Laryngology & Otology

cambridge.org/jlo

Review Article

Matteo Lazzeroni takes responsibility for the integrity of the content of the paper

Cite this article: Lazzeroni M, Del Fabbro M, Gaffuri M, McGurk M, Novarria GA, Tartaglia GM, Pignataro L, Capaccio P. Sublingual ranulas, is it time for a new classification? A systematic review and meta-analysis. *J Laryngol Otol* 2025; 1–7. https://doi.org/10.1017/ S0022215124001464

Received: 6 May 2024 Accepted: 22 August 2024

Keywords:

mouth floor; oral surgical procedures; ranula; salivary glands; sublingual gland

Corresponding author: Matteo Lazzeroni; Email: matteo.lazzeroni@unimi.it

© The Author(s), 2024. Published by Cambridge University Press on behalf of J.L.O. (1984) LIMITED. This is an Open Access article, distributed under the terms of the Creative Commons Attribution licence (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted re-use, distribution and reproduction, provided the original article is properly cited.

Sublingual ranulas, is it time for a new classification? A systematic review and meta-analysis

Matteo Lazzeroni^{1,2}, Massimo Del Fabbro², Michele Gaffuri^{3,4}, Mark McGurk⁵, Gabriele Alessandro Novarria⁴, Gianluca Martino Tartaglia², Lorenzo Pignataro^{3,4} and Pasquale Capaccio^{2,6}

¹Department of Otorhinolaryngology & Head and Neck Surgery, Amsterdam UMC, University of Amsterdam, Amsterdam, The Netherlands, ²Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy, ³Department of Otorhinolaryngology & Head and Neck Surgery, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy, ⁴Department of Clinical Sciences and Community Health, University of Milan, Milan, Italy, ⁵Head and Neck Academic Centre, Department of Head and Neck Surgery, University College London Hospital, London, United Kingdom and ⁶Department of Otorhinolaryngology & Head and Neck Surgery, Fatebenefratelli Hospital, ASST Fatebenefratelli Sacco, Milan, Italy

Abstract

Objectives. Sublingual ranulas present diagnostic and therapeutic challenges due to their heterogenous clinical presentations. This systematic review and meta-analysis aims to synthesise treatment outcomes and proposes a new classification for this condition.

Methods. Following PRISMA guidelines, a thorough literature search identified studies on patients with sublingual ranulas receiving medical or surgical treatment. Proportion meta-analysis compared success rates among studies using a random-effects model.

Results. Forty-two studies were included, covering 686 endoral ranulas, 429 plunging ranulas, and 16 ranulas extending into the parapharyngeal space. Sublingual sialoadenectomy with or without pseudocyst wall excision showed low heterogeneity and the highest success rates. Consequently, a new classification system is proposed categorising ranulas by intraoral (Type 1), cervical (Type 2) or parapharyngeal space (Type 3) extension.

Conclusion. This study confirms the role of sublingual gland resection as standard of care and highlights the need for a revised classification to improve patient outcomes.

Introduction

A sublingual ranula is an extravasation mucocele that arises from ruptured acini or ducts of the sublingual gland.^{1,2} Ranulas can only occur from sublingual or minor salivary glands, which are able to produce saliva against a pressure gradient. Major glands down-regulate salivary production if obstructed.^{3,4} The submandibular and parotid gland generate a discontinuous secretory flow driven by nervous stimulation, whereas the sublingual gland spawns a continuous, spontaneous secretion of saliva, not strictly dependent of food intake.¹ Consequently, when a leak develops within its drainage system, it continues to secrete saliva through the breach. This phenomenon is most effective in areas where the surrounding tissues are loose and lax, such as the floor of the mouth, and is less effective in regions like the hard palate where tissues are more rigid.

Sublingual ranulas are typically acquired, post-traumatic conditions.⁵ They can arise from incidental damage caused by mastication, dental implantation or iatrogenic manoeuvres,⁶ yet their aetiology remains often unclear,⁷ especially in case of unnoticed mechanical trauma to the gland. The so-called "congenital" sublingual ranula in newborns and infants, with 14 cases reported in current literature,^{8–11} is the consequence of mucus retention and extravasation from duct atresia, acinus dilatation, ostia stenosis or imperforated sublingual salivary gland.

