

ORIGINAL ARTICLE

WILEY

Perioperative instrumental swallowing evaluation in adult airway reconstruction: A retrospective observational cohort study

Matthew Haywood  | Lindsay Lovell | Justin Roe | Gemma Clunie | Guri Sandhu | Chadwan Al Yaghchi 

National Centre for Airway Reconstruction,
Charing Cross Hospital, London, UK

Correspondence

Matthew Haywood, National Centre
for Airway Reconstruction, Charing
Cross Hospital, Fulham Palace Road,
Hammersmith, London W68RF, UK.
Email: matthewhaywood0@gmail.com

Funding information

Gemma Clunie receives funding from the
National Institute for Health Research
(NIHR) Integrated Clinical Academic
Clinical Doctoral Fellowship Programme.
Dr Justin Roe receives funding from the
Imperial Health Charity and Imperial
NIHR Biomedical Research Centre. We
acknowledge the support and infrastructure
provided by the NIHR Imperial Biomedical
Research Centre.

Abstract

Objectives: Airway reconstruction for laryngotracheal stenosis (LTS) encompasses several procedures. Dysphagia is a well-recognised sequela of LTS and airway surgery, however studies have employed mostly non-validated assessments post-operatively in small, heterogenous samples, perpetuating uncertainty around the contributions of LTS and its management to impaired deglutition. Consequently, considerable variation in LTS perioperative nutritional management exists. Our objective was to characterise baseline and post-operative dysphagia with instrumental assessment in an LTS cohort undergoing airway reconstruction and provide a gold-standard management framework for its management.

Design, setting, participants and main outcome measures: We performed a retrospective cohort study of adult airway reconstruction procedures from 2016-2020 at our quaternary centre. Patient background, LTS aetiology, procedure type, tube feeding duration, length of stay and serial Functional Oral Intake Scale (FOIS) and International Dysphagia Diet Standardisation Initiative (IDDSI) scores were noted. Baseline, post-operative day one and post-stent removal Fiberoptic Endoscopic Evaluation of Swallow (FEES) generated Penetration Aspiration Scale (PAS) scores.

Results: Forty-four patients underwent forty-six reconstructions. Baseline incidence of penetration-aspiration was considerably higher than the general population and worsened in the immediate post-operative period, however FOIS and PAS scores generally returned to baseline by discharge. Post-operative FOIS correlated negatively with tracheostomy or airway stent placement. At discharge, 80% tolerated soft or normal diet and 93% were feeding tube independent.

Conclusions: We present the largest adult airway reconstruction cohort with instrumental swallow assessment perioperatively. LTS patients have a higher incidence of underlying dysphagia but swallowing tends to return to baseline with appropriate postoperative rehabilitation. Such practice may avoid the complications, costs and morbidity of prolonged nutritional support.

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2021 The Authors. *Clinical Otolaryngology* published by John Wiley & Sons Ltd.

1 | INTRODUCTION

Airway reconstruction is indicated for the definitive management of laryngotracheal stenosis (LTS), a condition characterised by narrowing at one or more sites between the supraglottic larynx and carina.¹ Augmentation of airway calibre with autologous cartilage grafting and/or resection of the affected segment form the basis for a diverse group of procedures, which target different disease patterns; as such, the term “airway reconstruction” may refer to tracheal resection, open or endoscopic laryngotracheal reconstruction (LTR) or cricotracheal resection (CTR).² Although congenital cases of LTS are recognised, acquired aetiologies predominate and most commonly follow intubation or tracheostomy-related airway trauma. Less common causes include idiopathic subglottic stenosis, autoimmune disease (sarcoidosis, granulomatosis with polyangiitis, relapsing polychondritis), infection (rhinoscleroma), benign and malignant tumours and their surgical treatment, radiotherapy and blunt or thermal injury.^{3–5} For patients afflicted with LTS, long-term effects on voice and swallow are experienced both as a result of the underlying condition but also the attempts to treat it, often in the form of repeated endoscopic airway dilatations which precede more formal reconstructive surgery.^{6–8} Impaired deglutition can result in profound morbidity or death as a result of tube feeding dependency and recurrent aspiration, the aetiology of which is multifactorial and includes postoperative and post-radiotherapy oedema and fibrosis, reduced laryngeal sensation and hyolaryngeal excursion, intra-operative supra- and infra-hyoid muscle release, the presence of an airway stent, cricoarytenoid joint fixation, the sequelae of laryngofissure and recurrent laryngeal nerve injury affecting vocal cord adduction and upper oesophageal sphincter opening.^{2,6}

