lumbar	50 (20%)	3 (4%)
	Multi-level – Cervical/thoracic/lumbar	1 (0.5%)	–
ASIA ¹ scores reported on discharge report from acute care*	Grade A	76 (33%)	29 (42%)
	Grade B	16 (7%)	10 (40%)
	Grade C	29 (13%)	9 (14%)
	Grade D	97 (43%)	22 (31%)
	Grade E	6 (3%)	2 (3%)

¹American Spinal Injury Association (2019).

*ASIA scores not available for 26 patients. Often not completed for patients with infection or tumor.

statistics and graphing. Objective VFSS measures were compared to established normative data.²⁰ Statistical analyses were conducted using IBM SPSS Statistics Data Editor (Version 23, IBM Corporation, Chicago, IL). Inter-rater reliability was calculated for FEES and VFSS ratings. Intra-class correlation coefficients (ICC 3,1) and their 95% confidence intervals (C.I.) were used to assess agreement for ordinal and continuous measures. The Cicchetti interpretation of ranges of ICC values was used to determine the strength of agreement: poor (0.00–0.39), fair (0.40–0.59), good (0.60–0.74), and excellent (0.75–1.00).²²

Correlation statistics were used to determine the association between FEES scores and patient variables. Normality testing (graphically and using the Kolmogorov–Smirnov Test) was conducted on all continuous data. No continuous data was normally distributed. Spearman's correlation coefficient were used for all continuous and interval data. For dichotomous data, Point-biserial correlation coefficient was calculated. A $P < .05$ was considered statistically significant for all analyses.

Results

Of the 250 patients following spinal surgery, approximately half had a cervical level SCI (49%). Seventy-five patients were referred to SLP for swallowing assessment [80% male; mean age 50 years (range 17–87, SD 20)] with 62 receiving a FEES assessment and 11

additionally receiving a VFSS. Of the patients referred to SLP, 85% had a cervical level SCI. Table 1 displays the comparison of demographic and clinical information for those referred to SLP compared with the full cohort.

Swallowing characteristics

Sixty-two patients received one or more FEES assessments. Table 2 displays clinical indices for patients referred for a swallowing assessment ($n = 75$). Figure 2 shows patients' symptoms scores over time (FOIS, NZSS, PAS, Yale).

VFSS assessments were conducted on 11 patients with persisting dysphagia (4 = ACDF; 3 = posterior approach cervical surgery; 2 = multi-level cervical/thoracic spinal; 2 = thoracic). All patients had already received at least 2 FEES prior to their VFSS and VFSS occurred between 25 and 40 days post-surgery. Seven patients who received a VFSS had a percutaneous endoscopic gastrostomy (PEG) *in situ*. All 11 patients aspirated (PAS 6+); 7 silently (PAS 8) and aspiration occurred on residue post-swallow and occurred both on Level 0: Thin Drinks as well as Level 4: Extremely Thick Drinks (iddsi.org). Figure 3 displays objective VFSS measures across patients on their first VFSS compared to published normative data.²⁰ Hyoid displacement, pharyngeal constriction and pharyngoesophageal segment maximum opening were impaired in most patients (11, 10 and 6 patients respectively).

Table 2 Clinical outcomes for patients referred for swallowing assessment ($n = 75$).

Variable		All patients referred ($n = 75$)
Length of stay (days) (mean, range, SD)	Acute Hospital (incl. ICU stay)	36, 3–157, 34
	Rehabilitation Unit	48, 1–132, 38
Discharge destination from acute hospital	Home	3 (4%)
	Auckland Spinal Rehabilitation Unit	66 (91%)
	Other public hospital	2 (3%)
	International	2 (3%)
Discharge destination from rehabilitation unit	Died in hospital	2 (3%)
	Home	55 (73%)
	Private hospital	15 (20%)
	Other public hospital	3 (4%)
	Died in hospital	2 (3%)
Tube feeding incidence	Nasogastric tube	44 (57%)
	Percutaneous endoscopic gastrostomy (PEG)	7 (9%)
Tube feeding duration (days) (mean, range, SD)		25, 0–253, 47
Pneumonia		32 (43%)
FOIS on first FEES	1	19
	2	13
	3	6
	4	3
	5	14
	6	10
	7	10

FOIS = Functional Oral Intake Scale (1 = enteral fed; 7 = regular diet).

All 11 patients had pharyngeal wall thickness (PWT) exceeding published norms (Mean 0.88, range 0.66–1.21, SD .44).²⁰ Figure 4 demonstrates impaired maximum hyoid displacement in one patient.