Ranulas have traditionally been classified as simple or endoral, when confined to the oral floor, or plunging, when the pseudocyst extends into the neck, usually in the submandibular space, through a hiatus of mylohyoid muscle or behind the posterior border of the mylohyoid muscle.^{3,12}

Simple ranulas are common during the first and second decade of life,³ while plunging ranulas occur frequently during the third decade of life, with a higher prevalence in specific ethnic groups. For this reason, a genetic predisposition for the development of plunging ranulas has been proposed in relation to the prevalence of mylohyoid defects and sublingual gland herniations in the cervical region.^{13,14}

Cornerstone of the diagnostic algorithm for sublingual ranula is clinical examination, involving inspection and palpation.¹² Radiologic assessment can be useful for differential diagnosis with other cervical space occupying lesions and for treatment planning, especially for recurrent ranulas. Ultrasonography can be considered a valid first choice

examination, since it has shown accuracy in characterising ranulas regardless of their dimensions and can easily determine their possible extension in the surrounding spaces.¹⁵ Second choice examinations are computed tomography (CT) and magnetic resonance imaging (MRI), in which the presence of the "tail sign" is pathognomonic for plunging ranulas.¹⁶ When imaging is not conclusive, aspiration of the ranula's content and its testing for amylase to assess the likelihood of salivary origin can be pursued.¹⁷

Treatment strategies for sublingual ranulas have been a debated issue even in recent years.¹⁸ Complete resection of the sublingual gland is considered the most effective therapeutic strategy for this condition regardless of its extension to the surrounding regions due to its pathogenesis,^{1,12} yet, this is an invasive procedure, not free of serious complications, such as nerve injury, bleeding, infections and damage to Wharton's duct.¹⁹ Over time many conservative, minimally invasive techniques have been proposed to treat ranulas by means of marsupialisation^{3,20} or of injection of sclerotic drugs capable of inducing fibrosis to seal the mucous leak.²¹ The study by Chung et al.,¹⁹ in line with previous reviews,¹ is to the best of our knowledge the only meta-analysis that has tried to synthetise and analytically compare the results of different therapeutic options available for sublingual ranulas.

Most patients with this condition are generally young²²; therefore, the therapeutic goal has been focused on reducing treatment invasiveness. In recent years, several innovative approaches have been proposed for sublingual ranulas,^{3,23} especially regarding the use of sclerosing agents^{21,24} or botulinum toxin therapy.²⁵ Given these developments, our objective is to provide an updated quantitative analysis of the results from these studies.

Heterogeneity, as in the treatment spectrum for ranulas, arises when there is a lack of uniformity in thought. Creating a systematic approach to the diagnostic-therapeutic process can be useful to harmonise data. The aim of this study was to make progress in this direction, towards systematisation, proposing a new anatomical classification and synthetising the results of different surgeons in treating this condition.

Methods

The present systematic review was registered to the PROSPERO database (registration number CRD42023433994). The reporting of this study is in accordance with PRISMA statement²⁶ and followed the guidelines in the Cochrane Handbook for Systematic Reviews of Interventions.²⁷

Population, Intervention, Comparison, Outcomes, Type of study design, Time of follow-up criteria

The PICOTT criteria for the present review were as follows: P: patients with sublingual ranula; I: different medical and surgical treatments for sublingual ranula: sclerotherapy, micromarsupialisation, marsupialisation, sublingual sialoadenectomy, excision of the pseudocyst wall or simple aspiration of the ranula, transcervical approaches; C: not applicable; O: success rates in terms of recurrences, complication rates. Elaboration of a new classification for sublingual ranulas; T: observational and randomised studies with minimum five patients; T: mean follow-up time of minimum six months.

Search strategy and data extraction

Systematic searches were conducted for English written studies published until the search date that reported rates of recurrences and complications after surgical or medical treatment for sublingual ranulas.

PubMed, Web of Science and Scopus databases were searched using as search strategy "sublingual ranula" on November 2, 2023. Abstracts and full texts were reviewed in duplicate by two different authors (M.L. and M.G.). To maximise the rate of inclusivity in the early stages of the review, at the abstract stage, all studies deemed eligible by at least one rater were included. Then, during the full-text review stage, disagreements were resolved by consensus between raters.

Inclusion criteria were: patients with sublingual ranulas undergoing medical or surgical therapy; age range of 1–100 years; follow-up time of a minimum period of six months; studies involving human subjects only; accurate reporting of post-operative complications, recurrence rate and of the anatomical extension of each sublingual ranula considered in relation to the outcomes described; and observational or randomised studies with a minimum of five patients.

For each study the following information was acquired: name and country of origin of first author, year of publication, study design (observational, randomised), number of patients included, mean age of the enrolled patients, radiological examinations used for diagnosis, localisation of the ranula (intraoral, plunging, extended to the parapharyngeal space), primary treatment, success rates (success = recurrence free patient after six months of treatment) and complication rates. In accordance with previous literature,¹⁹ treatments were categorised as: resection of sublingual gland (including partial or total resection of the sublingual gland by means of traditional or robotic approaches), excision of ranula alone or aspiration of ranula's content, sclerosing injections, transcervical approaches and/or submandibular sialoadenectomy, marsupialisation, micro-marsupialisation (for all types of suture-based techniques that did not remove the overlying mucosa of the ranula). The complications that were considered relevant for the present review were transient or permanent nerve injuries, formation of a haematoma or sialocele, infection, or injury to Wharton's duct.