1.1 | Instrumental swallow assessment around the time of airway reconstruction

Despite the widespread recognition that LTS-related swallow impairment is commonplace—often subclinical—and potentially exacerbated by airway reconstruction, attempts to measure the degree and incidence of preoperative dysphagia meaningfully and how it evolves with time and intervention have been extremely limited. Studies of adult airway reconstruction cohorts have thus far employed mostly non-validated assessment tools in small and heterogeneous groups at a single time point (ie the postoperative phase) only. Visual-analogue scales,⁷ self-reports,⁹ tolerance of diet,¹⁰ discomfort on swallowing,¹¹ bedside assessment and aspiration on videofluoroscopy (VFS)² have all been utilised as measures of swallow difficulty. This lack of consensus has resulted in considerable variation in practice with respect to nutritional management of the newly reconstructed airway, specifically the duration of tube feeding, timing and nature of swallow assessment and length of hospital stay.⁶

A clear understanding of preoperative swallow status based upon instrumental evaluation (ie VFS and Fibreoptic Endoscopic Evaluation of Swallow, [FEES]) with validated scoring systems may

Keypoints

- Chronic dysphagia is experienced as a result of Laryngotracheal Stenosis (LTS) but also its surgical management, potentially resulting in profound morbidity.
- Previous reports measuring the degree and incidence of perioperative dysphagia in patients undergoing airway reconstruction for LTS are of limited validity.
- Gold-standard instrumental swallow assessment may aid patient selection for surgery and guide postoperative rehabilitation when used in combination with patient and clinician-reported outcome measures.
- Swallowing is generally preserved in the context of airway reconstruction with appropriate rehabilitation and may enable earlier discharge.
- Given the low incidence of LTS, a universally agreed protocol for instrumental swallowing assessment in airway reconstruction may advance understanding through consistent data reporting.

support appropriate patient selection and preparation for airway reconstruction, as well as helping to predict the likely degree and duration of postoperative dysphagia. This is of critical importance because it is recognised that underlying aspiration pre-disposes to reconstruction failure and may deteriorate with surgery such that significant chronic lung damage ensues.¹² Additionally, both clinicians and patients can anticipate the level of commitment to rehabilitation commensurate with achieving a good swallow outcome, as well as any likely requirement for longer-term tube feeding.^{13,14}

Repeat assessment in the acute postoperative phase may enable an earlier return to oral diet, thus mitigating the risks of laryngeal disuse-dysfunction and subsequent aspiration whilst expediting discharge and improving patient experience. Furthermore, a longitudinal comparison of these data (ideally prospectively) would aid in delineating the relative contribution of airway reconstruction to overall swallow dysfunction and the nature of the recovery phase, improving understanding of the procedure morbidity and empowering clinicians to better counsel candidates for surgery. Such an approach could lead to better standardisation of care and facilitate useful comparisons between centres as part of good clinical practice.

1.2 | Other measures of swallow dysfunction

Instrumental assessment remains critical to understanding swallowing biomechanics; however, patient- and clinician-reported outcome measures can be equally important, particularly when measuring interval change as therapy progresses. Recent studies of head and neck cancer and neurological dysphagia suggest no statistically significant correlation exists between Functional Oral Intake Score (FOIS) and Penetration-Aspiration Scale (PAS) score as determined by FEES.^{15,16}

It is also recognised that tube feeding in head and neck malignancy should not be used as a surrogate measure for swallowing ability, as this may underestimate the level of dysphagia in those who choose to eat irrespective of instrumental assessment recommendations.¹⁷ Whilst we could not identify any similar studies published within the LTS literature, the above conclusions can be reasonably extrapolated to this group, thus emphasising the importance of instrumental evaluation in accurately characterising swallow dysfunction.

We report here on the largest adult airway reconstruction cohort to date with protocolled pre- and postoperative multidimensional swallowing evaluation. Our primary objective was to more clearly define the baseline dysphagia and perioperative swallowing trajectory in this group using our proposed “gold-standard” assessment and management framework.

