

The voice and swallowing profile of adults with laryngotracheal stenosis before and after reconstructive surgery: A prospective, descriptive observational study

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Abstract

Objectives: Airway reconstruction for laryngo tracheal stenosis (LTS) improves dyspnoea. There is little evidence relating to impact upon voice and swallowing. We explored voice and swallowing outcomes in adults with LTS before and after reconstructive surgery.

Design: Outcome measures were collected pre-reconstructive surgery, two-weeks post-surgery and up to 4-6 months post-surgery.

Setting: Tertiary referral centre.

Participants: With ethical approval, twenty consecutive adult (≥ 18 years) LTS patients undergoing airway reconstruction were prospectively recruited.

Main outcome measures: These included physiological values (maximum phonation time (MPT) and fundamental frequency; penetration aspiration score, residue score), clinician-reported (GRBAS, functional oral intake score, 100ml Water Swallow Test) and patient-reported outcomes (Voice Handicap Index-10, Reflux Symptoms Index, Eating Assessment Tool, Dysphagia Handicap Index).

Results: The observational study identified patient-reported and clinician-reported voice and swallow difficulties pre- and post-surgery; median and interquartile range are reported at each time point: Voice Handicap Index-10 23 (8-31); 20.5 (9-33.5), 24.5 (12.5-29); Dysphagia Handicap Index 9 (0-37); 13 (7-44); 15 (4-34); GRBAS grade 1(1-2); 2 (1-2.5); 2(1-2); 100ml Water Swallow Test volume score 16.7 (11.1-20); 14.3 (12.5-16.7); 16.7 (14.3-20.0); 100ml Water Swallow Test capacity score 16.3 ± 9.0 ; 11.0 ± 4.1 ; 12.5 ± 2.6 .

Conclusions: We present the first prospective data on voice and swallowing outcomes in adults with LTS before and after reconstructive surgery. The variability of the outcomes was higher than expected but importantly, for many the voice and swallow outcomes were not within normal limits before surgery. The clinical value of the study demonstrates the need for individual assessment and management of LTS patients' voice and swallowing.

KEYWORDS

laryngotracheal reconstruction, laryngotracheal stenosis, swallowing, voice

1 | INTRODUCTION

People living with laryngotracheal stenosis (LTS) experience a narrowing of the upper airway. In adults, most cases are acquired, with intubation-related injuries and prolonged tracheostomy insertion the most common causes.¹ In cases of refractory LTS where endoscopic procedures are needed with increasing frequency, or to achieve decannulation, patients are offered more definitive procedures such as laryngotracheal reconstruction (LTR) or tracheal resection (TR).²

The main symptom of LTS is dyspnoea, and a common sign is stridor. The primary focus of surgery is to improve this symptom.² Outcomes such as voice and swallowing are implicated both by LTS itself and surgeries, particularly reconstructive procedures. However, they are rarely assessed in detail.³ Existing studies are retrospective and consider voice and swallowing as secondary outcomes.⁴ There is minimal focus on the patient-reported experience of difficulties and reporting of pre- and post-surgery outcomes is inconsistent.⁵ This makes patient counselling, preparation, and management challenging, particularly since studies are often focused on a specific cause of LTS,³ or a specific reconstructive procedure⁶ without consideration of broader variabilities in aetiology, demographics, and surgery.

1.1 | Objectives

In this article, we describe the clinical voice and swallowing features of a series of LTS patients who underwent reconstructive surgery focusing on a range of voice and swallowing outcome measures pre- and post-surgery.

2 | MATERIALS AND METHODS

2.1 | Ethical approval

Ethical approval (reference 19/LO/1007) was granted by a UK-based NHS Research Ethics Committee (REC).

2.2 | Design

A single centre, prospective observational study was completed between July 2019 and December 2021. This study was reported using The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist.

2.3 | Setting

Tertiary Referral Centre.

Key points

- Laryngotracheal stenosis (LTS) is a heterogenous condition, and the voice and swallowing profile of different patients is also heterogenous requiring multidisciplinary team management.
- Reconstructive surgery has often been reported as the cause of voice and swallowing changes, but patient-reported outcome measures show that for some patients there are difficulties before surgery.
- 'Gold standard' pathway planning for patients with LTS should include access to pre-surgical voice and swallow assessment and therapy.
- An individual approach to voice and swallowing rehabilitation and management based on repeated assessment is key.
- Patient-reported outcome measures capture different information to more traditional physiological outcome measures and are of value to the multidisciplinary team in identifying individual challenges.