Risk of bias assessment

Two reviewers have independently assessed the risk of bias (ROB) through the appropriate JBI critical appraisal checklist tool. Disagreements between reviewers' judgements were resolved by discussion until a consensus was achieved.

Strategy for data synthesis

The main outcomes were the proportion of success and complications after intervention. Proportion meta-analysis was used to address them effectively, using a random-effects model. If at least two comparative studies comparing the same treatments were identified, pairwise meta-analysis was performed, using the random effects model in the presence of significant heterogeneity, otherwise the fixed effects model was used. The results were presented in the form of Forest plots. Heterogeneity was assessed using the Cochran Q and the I2 tests. For undertaking meta-analysis, STATA 17.0 software was used.

Results

Study selection and baseline characteristics

Figure 1 reports the PRISMA flowchart of the study selection process. A total of 762 records were retrieved from PubMed, Web of Science and Scopus. After abstract screening, 90 studies were deemed eligible for full text examination. Lastly, $42^{3,28-68}$ studies were judged fit for the present meta-analysis according to inclusion criteria. Only one randomised control trial was found, while the others were all observation studies. The selected studies included a total of 686 endoral ranulas, 429 plunging ranulas and 16 ranulas extending into the parapharyngeal space. Detailed information about studies' characteristics can be found in Supplementary Table 1.

Pooled analyses of all studies and subgroup analysis

As shown in Figure 2, no statistically significant differences (p = 0.14) were found between the success rates of treatment strategies for endoral and plunging ranulas, although effect size for plunging ranula was 0.80 (95 per cent confidence interval [CI] 0.65-0.89; I2 = 73.96 per cent), while the effect size for intraoral ranula was slightly higher at 0.88 (95 per cent CI 0.83-0.91; I2 = 35.87 per cent). Intraoral sublingual ranulas showed a tendency for better success rates and more homogeneous results compared to plunging ranulas, which instead showed more heterogeneity.

Subgroup analysis was conducted for treatment strategies that were sufficiently described in three or more separate studies to ensure an adequate level of evidence for comparative assessment.

Regarding endoral ranulas a global effect size of 0.85 (95 per cent CI 0.81-0.88; I2 = 14.05 per cent) across all studies was observed (Figure 3), indicating a high overall success rate. Sublingual sialoadenectomy with or without pseudocyst walls removal have shown the best success rates with an effect size of 0.95 (95 per cent CI 0.86-0.98; I2 = 0.00 per cent) and 0.94 (95 per cent CI 0.86-0.98; I2 = 0.00 per cent), respectively. The heterogeneity within the two groups was also very low, denoting highly predictable treatment outcomes. Instead, marsupialisation techniques had a wider range of success rates and an effect size of 0.80 (95 per cent CI 0.72-0.87; I2 = 7.77 per cent), indicating lower and less predictable success rates. Statistically significant differences between the groups were observed (p < 0.05).

Figure 4 shows results of treatments for plunging ranulas with a global effect size of 0.79 (95 per cent CI 0.65-0.88; I2 = 69.49 per cent), indicating lower overall success rates for plunging ranulas compared to simple endoral ranulas. Statistically significant differences are observed between the groups (p < 0.05). Heterogeneity within different treatments is variable, with sublingual sialoadenectomy with or without pseudocyst wall excision showing low heterogeneity ($I^2 = 0.00$ per cent and $I^2 = 16.95$ per cent, respectively), suggesting consistency and reproducibility of the results. In contrast,

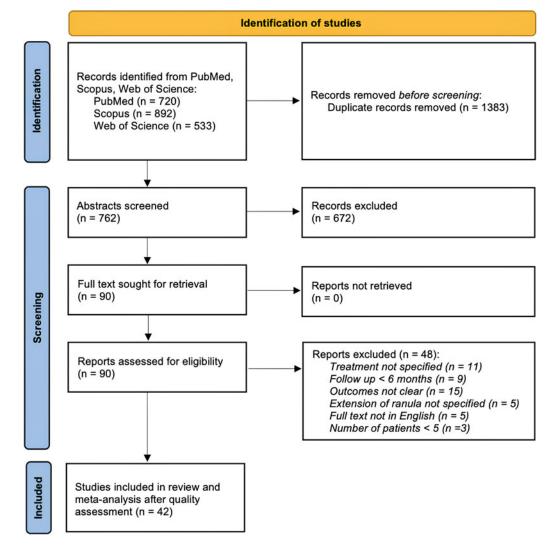


Figure 1. PRISMA flow diagram for the papers' selection process.