2 | MATERIALS AND METHODS

2.1 | Patient evaluation and treatment

We perform a baseline bedside swallow assessment or FEES on all patients due to undergo airway reconstruction followed by a FEES on the day following surgery unless their clinical condition is preclusive. If day 1 postoperative assessment is impossible, then re-assessment is carried out within the first 7 days. The findings from FEES studies generate PAS scores,¹⁸ whilst FOIS and International Dysphagia Diet Standardisation Initiative (IDDSI) scores are assigned based on both the FEES and the evaluation of progression of oral intake at the bedside.^{19,20} The decision to perform preoperative bedside or instrumental assessment is guided by the patient's symptoms and the clinician's perceived severity of any underlying dysphagia, with instrumental assessment being indicated in cases of more severe swallowing dysfunction. In the event of airway stent placement (usually for stenosis at or near the glottis), a further FEES is performed after stent removal, that is, at the point of discharge. Skin-covered stents aim to prevent recurrent circumferential airway scarring and remain in situ for 2 weeks.⁵ Closed transglottic airway stents provide mechanical obstruction to frank aspiration and make detection of micro-aspiration on FEES difficult, rendering an accurate grading beyond PAS 2 impractical and of minimal clinical benefit. Therefore, PAS scores are reported as either 1-2 or 3-8 in our results. A follow-up FEES in the outpatient setting is only performed in selected cases when there is ongoing clinical concern regarding swallow function or dietary modification is being considered. FEES is preferred over VFS as it offers visualisation of the laryngopharynx, voice and swallow mechanisms, oedema, penetration and aspiration, secretion management and airway stent position, as well as the ability to perform serial inpatient bedside assessments postoperatively.¹ If an oesophageal issue is suspected or the degree of aspiration on FEES is in doubt, a VFS may be performed if it is likely to change management. The treatment of any identified dysphagia includes therapeutic manoeuvres, dietary modifications, interim tube feeding and swallowing rehabilitation exercises as part of a regular review process to ensure

progression,⁶ with avoidance of nil by mouth status wherever possible. Such an approach is supported by our belief that oral intake and swallow rehabilitation are the major independent (and interrelated) factors influencing long-term swallowing outcomes in a mobile, independent and otherwise healthy patient cohort, whilst excessive caution risks further deterioration in function.²¹

2.2 | Data collection and analysis

Our service evaluation was approved by Imperial College Healthcare Trust (ICHT, reference ENT 408) and governance was provided via the ICHT Service Evaluation and Audit governance committee; the present work was produced in conjunction with the STROBE guidelines for reporting on cohort studies. An electronic database was populated from a retrospective operative log and case note analysis encompassing airway reconstruction procedures performed between January 2016 and August 2020 at a single centre. Patient background, LTS aetiology, type of airway reconstruction procedure, presence of a skin-covered Silastic stent and/or covering tracheostomy, duration of nasogastric tube (NGT) feeding, gastrostomy placement, postoperative complications, length of stay and pre- and postoperative FOIS and IDDSI scores were noted. FOIS and IDDSI scores were included if they were explicitly documented, otherwise they were recorded as “not assessed.” Whilst some of these scores can be inferred from the notes, we did not feel the accuracy and continuity of the data could be guaranteed. Pre- and postoperative FEES recordings were reviewed by two speech and language therapists (SLT) immediately after assessment and assigned a PAS score by consensus. Spearman correlation multivariate analysis was performed using GraphPad Prism 8.4 software.

3 | RESULTS

Forty-four patients (25 females, 19 males) with a mean age of 46.7 years (23-81; standard deviation [SD] 14.4) underwent 46 airway reconstruction procedures, employing 41 airway stents and 38 covering tracheostomies. Two revision cases were performed: one patient had two open LTRs and another received an open LTR followed by open tracheoplasty. The incidence of different cohort LTS aetiologies is presented in Table 1. All patients had a history of endoscopic airway procedures and eight had undergone previous airway reconstruction.

Twenty-eight LTRs (25 transglottic and three open tracheal stents); seven endoscopic LTRs (one closed transglottic, three open tracheal and three Eliachar stents), 10 tracheal resections (five open tracheal stents) and one open tracheoplasty (T tube stent) were performed. Mean length of hospital stay was 18.2 days (7-32; SD 4.9), with one immediate postoperative intensive care admission and four unplanned returns to theatre. No VFS were indicated during the study.

Functional Oral Intake Score and PAS scores for the cohort generated preoperatively, within the first postoperative week, post-stent removal and at clinical follow-up are shown in Figures 1 and 2A, respectively. The PAS scores represent the worst performance

Cause of LTS	Frequency	Cause of LTS	Frequency
ISGS	10	IgG4 disease	1
Post-intubation	11	ENT limited vasculitis	1
GPA	6	Idiopathic supraglottic stenosis	1
Post-tracheostomy	4	Relapsing polychondritis	1
Trauma	2	Laryngeal plasmocytoma	1
Congenital SGS	2	Laryngeal chondrosarcoma	1
Radiotherapy	1	Subglottic adenocarcinoma	1
Rhinoscleroma	1		

Abbreviations: GPA, glomerulonephritis with polyangiitis; ISGS, idiopathic subglottic stenosis.