2.4 | Participants

All LTS patients listed for a reconstructive procedure at a tertiary referral centre were screened for inclusion, with key clinical data collected from medical notes. Inclusion criteria were defined as ≥ 18 years old, adequate understanding of verbal explanations and/or written information in English, and able to give informed consent. Exclusion criteria included any medical history including neurological conditions that could confound voice and swallowing assessment, malignancy as a cause of LTS or radiotherapy to neck/chest. This was a pragmatic, clinically focused study, therefore, all aetiologies and levels of LTS and reconstructive procedures were included to mirror the population seen within a tertiary service. All participants provided written, informed consent.

2.5 | Outcome measures

A broad range of patient-reported (Voice Handicap Index-10, Reflux Symptoms Index, Dysphagia Handicap Index, Eating Assessment Tool-10), clinician-directed (GRBAS rating, Functional Oral Intake Scale, 100 mL Water Swallow Test [WST]), and physiological outcomes (Laryngograph recording for maximum phonation time, fundamental frequency and irregularity percentage, Flexible Endoscopic Evaluation of Swallowing for Penetration Aspiration Scale score and Yale Residue Severity Rating Score) were collected. These were taken by two experienced speech and language therapists at baseline, on the surgical ward 2 weeks after

reconstruction, and then at the 4- to 6-month point post-surgery during an outpatient clinic follow-up appointment. This timepoint matched usual clinical follow-up time, accounting for patient availability to return to clinic.

3 | RESULTS

3.1 | Participants

All 22 patients listed for a reconstructive surgical procedure between July 2019 and September 2021 were approached and all consented to participation. Twenty patients were considered eligible as one participant dropped out of the study due to malignancy and another was recruited but did not undergo the surgery. Due to coronavirus (COVID-19) pandemic restrictions limiting in-person visits, three participants did not receive follow-up physiological voice and swallow outcome measures. Laryngograph measures were only partially recorded pre- and post-surgery due to repeated equipment failure and presence of tracheostomy.

3.2 | Descriptive data

Table 1 presents the demographics for the 20 participants. There was an equal split between men and women. Median age was 46 (interquartile range [IQR] 34–58) and causes of LTS were evenly distributed. All patients had had at least one previous endoscopic surgery involving laser, balloon dilatation and steroid injection. Three patients had had previous airway reconstruction. The surgery was successful for 18 patients in terms of improving dyspnoea. All patients had one planned 'second-look' endoscopic procedure 6 weeks post-reconstruction before the final timepoint. All 20 patients completed the study.

3.3 | Patient-reported outcome measures

Figure 1 shows median and IQR of patient-reported outcome measures (PROMs) at each timepoint. Each participant is plotted as a separate data point. The higher the score for each outcome measure, the worse the patient reported difficulty with voice or swallowing. For each PROM the wide IQR demonstrated variability pre- and post-surgery. The range of scores between participants was broad with the VHI-10 demonstrating a maximum range (0–40) both pre- and post-surgery.

3.4 | Clinician-reported outcome measures

The median and IQR of GRBAS and FOIS ratings are presented in Table 1. For the GRBAS, 0 represents normal voice for each parameter (grade, roughness, breathiness, asthenia), with mild, moderate, and

TABLE 1 Demographics of study group.

Demographics	
Median age in years (interquartile range)	46 (34–58)
Age category (years)	n (%)
25–34	5 (25)
35–44	4 (20)
45–54	5 (25)
55–64	5 (25)
>65	1 (5)
Sex	n (%)
Female	10 (50)
Male	10 (50)
Ethnicity	n (%)
Asian – any other	2 (10)
Black – any other	1 (5)
White British	15 (75)
White – any other	2 (10)
Cause of LTS	n (%)
Intubation/Tracheostomy	11 (55)
Autoimmune disorder	6 (30)
Trauma	2 (10)
Idiopathic	2 (10)
Level of stenosis	n (%)
Supraglottic	1 (5)
Glottic	6 (30)
Subglottic	11 (55)
Multilevel	2 (10)
Pre-operative vocal fold function	n (%)
No issues	11
Posterior glottic scar/cricoid joint fixation	7
Glottic web	1
Vocal fold scar	1
Type of Reconstruction	n (%)
Laryngotracheal reconstruction ^a	12 (60)
Endoscopic laryngotracheal reconstruction ^b	2 (10)
Tracheal resection ^c	6 (30)
Previous surgical input	n (%)
Reconstruction procedure	3 (15)
Endoscopic surgery	20 (100)
Tracheostomy pre-reconstruction	n (%)
Yes	8 (40)
No	12 (60)
Tracheostomy post-reconstruction	n (%)
Yes	2 (10)
No	18 (90)

^aLaryngotracheal reconstruction involved a transverse cervical incision, laryngofissure and post-cricoid split to excise the stenosed lesion, with a rib cartilage spacer between the posterior cricoid and upper oesophageal fibres to separate the scar tissue and a skin covered closed stent to cover and support the surgical site for 2 weeks, a temporary tracheostomy provided the only airway during this time.