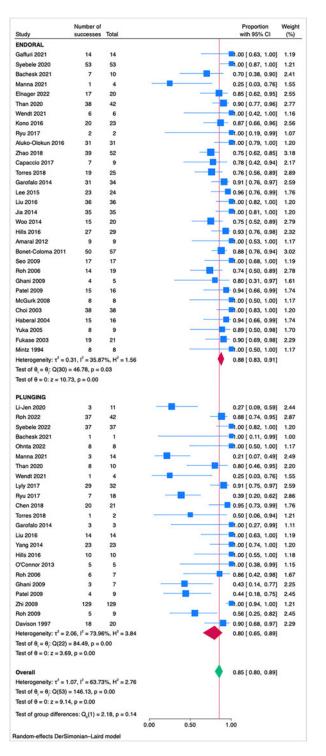


Figure 2. Forest plot for the overall success rates of treatment strategies for endoral type 1 and plunging - type 2 ranulas.

sclerotherapy has shown a high heterogeneity ($I^2 = 57.35$ per cent) and an effect size of 0.54 (95 per cent CI 0.33-0.74), below the overall effect size.

Subgroup analysis for ranulas extending to the parapharyngeal space and for complication rates was deemed unfeasible due to the limited numbers reported in the studies included in this review, in order to avoid overinterpretation of data with insufficient statistical power.

Quality assessment

According to the JBI critical appraisal tool (Supplementary Table 2) 17 articles were rated as low risk of bias, 15 as