TABLE 1 Frequency of different causes of laryngotracheal stenosis (LTS, n = 44)

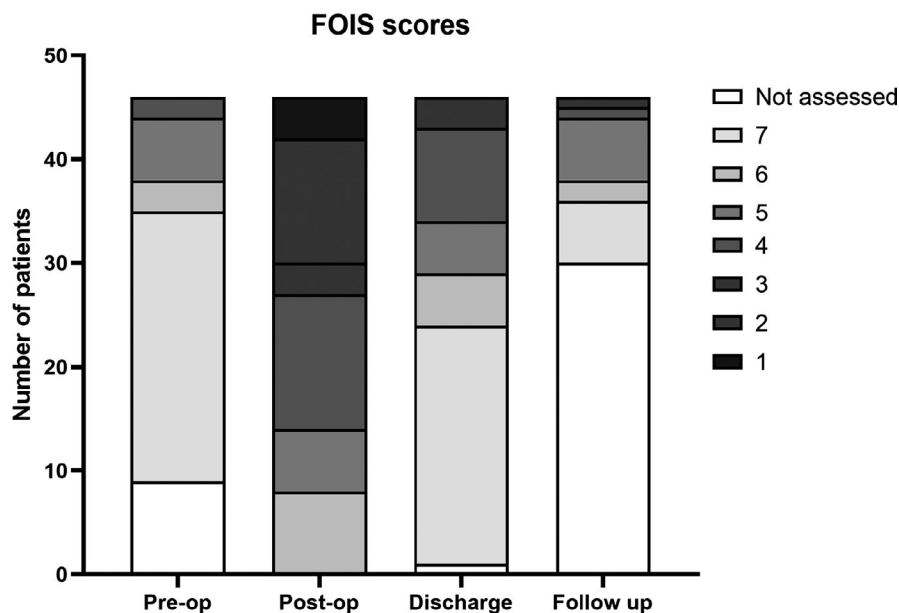


FIGURE 1 Perioperative Functional Oral Intake Scale (FOIS) scores

across the whole FEES examination for any texture. Both measures reveal a tendency for patients to return to baseline swallow function following a period of postoperative recovery. Figure 2B,C detail postoperative PAS scores by stent type and procedure. The mean duration of follow-up amongst patients with an outpatient FEES (n = 13) was 28 weeks (6-146; SD 37.7).

Swallowing function did not correlate with type of airway reconstruction, either at first postoperative assessment (surgery vs FOIS $r = -.05$, $P = .74$; surgery vs PAS $r = -.09$, $P = .54$) or at discharge (surgery vs FOIS $r = .07$, $P = .65$, surgery vs IDDSI $r = .08$, $P = .6$). However, postoperative FOIS scores were negatively correlated with the presence of a tracheostomy ($r = -.32$, $P = .03$) or airway stent ($r = -.33$, $P = .025$).

Figure 3 depicts the matched data points for the 22 stented patients with postoperative and post-stent removal (ie at discharge) PAS scores. Whilst most experienced improvement in swallow following stent removal, this difference was non-significant (Wilcoxon's Signed-Rank Test, $P = .75$). Figure 4 provides a breakdown of IDDSI scores for the entire cohort preoperatively, at discharge and at clinic follow-up. IDDSI and FOIS data at discharge were available for all but one patient, with 80% per cent tolerating soft or normal diet

(IDDSI 6 or 7) and all cases managing at least pureed diet (IDDSI 4). Ninety-three per cent were feeding tube independently (FOIS 4-7).