^bEndoscopic laryngotracheal reconstruction in these two cases involved endoscopic debridement of the stenosis with placement of a temporary, open, skin covered stent for 2 weeks.

^cTracheal resection involved excision of the stenosis and end to end anastomosis, no stent or tracheostomy required.

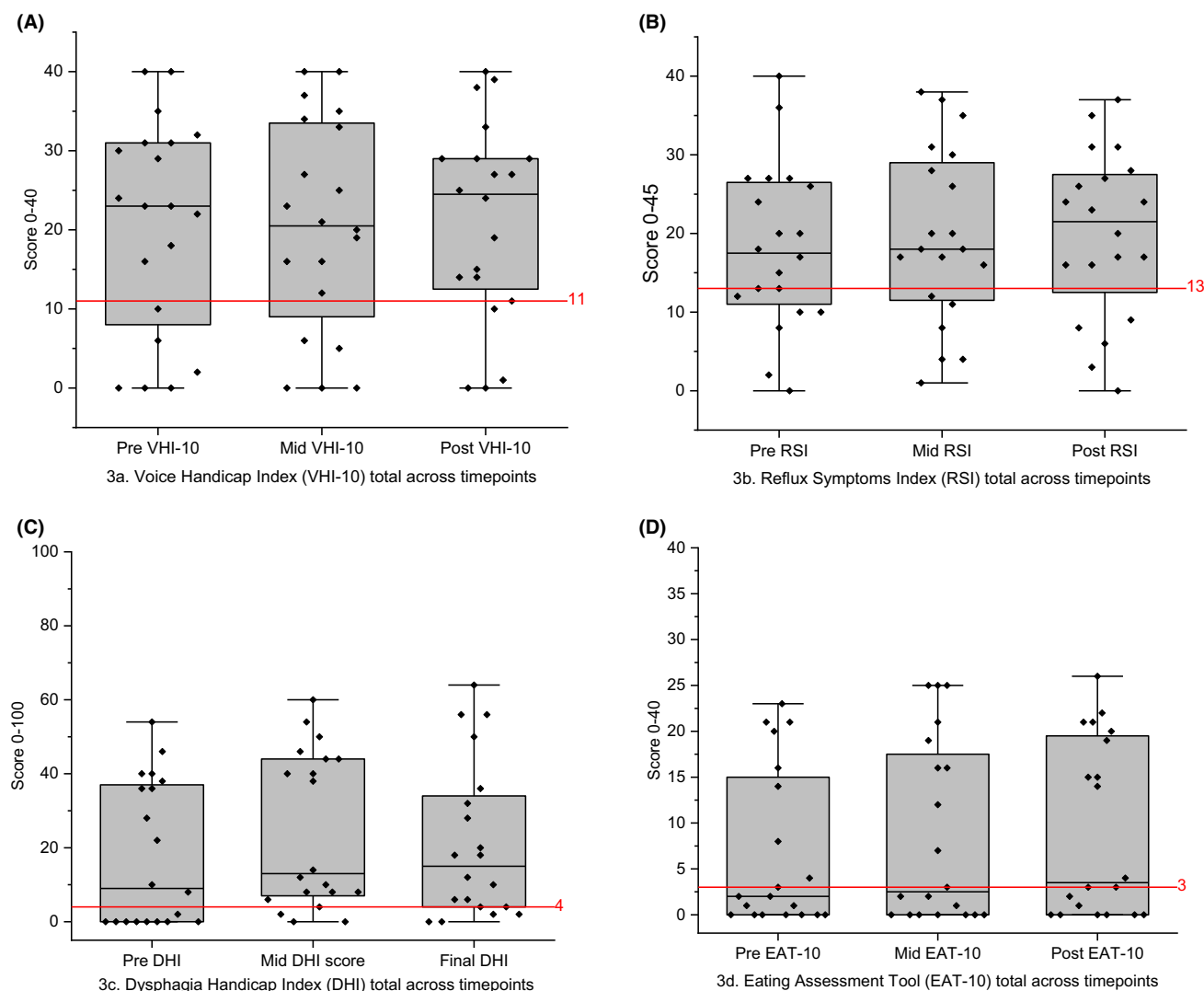


FIGURE 1 (a–d) Box and whisker plot of all patient-reported outcome measures (PROMs) at each timepoint. ♦ Represents each patient's raw score. The horizontal line represents the normative scores. VHI-10 is scored from 0 to 40, normative cut off <11(30). The RSI is scored from 0 to 45, normative cut off <13(22). The DHI is scored from 0 to 100, normative cut off <4(31). EAT-10 is scored from 0 to 40, normative cut off <3(24). For all PROMs a higher score indicates a greater impairment.