	Number of successes	Total		Proportion with 95% CI	Wei (%
Study Mansuplalization					
Bachesk 2021	1	2 -		0.50 [0.06, 0.94]	1.0
Than 2020	5	7		0.71 [0.33, 0.93]	
Zhao 2018	39	52		0.75 [0.62, 0.85]	8.8
Capacolo 2017	4	6	-	0.67 [0.27, 0.92]	2.4
Torres 2018	4	4		1.00 [0.33, 0.99]	0.9
Garofalo 2014	12	15	_	0.80 [0.53, 0.93]	3.9
Jia 2014	35	35		1.00 [0.81, 1.00]	
Bonet-Coloma 2011 Ghani 2009	32	35		0.91 [0.77, 0.97]	4.3
Ghani 2009 Haberal 2004	2	3	100	0.67 [0.15, 0.96]	
Haberal 2004 Yuka 2005	6	6		0.86 [0.42, 0.98]	1.6
Heterogeneity: τ ² = 0.05, l ² = 7.77%, H ² = 1.08	0	'		0.80 [0.72, 0.87]	1.6
Test of 0, = 0; Q(10) = 10.84, p = 0.37				0.00[0.72, 0.07]	
Test of 0 = 0; z = 5.81, p = 0.00					
Micromansupialization Gallwi 2021	14	14	-	1.00 [0.63, 1.00]	0.5
Bachesk 2021	2	3	-	0.67 [0.15, 0.96]	1.3
Einager 2022	17	20		0.85 [0.62, 0.95]	
Aluko-Olokun 2016	31	31	1	1.00 [0.79, 1.00]	1.0
Capaccio 2017	2	2		1.00 [0.19, 0.99]	
Torres 2018		10	-	0.80 [0.46, 0.95]	
Woo 2014	15	20		0.75 [0.52, 0.89]	5.5
Hills 2016	7	9		0.78 [0.42, 0.94]	
Amaral 2012				1.00 [0.53, 1.00]	
Heterogeneity: τ ² = 0.00, l ² = 0.00%, H ² = 1.00	-			0.83 [0.73, 0.90]	
Test of 0 = 0; Q(8) = 7.34, p = 0.50					
Test of 0 = 0: z = 5.46, p = 0.00					
Pseudocyst wall excision and/or aspiration Bachesk 2021	4	5		0.80 [0.31, 0.97]	1.
Than 2020	6	8	-	0.75[0.38, 0.94]	
Capaccio 2017	1	1 -		1.00 [0.11, 0.99]	
Torres 2018	3	7 -	_	0.43 [0.14, 0.77]	
Leg 2015	1	1 -		1.00 [0.11, 0.99]	0.7
Hills 2016	9	9			
Bonet-Coloma 2011	18	22	-	0.82 [0.60, 0.93]	
Ghani 2009	1	1 -		-1.00 [0.11, 0.99]	
Patel 2009	7		_	0.88 [0.46, 0.98]	1.3
Choi 2003	38	38		1.00 [0.83, 1.00]	1.0
Mintz 1994	8	8		-1.00 [0.50, 1.00]	
Heterogeneally: r ² = 0.20, l ² = 15.24%, H ² = 1.18 Text of θ ₁ = θ ₁ : Q(10) = 11.80, p = 0.30 Text of θ = 0: z = 4.15, p = 0.00 Sciencesing agents				0.81 [0.68, 0.89]	
Manna 2021	1	4 -		0.25 [0.03, 0.76]	1.4
Wendt 2021	6	6	-		
				1.00 [0.42, 1.00]	
	20	23		1.00 [0.42, 1.00] 0.87 [0.66, 0.96]	
Kono 2016					4.1
Kono 2016 Ryu 2017	20	23		0.87 [0.66, 0.96]	4.1
Kono 2016 Ryu 2017 Garofalo 2014	20 2	23 2		0.87 [0.66, 0.96] 1.00 [0.19, 0.99] 1.00 [0.68, 1.00]	4.1
Kono 2016 Ryu 2017 Garofalo 2014 Roh 2006	20 2 17	23 2 17	_	0.87 [0.66, 0.96] 1.00 [0.19, 0.99] 1.00 [0.68, 1.00] 0.74 [0.50, 0.89]	4.1 0.8 0.1 5.2
Κοτο 2016 Μγμ 2017 Ολατίδο 2014 Μαλα 2020 Τέλατο 20μη τ. (* - 30.34%, μ* = 1.65 Τέλατο 20μη 2.65, μ = 0.13	20 2 17 14	23 2 17 19		0.87 [0.66, 0.96] 1.00 [0.19, 0.99] 1.00 [0.68, 1.00]	4.1 0.8 0.1 5.2
Kono 2016 Ryu 2017 Garda 2014 Holerogenehy, t' = 0.50, i' = 39.34%, H' = 1.65 Test of 9, $e_{1} = 0.50, i' = 39.34%, H' = 1.65Test of e_{1} = 2.64, p = 0.03Sublingual gland sistoadenectomy$	20 2 17 14 19	23 2 17 19 21		0.87 [0.66, 0.96] 1.00 [0.19, 0.99] 1.00 [0.84, 1.00] 0.74 [0.50, 0.89] 0.90 [0.69, 0.98] 0.83 [0.67, 0.92]	4.1
Core 2016 Ayr 2017 Clancible 2014 Holt 2006 Teleforgenety: $T^2 = 0.50, f^2 = 30.34\%, H^2 = 1.65$ Teleforgenety: $T^2 = 0.50, f^2 = 30.34\%, p = 0.13$ Test of $0 = 0; z = 3.54, p = 0.00$ Sublinguit gland Saloadenectomy Systels 2020	20 2 17 14 19 53	23 2 17 19 21 53		0.87 [0.66, 0.96] 1.00 [0.19, 0.99] 0.74 [0.50, 0.89] 0.90 [0.69, 0.98] 0.83 [0.67, 0.92] 1.00 [0.87, 1.00]	4.1 0.8 0.1 5.2 3.1