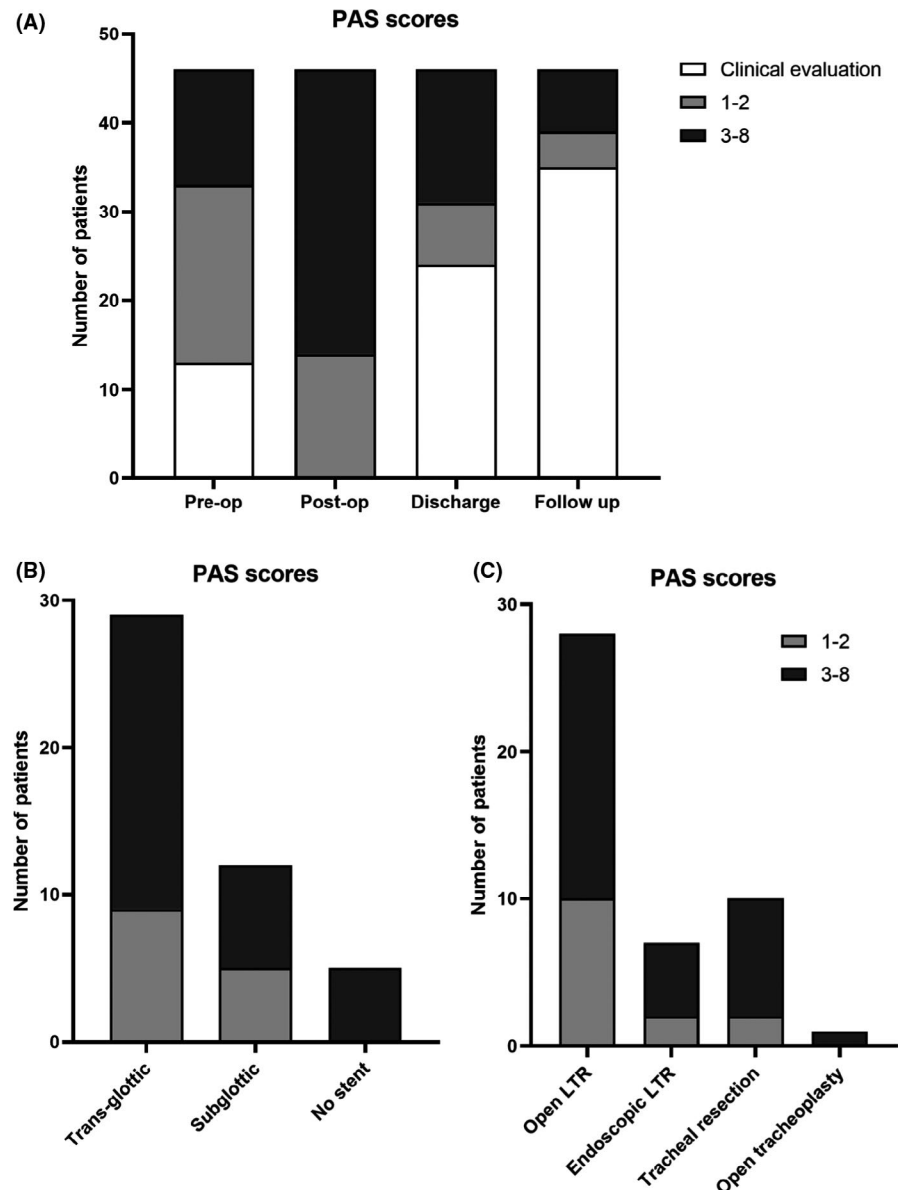
Nasogastric tube feeding duration data were available for 44 procedures as shown in Table 2. Two patients underwent gastrostomy insertion (one open and one endoscopic LTR); however, in both cases total oral intake was eventually re-established and the gastrostomy removed. Patients with an NGT feeding duration of 24 hours were permitted to return to full oral diet at their first postoperative swallow assessment; however in some cases, the NGT remained in situ for a further 24-48 hours until SLT and dietetic criteria for withdrawal of alternative nutritional support had been fulfilled. The mean NGT duration is expressed for each group requiring more than 3 days of postoperative tube feeding.

4 | DISCUSSION

4.1 | Timing of FEES and return to oral intake

Our PAS data revealed an increased risk of airway penetration (PAS ≥ 3) in the acute postoperative phase. Despite this,

FIGURE 2 Penetration-Aspiration Scale (PAS) scores as determined by FEES (Fibreoptic Endoscopic Evaluation of Swallow). A, Perioperative PAS scores for entire cohort; B, Postoperative PAS scores by stent type; C, Postoperative scores by procedure type



our prevailing practice is to feed via the oral route whenever possible, and as such only four patients were kept nil by mouth following their first postoperative assessment (59% were commenced on total oral intake, ie FOIS 4-7). We suggest performing the first assessment on the day after surgery and certainly within the first week. The recommendation to start oral intake in the presence of laryngeal penetration is based on several factors outside the scope of the PAS scoring system and includes the degree of coughing with solids and liquids, the risk of stent dislodgement, the patient's ability to perform swallowing manoeuvres, the volume of any suspected aspiration and susceptibility to chest infections. Dysphagia usually improves relatively quickly as pain and swelling subside and is evidenced by the trends in FOIS and IDDSI scores with time from surgery. Most patients, therefore, quickly return to their preoperative intake provided pain relief is adequate and they are motivated to engage with therapy.

In seven cases PAS scores deteriorated following stent removal (Figure 3), suggesting that the stent was having a protective effect on the airway. Whilst it is not unexpected that transglottic stents impair swallow to a greater degree than subglottic stents (Figure 2B), we did not anticipate that both endoscopic LTRs and tracheal resections would proportionally demonstrate more marked acute dysphagia than open LTRs. The *n* of these sub-groups are too small to draw more definitive conclusions; however, this finding highlights an area within airway surgery that would benefit from further research.

Incremental improvements in swallowing continue to occur in the months following surgery supported by a reduction in the number of low IDDSI and FOIS scores and high PAS scores at clinic follow-up compared to discharge. However, most patients are not assessed formally in clinic if they report their swallow function to be stable or improved and there are no clinical concerns. Careful questioning to elicit ongoing or new swallow difficulties aids in identifying the few patients who may benefit from repeat FEES.