severe perceptual change being represented by 1–3 ratings. Aphonic patients received a score of 3 across each domain to signify severity of their voice difficulty. The highest median score post-surgery for the GRBAS was an overall grade score of 2 (moderate perceptual dysphonia). The median value for all other perceptual parameters of voice was 1 (mild difficulties). The FOIS median rating was 7 (total oral diet, no restrictions) at baseline and final time point (Table 2).

3.5 | Physiological outcome measures

The median and IQR of fundamental frequency, irregularity percentage and MPT, alongside the swallowing measures of penetration-aspiration score and Yale Residue Severity Rating Scale (YPSRS) are presented in Table 2. The 100 mL Water Swallow Test (WST) data are presented in Table 3.

The 100 mL WST results showed variation from normative values for swallow capacity (mL/s) and swallow volume (mL).

4 | DISCUSSION

4.1 | Synopsis of key findings

This study is the first to describe the voice and swallowing profile of adults with LTS who undergo reconstructive surgery at baseline, and two timepoints post-surgery. This was with a view to understanding the patients' journey to improve patient care pathways.

The two key findings of this study relate to the heterogeneity of LTS presentations across time-points in relation to voice and swallowing outcome measures, and the indication that for many patients, their

TABLE 2 Median and interquartile range (IQR) of clinician-rated outcome measures ($n = 20$ for all timepoints) and median and IQR of physiological outcome measures (n stated in table).

	Timepoint	Median (IQR)
Clinician-rated measures		
Voice		
Grade	Baseline	1 (1–2)
	Post-surgery 1	2 (1–2.5)
	Post-surgery 2	2 (1–2)
Roughness	Baseline	1 (0.5–2)
	Post-surgery 1	1 (1–2)
	Post-surgery 2	1 (1–1.5)
Breathiness	Baseline	1 (0–1)
	Post-surgery 1	1 (0–2)
	Post-surgery 2	1 (0–1.5)
Aesthenia	Baseline	1 (0–1)
	Post-surgery 1	2 (1–2)
	Post-surgery 2	1 (0–1)
Strain	Baseline	1 (0–2)
	Post-surgery 1	1 (1–2)
	Post-surgery 2	1 (0–2)
Swallowing		
FOIS	Baseline	7 (6–7)
	Post-surgery 1	6 (4–7)
	Post-surgery 2	7 (6–7)
Physiological outcome measures		
Voice		
F0 (Hz)	Baseline $n = 12$	175.0 (143.0–188)
	Post-surgery $n = 14$	171.1 (156.1–213.0)
Irregularity %	Baseline $n = 12$	53.3 (49.3–85.0)
	Post-surgery 2 $n = 14$	45.8 (41.0–75.8)
MPT (s)	Baseline $n = 12$	9 (7.4–14.0)
	Post-surgery 2 $n = 14$	7 (4.8–9.0)
Swallowing		
PAS	Baseline $n = 19$	1 (1–3)
	Post-surgery 1 $n = 18$	3 (1–7)
	Post-surgery 2 $n = 17$	1 (1–5)
YPSRS – valleculae	Baseline $n = 19$	2 (1–2)
	Post-surgery 1 $n = 18$	2 (2–3)
	Post-surgery 2 $n = 17$	2 (2–3)
YPSRS – pyriforms	Baseline $n = 19$	2 (1–2)
	Post-surgery 1 $n = 18$	2 (0)
	Post-surgery 2 $n = 17$	2 (1–3)

Note: no post-surgery 1 timepoint for voice measures due to post-operative contraindication for laryngograph use.

Abbreviations: FOIS, Functional Oral Intake Scale; F0, fundamental frequency; MPT, maximum phonation time; PAS, penetration aspiration scale; YPSRS, Yale Residue Severity Rating Scale.

voice and swallowing are not within normal limits before they have surgery. Previous studies have focused on LTS in a homogenous group, either aetiology or type of reconstruction.⁷ This does not help

guide practice for clinicians working with the full range of causes and surgeries, and our study offers a clinical perspective on a heterogeneous group with multiple pathologies.