Kono 2016 Ryu 2017 Satarla 2014 Katas 2003 Katas 2003 Test of $0 = 0^{+}$ (0.50 , $l^{+} = 30.34\%$, $pl^{+} = 1.65$ Test of $0 = 0^{+}$ ($2 = 0.50$, $p = 0.13$ Test of $0 = 0^{+}$ ($2 = 3.54$, $p = 0.00$ Sublingual gland sialoadenectomy Systemia 2020	20 2 17 14 19 53 6	23 2 17 19 21 53 6		0.87 [0.66, 0.96] 0.80 [0.19, 0.99] 1.00 [0.19, 0.09] 0.74 [0.50, 0.89] 0.90 [0.69, 0.98] 0.83 [0.67, 0.92] 0.83 [0.67, 0.92] 0.83 [0.67, 1.00] 0.87, 1.00]	4.1 0.8 0.1 5.2 3.1 1.0 0.1
$\label{eq:constraint} \begin{split} &cons 2016 \\ &Rya 2017 \\ &Ruh 2006 \\ &Ruh 2006 \\ &Ruh 2006 \\ &Ruh 2006 \\ &Ruh 2008 \\ &Ruh 2018 \\ &Ru$	20 2 17 14 19 53 6 36	23 2 17 19 21 53 6 36		. 0.87 [0.66, 0.96] . 0.0 [0.19, 0.99] . 0.0 [0.64, 1.00] . 0.90 [0.68, 1.00] . 0.90 [0.69, 0.98] . 0.90 [0.69, 0.98] . 0.93 [0.67, 0.92] . 0.93 [0.67, 1.00] . 0.0 [0.42, 1.00] . 0.0 [0.42, 1.00]	4.1 0.8 0.1 5.2 3.1 1.0 0.1 1.0
Kono 2016 Rya softa Rya softa Kalasa 2003 Hotinogoneth, et al. (2003) Hotinogoneth, et al. (2004) Hotinogoneth, et al. (2004)	20 2 17 14 19 53 6	23 2 17 19 21 53 6		0.87 [0.66, 0.96] 0.87 [0.68, 0.96] 0.010, 19, 0.98 0.74 [0.50, 0.89] 0.90 [0.69, 0.98] 0.90 [0.69, 0.98] 0.90 [0.67, 0.92] 1.00 [0.87, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00]	4.1 0.8 0.1 5.3 3.1 1.0 0.1 1.0 0.1
$\label{eq:constraint} \begin{split} &cons 2016 \\ &Ryy 2017 \\ &Rw 2006 \\ &Rw 2006 \\ &Rw 2008 \\ &Rw 2016 \\ &Rw 2008 \\ &Rw 2016 \\ &Rw 2008 \\ &Rw 2016 \\ &Rw $	20 2 17 14 19 53 6 36 11 1	23 2 17 19 21 53 6 36 11		0.87 [0.46, 0.46] 1.00 [0.8, 0.90] 0.90 [0.48, 0.90] 0.90 [0.48, 0.90] 0.90 [0.49, 0.90] 0.90 [0.49, 0.90] 0.90 [0.49, 0.90] 0.90 [0.49, 1.90] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00]	4.1 0.8 0.1 5.3 3.1 1.0 0.1 0.1 0.5 0.5 0.5
Kono 2016 May 2017 Gardalo 2014 Khase 2003 Holescogenetic for the formation of the for	20 2 17 14 19 53 6 36 36 11 1 8	23 2 17 19 21 53 6 36 36 11 1 8		0.87 [0.46, 0.96] 1.00 [0.19, 0.90] 0.00 [0.48, 1.00] 0.74 [0.50, 0.89] 0.80 [0.47, 0.30] 0.80 [0.47, 0.32] 0.83 [0.47, 0.32] 0.83 [0.47, 0.32] 0.100 [0.42, 1.00] 1.00 [0.42, 1.00] 0.01 [0.42, 0.00] 0.01 [0.42, 0.00	4.1 0.8 0.1 5.3 3.1 1.0 0.1 0.1 0.1 0.1 0.1
Kono 2016 Nya 2017 Kanolako 2014 Nea 2006 Fakase 20003 Fakase 20003 Fakase 20003 Faka 2000 Faka 2000 Sublingual gland slakoadenectomy Systels 2020 Faka 2010 Ganual 2000 McGuk 2006 Hostar 2006	20 2 17 14 19 53 6 36 11 1 8 9	23 2 17 19 21 53 6 36 11 1 8 10		0.87 [0.66, 0.66] 1.00 [0.19, 0.99] 0.80 [0.67, 0.68] 0.90 [0.69, 0.68] 0.90 [0.67, 0.92] 0.83 [0.67, 0.92] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 0.00 [0.50, 1.00] 0.00 [0.50, 1.00] 0.00 [0.50, 1.00]	4.1 0.8 0.1 5.3 3.1 1.0 0.1 0.1 0.1 0.1 1.5
Kono 2016 Aya 2017 Samrlabu 2014 Khaka 2023 Heterogenetik 4 = 0.50, $l^{+} = 39.34\%$, $h^{+} = 1.65$ Heterogenetik 4 = 0.50, $l^{+} = 39.34\%$, $p = 0.13$ Test of $0 = 0$: $z = 3.54$, $p = 0.00$ Stublingung signal statoadenectomy Synchro 2020 Dana 2020 Dana 2020 Dana 2020 Hahma 2020 Hahma 2020	20 2 17 14 19 53 6 36 36 11 1 8	23 2 17 19 21 53 6 36 36 11 1 8		0.87 [0.66, 0.66] 1.00 [0.19, 0.99] 1.00 [0.19, 0.99] 0.00 [0.48, 1.00] 0.74 [0.50, 0.89] 0.39 [0.60, 0.98] 0.39 [0.60, 0.98] 0.39 [0.60, 0.98] 0.39 [0.60, 0.98] 0.39 [0.60, 0.98] 0.00 [0.42, 1.00] 1.00 [0.42, 1.00]	4.1 0.8 0.1 5.3 3.1 1.0 0.1 0.1 0.1 0.1 1.5