4.2 | Preoperative dysphagia in LTS

Our preoperative PAS data reveals 58% exhibited some degree of penetration or aspiration at baseline (PAS 2-8). Although subclinical airway penetration is well-recognised in healthy individuals, the overall incidence is likely to be below 15%.^{22,23} Swallow impairment may not be apparent on questioning or simple bedside assessment, and our data suggest that many LTS patients are not sensate to material entering the airway. This highlights the importance of instrumental assessment in capturing the full extent of penetration and aspiration, and as such our practice has since evolved to include a preoperative FEES assessment on *all* airway reconstruction patients. Additionally, FOIS and PAS scores are generally discordant in terms of characterising the severity of the acute postoperative phase dysphagia,^{15,16,24} necessitating instrumental swallow assessment

to reassure clinicians and patients that re-commencement of early oral intake is safe as part of an expedited approach to swallow rehabilitation.

4.3 | Other studies reporting swallowing outcomes in airway reconstruction

The only other postoperative instrumental swallow assessment data in an adult airway reconstruction cohort was published by Lennon et al² in 2015. However, the timing of postoperative VFS is not disclosed and other non-validated measures of dysphagia are employed, making direct comparisons difficult. Furthermore, considerably fewer airway stents were placed (45% vs 89% in our study) and over half of the cohort received a tracheal resection, both of which are associated with less severe swallow dysfunction.^{1,2,7} Amongst their cohort of 38, 17 had a stent placed and 16 of these patients underwent postoperative VFS. Within the VFS sub-group, six (35%) were kept nil by mouth due to frank aspiration whilst the remaining 10 demonstrated either minimal aspiration which responded to compensatory strategies or trace penetration; all were ultimately cleared for oral intake. Only 7% of our stented patients remained nil by mouth after the first postoperative swallow evaluation and 61% were deemed feeding tube independent. Overall, 47% of stented patients in the Lennon et al study had a feeding tube placed for the duration of stenting (mean 27 days), whereas 54% of our stented patients had their NGT removed within 3 days of surgery and stents were placed in nearly 90% of our cohort. The data do not permit speculation as to the reasons for the differences in these swallowing outcomes; however, it is likely to be multifactorial. Considerable variation between centres and lack of transparency in the management of the post-LTR swallow has made the value of instrumental swallow assessment difficult to definitively prove. However, we strongly

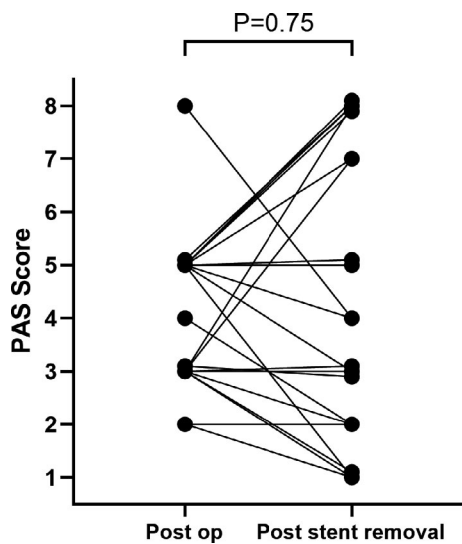


FIGURE 3 Patients with postoperative and corresponding post-stent removal Penetration-Aspiration Scale (PAS) scores (n = 22)

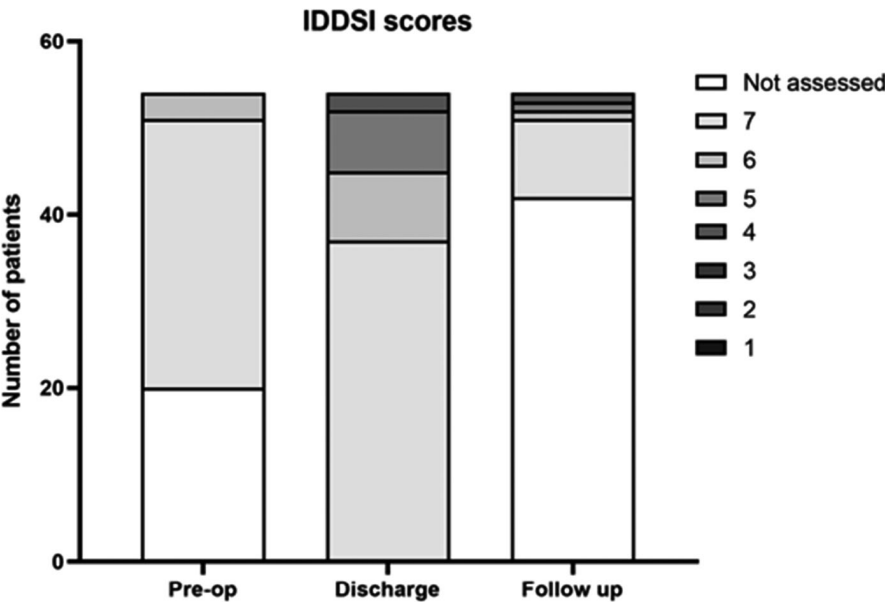


FIGURE 4 Perioperative International Dysphagia Diet Standardisation Initiative (IDDSI) scores