Dysphagia longevity and severity

Longevity and severity of dysphagia varied across patients, with the number of patients continuing to require a modified diet decreasing from 21% (52/250) between 1 and 7 days post-surgery to 1% (3/250) by 121–180 days post-surgery (Figure 3). By acute hospital discharge, only three patients remained fully enterally fed by PEG with no oral intake – all following ACDF; two additional PEG were being used supplementary to oral intake; and two PEG were still *in situ* but no longer used.

Impact of dysphagia

There were significant correlations between pneumonia and other variables: referral to SLP ($r_{ps} = .25$, $p < .001$), length of stay ($r_{ps} = .33$, $P < .001$), tracheostomy placement ($r_{ps} = -.28$, $P < .001$) and days nil-by-mouth ($r_{ps} = .41$, $P < .001$). Length of acute stay was significantly associated with: referral to SLP ($r_{ps} = .30$, $P < .001$), tracheostomy ($r_{ps} = .55$, $P < .001$), NZSS ($r_s = .30$, $P < .001$), and PAS ($r_s = .37$, $P < .001$).

Figure 2 Oral intake recommendations and swallowing symptoms over time in those who received FEES (a) Functional Oral Intake Score (FOIS), (b) New Zealand Secretion Scale (NZSS), (c) Penetration-Aspiration Scale (PAS) and (d) Yale Residue Scale (Yale) ($n = 62$).

Figure 3 Number of objective VFSS measures within and outside normal limits across patients ($n = 11$). Outside normal limits = outside 1 Standard Deviation (SD) of age and sex matched norms.²⁰

Length of rehabilitation stay was also significantly associated with swallowing-related indices: referral to SLP ($r_{ps} = .28$, $P < .001$), tracheostomy ($r_{ps} = .28$, $P < .001$), NZSS ($r_s = .36$, $P < .001$), PAS ($r_s = .36$, $P < .001$) and acute length of stay ($r_s = .58$, $P < .001$).

Discussion

This is the first study of swallowing difficulties in patients following spinal surgery in New Zealand. The wide age range, heavy weighting of males, cervical injuries and traumatic causes is consistent with spinal units worldwide.³ As has been previously reported, this large study demonstrates that cervical level injuries and anterior approach surgeries are referred to SLP most often.^{2,9,10} While a quarter of patients presented with dysphagia in the first week after spinal surgery; for

most, symptoms decreased significantly by two months and patients returned to regular diets. This transient nature of dysphagia post-spinal surgery is well documented.^{1,8,23}

The fundamental objective of this study was to explore physiological characteristics of dysphagia after spinal surgery using objective instrumental measures. The majority of reporting on dysphagia following spinal surgery has been through binary measures such as a pass/fail on a swallowing screen or aspirated/did not aspirate on instrumental assessment. In order to develop individualized rehabilitation programmes for those with persisting dysphagia, SLPs need to go beyond aspiration to its physiological cause. SLP swallowing exercises treat physiological impairments not symptoms. A recent systematic review of intervention

Figure 4 Videofluoroscopic image of reduced hyoid displacement (i) hyoid at rest and (ii) hyoid at maximum displacement.

following traumatic spinal cord injury reports case studies primarily describing compensatory interventions such as enteral feeding, steroids and antibiotics and compensatory swallowing techniques.²⁴ Further research is needed to support rehabilitation teams.

Swallowing characteristics

In the acute stages, a quarter of patients presented with swallowing difficulties; displaying patterns of pharyngo-laryngeal secretion accumulation, silent aspiration of secretions (NZSS 7) and food/drinks (PAS 5 or 8), and pharyngeal residue build-up. Aspiration was often a consequence of residue (post-swallow). These symptoms are common in other surgeries where prolonged intubation is required.^{25,26,27,28} The majority of patients recovered in the acute period post-surgery similarly to an early study comparing aspiration in those <2 month post-operatively and >2 months post-operatively.²³ In patients after cardiothoracic surgery, similar patterns of spontaneous recovery have also been reported.^{28,29,30} Possible causes of these transient difficulties includes localized intubation trauma to the upper airway leading to edema and sensory impairment; alongside overall poor patient medical condition such as tracheostomy placement, level of consciousness, ability to sit upright, medicine effects and fatigue.