Core 2016 App 2017 Sanchiz 2014 Kha 2006 Teleforogenety: $\Gamma^{2} = 30.34\%, \ H^{2} = 1.65$ Teleforogenety: $\Gamma^{2} = 0.50, \ \Gamma^{2} = 30.34\%, \ H^{2} = 1.65$ Teleforogenety: $\Gamma^{2} = 0.50, \ \Gamma^{2} = 3.54, \ p = 0.00$ Sublinguit gland Salcostenectomy Systels: 2020 Than 2020 Lis 2016 Shana 2020 Kolom 2020 Ko	20 2 17 14 19 53 6 36 11 1 8 9	23 2 17 19 21 53 6 36 11 1 8 10		0.87 [0.66, 0.66] 1.00 [0.19, 0.99] 0.80 [0.67, 0.68] 0.90 [0.69, 0.68] 0.90 [0.67, 0.92] 0.83 [0.67, 0.92] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 1.00 [0.42, 1.00] 0.00 [0.50, 1.00] 0.00 [0.50, 1.00] 0.00 [0.50, 1.00]	4. 01 01 51 3. 10 01 01 01 01 01 01 01
Kono 2016 Nano 2016 Nan 2008 Fraisas 2003 Heterogramity: $r = 0.50$, $l^{+} = 30.34\%$, $H^{+} = 1.65$ Time of $\eta = -0$; $Q(\eta) = 3.85$, $p = 0.13$ Time of $\eta = -0$; $Q(\eta) = 3.85$, $p = 0.03$ Sublingual gland skieloadenectomy Systels 2020 Nano 2020 National 2020 Nat	20 2 17 14 19 53 6 36 11 1 8 9 2	23 2 17 19 21 53 6 36 11 1 8 10		- 0.87 (0.46, 0.46] - 0.87 (0.46, 0.46] - 0.00 (0.18, 0.40) - 0.00 (0.48, 1.00) - 0.00 (0.48, 0.40) - 0.00 (0	4.1 0.8 0.1 5.2 3.1 1.0 0.1 0.1 0.1 0.1 0.1 0.1
Koro 2016 Apr 2017 Cauchia 2014 Roh 2006 Future 2017 False 2003 False 2003 False of $q = 0; 2; q = 3.85, p = 0.13$ Teat of $q = 0; 2; q = 3.85, p = 0.01$ Subliguit gland sialoadenectomy Systels 2020 KuGut 2006 Hill 2016 Chavi 2009 KuGut 2006 Hill 2016 Chavi 2009 Kug 200 Chavi 2007 Hill 2016 Chavi 2009 Kug 2007 Hill 2016 Chavi 2009 Hill 2016 Chavi 2007 Hill 2016 Chavi 2007 Hill 2017 Hill	20 2 17 14 19 53 6 36 11 1 8 9	23 2 17 19 21 53 6 36 11 1 8 10		- 0.87 (cold, cold) - 0.87 (cold, cold) - 0.97 (cold, cold) - 0.97 (cold, cold) - 0.97 (cold, cold) - 0.98 (cold, cold) -	4.1 0.4 0.1 5.2 3.1 1.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1
Kono 2016 Ayr,2017 Cauroliao 2014 Knoi 2006 Fraisas 2003 Heterogramity, tr = 0.50, t ² = 30.34%, H ⁴ = 1.65 Tate of 9 = 0, 20(0) = 3.88, p = 0.13 Tate of 9 = 0, 20(0) = 3.88, p = 0.03 Sublinguit gland slaloadenectomy System 2020 Sublinguit gland slaloadenectomy McGuk 2006 Halavai 2004 McGuk 2006 Halavai 2004 McGuk 2006 Halavai 2004 McGuk 2006 Halavai 2004 Tate of 9 = 0, 2 = 5.68, p = 0.07 Tate of 9 = 0, 2 = 0.07 Tate of 9 = 0.07 Tate of 9 = 0.07 Tate of 9 = 0.07 Tate of	20 2 17 14 19 53 6 36 36 36 31 1 1 8 9 2 2 4	23 2 17 19 21 53 6 36 36 11 1 8 10 2 21 4		- 0.87 (0.46, 0.46] - 0.87 (0.46, 0.46] - 0.00 (0.11, 0.49) - 0.00 (0.47, 0.47) - 0.00 (0.47, 1.00) - 0.00 (0.47, 0.47) - 0.00	4.1 0.8 0.1 5.2 3.1 1.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0
Kono 2016 Ayr,2017 Cauroliao 2014 Knoi 2006 Fraisas 2003 Heterogramity, tr = 0.50, t ² = 30.34%, H ⁴ = 1.65 Tate of 9 = 0, 20(0) = 3.88, p = 0.13 Tate of 9 = 0, 20(0) = 3.88, p = 0.03 Sublinguit gland slaloadenectomy System 2020 Sublinguit gland slaloadenectomy McGuk 2006 Halavai 2004 McGuk 2006 Halavai 2004 McGuk 2006 Halavai 2004 McGuk 2006 Halavai 2004 Tate of 9 = 0, 2 = 5.68, p = 0.07 Tate of 9 = 0, 2 = 0.07 Tate of 9 = 0.07 Tate of 9 = 0.07 Tate of 9 = 0.07 Tate of	20 2 17 14 19 53 6 36 11 1 8 9 2 2	23 2 17 19 21 53 6 53 6 53 6 11 1 8 10 2 21			4.1 0.8 0.1 5.2 3.1 1.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0