TABLE 3 100 mL Water Swallow Test across the time points and normative values (male:female matched).

100 mL Water Swallow Test results				
	Pre- (n = 20) (M:F 10:10)	Post-surgery 1 (n = 19) (M:F 10:9)	Post-surgery 2 (n = 17) (M:F 10:7)	Normative values
Speed (time/swallow) s (median (IQR) s)				
Male	1.2 (0.9–1.3)	1.5 (1.2–1.9)	1.3 (1.2–1.6)	1.2 (1.0–1.4)
Female	1.6 (1.0–2.3)	1.9 (1.4–3.8)	1.5 (1.3–1.6)	1.3 (1.1–1.7)
Capacity (volume/time) – mL/s (mean ± SD mL)				
Male	16.3 ± 8.0	11.0 ± 4.1	12.5 ± 2.6	24.8 ± 7.8
Female	11.7 ± 8.7	4.6 ± 3.8	8.6 ± 4.0	13.6 ± 4.8
Volume/swallow – mL (median IQR) mL				
Male	16.7 (11.1–20.0)	14.3 (12.5–16.7)	16.7 (14.3–20.0)	30.0 (21.4–37.5)
Female	14.6 (11.1–20.0)	7.1 (7.1–9.1)	12.5 (10.0–16.7)	16.7 (13.6–17.4)

Abbreviation: IQR, interquartile range.

4.2 | Clinical applicability of the study

PROMs revealed that some patients describe difficulties with voice and swallowing at baseline, with many participants scoring above normative values (described in Figure 1) at each timepoint, despite functional performance in the physiological measures of voice and swallowing. Similarly clinician-rated GRBAS score reported perceptual dysphonia pre- and post-surgery. This has clinical relevance to teams managing patients with LTS because voice and/or swallowing assessment and therapy may be necessary from the point of diagnosis of LTS onwards. This matches with what patients have indicated is important.^{8,9}

In existing literature, focused on changes in women's voices,⁶ fundamental frequency is lower post-surgery. In our study the median overall fundamental frequency pre- and post-surgery did not demonstrate this change. This may relate to our preference for augmentation procedures and endoscopic LTR, preserving the function of the cricothyroid muscle, unlike cricotracheal resection.⁶ The MPT is below normative values for men (18.6–20.2 s) and women (15.1–18.9 s)¹⁰ at both baseline and final timepoint, with the median value reducing after surgery. We can hypothesize that whilst airway calibre has improved, this leads to posterior glottic air escape with reduced glottic closure leading to a drop in MPT. For clinicians this is important to consider as MPT has implications for vocal function and is useful to consider in therapy.

In the normal population the 100 mL WST test has been used to help identify respiratory coordination patterns-expiration-swallow-expiration is most common.¹¹ In this study, the results of the 100 mL WST highlight a disparity between normative values for swallow volume and capacity. LTS impacts breathing therefore it is hypothesized that there is disruption to the coordinated respiratory-swallow patterns required for rapid, sequential drinking. For clinicians this is a useful screening test to use with LTS patients to guide treatment and identify sub-clinical dysphagia.

4.3 | Limitations and strengths

There are limitations to this study. It was a small population and did not allow for more complex analysis of variables that may impact voice and

swallowing outcomes. Unavoidable gaps in physiological outcomes relate to limitations due to COVID-19 and equipment failure. We did not collect breathlessness outcomes. This is a single-centre study based in the United Kingdom, limiting generalisability to other centres due to potential differences in surgical protocols.

5 | CONCLUSION

This study describes the clinical outcomes of voice and swallowing pre- and post-reconstructive surgery for LTS. Patient-reported and clinician reported outcome measures provide evidence that voice and swallowing are not within normal limits for patients even before they undergo reconstructive surgery. This pattern continues following their surgery. It indicates the need for multidisciplinary team management and consideration of voice and swallowing throughout the care pathway for LTS.

AUTHOR CONTRIBUTIONS

Gemma M. Clunie is accountable for all aspects of the work. Justin W. G. Roe helped design the work, acquired and analysed data; revised and approved the article. Chadwan Al-Yaghchi revised and approved the article. Caroline M. Alexander helped design the work; revised and approved the article; Alison McGregor helped design the work; revised and approved the article. Gurpreet Sandhu helped design the work; revised, and approved the article.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

PEER REVIEW

The peer review history for this article is available at <https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/coa.14138>.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Ethical approval (reference 19/LO/1007) was granted by the London and Surrey Borders NHS Research Ethics Committee (REC).

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