Tracheostomy and dysphagia have a contentious past with some researchers un-convinced of a causal link between tracheostomy and aspiration, rather proposing the medical condition leading to the need for tracheostomy being the underlying cause of the swallowing difficulties.³¹ In this study, tracheostomy was associated with pneumonia and length of stay. In reality, for the clinical team, tracheotomy has repeatedly been reported as an independent 'red flag' for dysphagia across populations whether causal or not.³²

Spinal surgery, particularly with an anterior approach, is highly likely to have an impact beyond endotracheal tube trauma and tracheostomy placement. Laryngeal and pharyngeal structures, including muscles and nerves, are moved laterally to allow the surgeon to reach the anterior cervical spine. This likely leads to localized edema, as well as muscular and neurovascular injury.^{12,33} Localized swelling at the surgical and instrumentation site is inevitable. Its effect on dysphagia is unknown. Khaki and colleagues measured soft tissue swelling at the caudate endplates of C2 and C6 radiographically, pre-operatively, immediately post-operatively and at 6 and 12 weeks post-operatively.³³ At 6 weeks, the majority of swelling had reduced. They found no relationship between swelling and dysphagia. However, their dysphagia assessment was a self-reported

symptom rating scale and no physiological measures were taken.³³ Increased pharyngeal wall thickness, as seen in all of our 11 patients who received a VFSS, has been reported previously and likely corresponds with the Khaki team's soft tissue swelling.^{23,33,34} It is possible that recommendations such as those provided by Joaquim *et al* could reduce some of these acute causes of dysphagia.¹²

Motor and sensory swallowing impairments may arise from the spinal injury itself, surgery and/ or instrumentation placement, through temporary or permanent nerve damage, as well as soft tissue swelling. Few studies have documented physiological changes following spinal surgery.^{23,34} Leonard and colleagues, pioneers of objective physiological measurement, demonstrated patterns of increased pharyngeal wall thickness, reduced epiglottic deflection, reduced pharyngeal constriction, reduced pharyngoesophageal segment opening and reduced hyoid displacement in their early patient group (<2 month post-operatively, $n = 22$) compared to their late patient group (>2 month post-operatively, $n = 45$) and their controls.²³ Muss and colleagues provide one of the only other current explorations of objective pharyngeal parameters with both pre-operative and post-operative measures on 17 patients.³⁴ They report similar impairments in superior hyoid excursion and increased pharyngeal wall thickness post-operatively. They postulate on the impact of damaged longitudinal pharyngeal muscles on hyoid excursion and these observations are similar to patterns of impairment seen in the current study.³⁴ Contributions of cervical instrumentation on epiglottic deflection, pharyngeal shortening and constriction as well as anterior and superior hyoid movements need consideration. While, only a small number of patients continue to struggle with swallowing difficulties, rehabilitative treatment approaches need to be developed for this unfortunate group.

Consequences of dysphagia

This study corroborates a multitude of papers establishing a link between dysphagic symptoms such as diet modification, aspiration, residue and secretion accumulation with poor health outcomes.^{35,36} Pneumonia and ICU/acute hospital length of stay are costly to the health service³⁷ and risk delaying patients from receiving vital early intensive physiotherapy. With silent aspiration rates high in all populations where prolonged intubation is a presenting factor, early routine instrumental assessment is the only way to ensure the multidisciplinary team are well-informed about a patient's risk of aspiration. SLP are an essential team member and

should be involved in feeding decision-making as soon as a patient is medically stable enough for oral intake.

Limitations/future directions

This prospective study presented clinical practice and, in doing so, did not control for who received an instrumental assessment or the timing and frequency of instrumental assessments. Specific information regarding vocal fold movement and paresis was not consistently documented in patient clinical notes. This would have provided a greater understanding of potential surgical damage to tissue or nerves contributing to dysphagia severity.²⁸ A prospective longitudinal study design where all patients receive endoscopic and radiographic instrumentation prior to and post-surgery would truly provide an understanding of prevalence and pre-existing swallowing difficulties.

Limited clinical use of VFSS means VFSS objective measures are only reported on 11 patients, however, this provides rich data on those with persistent swallowing complaints. A validated patient self-report in combination with standardized instrumental assessment would be beneficial in capturing patient perceptions and the impact of dysphagia on quality of life. Rehabilitation for dysphagia in patients following SCI is under-researched and future investigations of associations between instrumental assessment and patient perceptions of their dysphagia could direct rehabilitative management plans for these patients. This would be particularly beneficial for the small proportion of patients who present with persistent dysphagia.

Conclusion

A quarter of patients following spinal cord injury and spinal surgery present with dysphagia. Dysphagia is seen across spinal levels though is most common in those with cervical level injuries and in those receiving an anterior approach surgery. For most, symptoms decrease significantly by two months and patients return to normal diets. Swallowing measures correlate with prolonged acute and rehabilitation center length of stay and development of pneumonia. Early screening of dysphagia is critical in acute care to avoid secondary complications and prolonged hospitalizations.

For some, significant pharyngeal impairments persist including reduced pharyngeal constriction, hyoid displacement and pharyngo-esophageal segment opening. Objective measures of pharyngeal parameters of swallowing within this population are needed to understand the pathophysiology. High-quality case series exploring efficacy of rehabilitation programmes are needed.

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ORCID

Anna Miles <http://orcid.org/0000-0003-3260-5824>

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