TABLE 2 Nasogastric tube (NGT) feeding duration postoperatively for different stent types

Stent type	NGT feeding duration (n)			>3 d Mean duration (range), SD (n)
	0 d	1 d	2-3 d	
Open	3	3	3	15 (7-21), 5.9, (3)
Closed	2	5	5	12.5 (5-28), 8.2 (15)
No stent	-	2	-	12 (8-18), 4.3 (3)

Abbreviations: NGT, nasogastric feeding tube; SD, standard deviation.

feel that it allows earlier and safer return to oral intake, with benefits for both the patient and clinical team which outweigh its resource-intensive nature.

5 | LIMITATIONS

Collating complete data sets is difficult due to the retrospective nature of this study, medical and human factors precluding timely assessment and the quaternary nature of our service which requires many patients to travel long distances. Any results derived from this information must, therefore, be interpreted with a degree of caution. Variation in timing of the first postoperative swallow evaluation means some patients were potentially kept nil by mouth and tube fed for longer than necessary whilst awaiting SLT review; however, the majority of assessments were undertaken on day 1 unless patient factors or surgeon preference prevented earlier assessment.

It was also not possible to adjust for the effect of previous airway reconstruction on baseline swallow function, and the timing from surgery to any outpatient FEES assessments varied depending on the clinical context. Whilst the negative impact of a tracheostomy or airway stent on FOIS score was expected, the lack of correlation between the type of airway reconstruction and postoperative swallow dysfunction may be confounded by the relatively small n values for particular procedures.

Although this retrospective analysis cannot directly evidence the prognostic capabilities of instrumental swallowing evaluation or its ability to significantly reduce the time to re-establishment of oral intake postoperatively, it does provide a basis for gold-standard protocol within future prospective research and an overview of the swallowing trajectory of patients undergoing airway reconstruction.²³ We also acknowledge that an absence of "clinical concern" in the postoperative outpatient setting relates to subjective assessment and not necessarily objective (instrumental) stability; however, FEES is readily available should there be any indication to repeat it.

6 | CONCLUSION

We present the largest adult airway reconstruction cohort to date with rigorous instrumental swallow assessment both pre- and postoperatively which drives early return to oral intake. Other measures of swallow impairment, whilst still useful in measuring a patient's swallow function and nutritional status, should only be used alongside FEES or VFS when making the decision to re-introduce or upgrade oral intake in the newly reconstructed airway. Such a policy can help expedite safe return to oral intake and avoid the complications, costs and morbidity of prolonged nutritional support, as well as helping to streamline and improve the consistency of practice. We have provided an evidence-based approach with clear and transparent data against which future studies can be usefully compared and designed as part of ongoing research in this field. Airway reconstruction should generally be regarded as a swallow-sparing procedure, and patients should normally expect to return to their preoperative baseline and diet provided they have access to a specialist multidisciplinary team who can deliver careful monitoring and rehabilitation. A multidimensional prospective evaluation of swallowing and voice using quantitative and qualitative measures following airway reconstruction surgery is currently underway at our centre.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTION

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was written by Matthew Haywood and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

ETHICAL APPROVAL

This anonymised, retrospective service evaluation was approved by the healthcare trust (ICHT reference ENT 408), with governance provided by the Service Evaluation and Audit governance committee.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Matthew Haywood  <https://orcid.org/0000-0003-3600-7987>
 Chadwan Al Yaghchi  <https://orcid.org/0000-0002-5771-5096>

REFERENCES

1. Clunie GM, Kinshuck AJ, Sandhu GS, Roe JWG. Voice and swallowing outcomes for adults undergoing reconstructive surgery for laryngotracheal stenosis. *Curr Opin Otolaryngol Head Neck Surg*. 2017;25(3):195-199.

2. Lennon C, Gelbard A, Bartow C, Garrett G, Nettekville J, Wootten C. Dysphagia following airway reconstruction in adults. *JAMA Otolaryngol Head Neck Surg.* 2016;142(1):20-24.
3. Gelbard A, Francis D, Sandulache V, Simmons J, Donovan D, Ongkasuwan J. Causes and consequences of adult laryngotracheal stenosis. *Laryngoscope.* 2015;125(5):1137-1143.
4. Puchalski J, Musani A. Tracheobronchial stenosis: causes and advances in management. *Clin Chest Med.* 2013;34(3):557-567.
5. Sandhu G, Nouraei S. *Laryngeal and Tracheobronchial Stenosis*, 1st edn. San Diego: Plural Publishing Inc.; 2014:512.
6. Holman A, Clunie G, Roe J, Goldsmith T. Management of swallowing in adults undergoing laryngotracheal resection and reconstruction. *Perspect ASHA Spec Interes Groups.* 2018;3(4):1-11.
7. Timman S, Schoemaker C, Li W, et al. Functional outcome after (laryngo)tracheal resection and reconstruction for acquired benign (laryngo)tracheal stenosis. *Ann Cardiothorac Surg.* 2018;7(2):227-236.
8. Miller C, Kelchner L, de Alarcon A, Willging J. Compensatory laryngeal function and airway protection in children following airway reconstruction. *Ann Otol Rhino Laryngol.* 2014;123(5):305-313.
9. Bryans L, Palmer A, Schindler J, Andersen P, Cohen J. Subjective and objective parameters of the adult female voice after cricotracheal resection and dilation. *Ann Otol Rhino Laryngol.* 2013;122(11):707-716.
10. Herrington H, Weber S, Andersen P. Modern management of laryngotracheal stenosis. *Laryngoscope.* 2006;116(9):1553-1557.
11. Hentze M, Schytte S, Pilegaard H, Ehlers KT. Single-stage tracheal and cricotracheal segmental resection with end-to-end anastomosis: outcome, complications, and risk factors. *Auris Nasus Larynx.* 2019;46(1):122-128.
12. Sandhu G, Nouraei S. Laryngotracheal stenosis. In: Costello D, Sandhu G, eds. *Practical Laryngology*. London: CRC Press; 2016:109-120.
13. Royal College of Speech and Language Therapists. Videofluoroscopic evaluation of oropharyngeal swallowing function (VFS): the role of speech and language therapists. RCSLT Position Paper 2013. London; 2013.
14. Langmore S, Schatz K, Olsen N. Fiberoptic endoscopic examination of swallowing safety: a new procedure. *Dysphagia.* 1988;2(4):216-219.
15. Nordio S, Di Stadio A, Koch I, Stritoni P, Meneghello F, Palmer K. The correlation between pharyngeal residue, penetration/aspiration and nutritional modality: a cross-sectional study in patients with neurogenic dysphagia. *Acta Otorhinolaryngol Ital.* 2019;40(1):38-43.
16. Arrese L, Schieve H, Graham J, Stephens J, Carrau R, Plowman E. Relationship between oral intake, patient perceived swallowing impairment, and objective videofluoroscopic measures of swallowing in patients with head and neck cancer. *Head Neck.* 2019;41(4):1016-1023.
17. Hutcheson K, Lewin J. Functional outcomes after chemoradiotherapy of laryngeal and pharyngeal cancers. *Curr Oncol Rep.* 2012;14(2):158-165.
18. Rosenbek J, Robbins J, Roecker E, Coyle J, Wood J. A penetration-aspiration scale. *Dysphagia.* 1996;11(2):93-98.
19. Crary M, Mann G, Groher M. Initial psychometric assessment of a functional oral intake scale for dysphagia in stroke patients. *Arch Phys Med Rehabil.* 2005;86(8):1516-1520.
20. Steele C, Navasivayam-MacDonald A, Guida B, et al. Creation and initial validation of the international dysphagia diet standardisation initiative functional diet scale. *Arch Phys Med Rehabil.* 2018;99(5):934-944.
21. Hutcheson KA, Bhayani MK, Beadle BM, et al. Eat and exercise during radiotherapy or chemoradiotherapy for pharyngeal cancers: use it or lose it. *JAMA Otolaryngol Head Neck Surg.* 2013;139(11):1127-1134. <https://doi.org/10.1001/jamaoto.2013.4715>
22. Daggett A, Logemann J, Rademaker A, Pauloski B. Laryngeal penetration during deglutition in normal subjects of various ages. *Dysphagia.* 2006;21(4):270-274.
23. Allen J, White C, Leonard R, Belafsky B. Prevalence of penetration and aspiration on videofluoroscopy in normal individuals without dysphagia. *Otolaryngol Head Neck Surg.* 2010;142(2):208-213.
24. Pedersen A, Wilson J, McColl E, Carding P, Patterson J. Swallowing outcome measures in head and neck cancer-how do they compare? *Oral Oncol.* 2016;52:104-108.

How to cite this article: Haywood M, Lovell L, Roe J, Clunie G, Sandhu G, Al Yaghchi C. Perioperative instrumental swallowing evaluation in adult airway reconstruction: A retrospective observational cohort study. *Clin Otolaryngol.* 2021;46:1229-1236. <https://doi.org/10.1111/coa.13820>