Kono 2016 App 2017 Samulao 2014 Kasa 2003 Teleforogenetic ($q = 0.50$, $l^{+} = 39.34\%$, $h^{+} = 1.65$ Teleforogenetic ($q = 0.50$, $l^{+} = 39.34\%$, $p = 0.13$ Teal of $q = 0.2$; $q = 3.54$, $p = 0.00$ Sublingual gland kialoudeneticmy Systels 2020 Dhani 2020 Dhani 2020 Haltongo ($q = 0.00$, $l^{+} = 0.00$, $l^{+} = 1.00$ Teal of $q = 0.2$; $q = 5.00$, $p = 0.00$ Sublingual gland kialoudeneticmy and pseudocyst wait removal Than 2020 Sublingual gland kialoudeneticmy and pseudocyst wait removal Than 2020 Sublingual gland kialoudeneticmy and pseudocyst wait removal Than 2020	20 2 17 14 19 53 6 36 31 1 1 8 9 2 2 4 2 2 2	23 2 17 19 21 53 6 56 11 1 8 10 2 21 4 2 23		- 0.87 (0.46, 0.46] - 0.87 (0.46, 0.46] - 0.00 (0.18, 0.40) - 0.00 (0.48, 0.40) - 0.00 (0.48, 1.00) - 0.00 (0.48, 1.00) - 0.00 (0.47, 1.00) - 0.00 (0.47, 1.00) - 0.00 (0.47, 1.00) - 0.00 (0.47, 0.40) - 0.00 (0.47, 0.40) - 0.00 (0.41, 0.40) - 0.00 (0	4.1 0.8 0.1 5.2 3.1 1.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0
Kono 2016 My 2017 Darolito 2014 Kasa 2000 Helenopenety: $t^{*} = 0.50, t^{*} = 30.34%, H^{*} = 1.85$ Helenopenety: $t^{*} = 0.50, t^{*} = 30.34%, H^{*} = 1.85$ Kel of $\theta = 0; c_{10} = 0.88, p. = 0.13$ Kel of $\theta = 0; c_{10} = 0.88, p. = 0.00$ Sublinguit gland skalesdenectomy Systels 2020 McGuit 2020 McGui	20 2 17 14 19 53 6 36 11 8 9 2 2 21 4 2 22 22 17	23 2 17 19 21 53 6 56 56 56 51 1 1 8 10 2 21 4 2 23 17			4.1 0.8 0.1 5.2 3.1 1.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0
Kono 2016 App 2017 Clambia 2014 Khas 2003 Taket 2019 Taket 2019 Taket 2019 Taket 2019 Taket 2019 Sublinguit gland sialoadenectomy Systels 2020 Chan 2000 Khas 2016 Chan 2000 Khas 2016 Chan 2000 Khas 2016 Chan 2000 Khas 2016 Chan 2000 Khas 2016 Chan 2000 Khas 2016 Chan 2001 Khas 2016 Chan 2001 Chan 2001	20 2 17 14 19 53 6 36 31 1 1 8 9 2 2 4 2 2 2	23 2 17 19 21 53 6 56 11 1 8 10 2 21 4 2 23		- 0.87 (0.46, 0.46] - 0.97 (0.46, 0.46] - 0.00 (0.18, 0.46) - 0.00 (0.18, 0.46) - 0.00 (0.47, 0.47) - 0.00	4.1 0.8 0.1 5.2 3.1 1.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0
Kono 2016 Nano 2016 Nano 2006 Fukase 2003 Fukase 2003 Fukase 2003 Fukase 2003 Fukase 2003 Fukase 2003 Fukase 2003 Sublingual gland skaloedenectomy Systels 2020 Sublingual gland skaloedenectomy Systels 2020 McGuk 2006 Hala 2006 McGuk 2008 Hala 2006 McGuk 2008 Hala 2006 McGuk 2008 Hala 2006 McGuk 2008 Hala 2006 McGuk 2008 Hala 2006 McGuk 2008 Hala 2016 Gaussian Sublingual gland skaloedenectomy and pseudocyst wait removal Tares 2018 Sublingual gland skaloedenectomy and pseudocyst wait removal Sublingual gland skaloedenectomy and pseudocyst wait removal	20 2 17 14 19 53 6 36 11 8 9 2 2 21 4 2 22 22 17	23 2 17 19 21 53 6 56 56 56 51 1 1 8 10 2 21 4 2 23 17			4.1 0.8 0.1 5.2 3.1 1.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0
Kono 2016 Apr 2017 Clancific 2014 Run 2003 Telese 2003 Telese 2003 Telese 2003 Telese 2004 Sublegual gland Saloadenectomy Systelse 2000 Sublegual gland Saloadenectomy Systelse 2000 Than 2000 Clanci 2000 Hills 2016 Ghavi 2000 Hills 2016 Hills 2016 Ghavi 2000 Hills 2016 Hills 2016 Hill	20 2 17 14 19 53 6 36 11 8 9 2 2 21 4 2 22 22 17	23 2 17 19 21 53 6 56 56 56 51 1 1 8 10 2 21 4 2 23 17		- 0.87 (0.46, 0.46] - 0.97 (0.46, 0.46] - 0.00 (0.18, 0.46) - 0.00 (0.18, 0.46) - 0.00 (0.47, 0.47) - 0.00	4.1 0.8 0.1 5.2 3.1 1.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0
Kono 2016 Apr 2017 Clancific 2014 Run 2003 Telese 2003 Telese 2003 Telese 2003 Telese 2004 Sublegual gland Saloadenectomy Systelse 2000 Sublegual gland Saloadenectomy Systelse 2000 Than 2000 Clanci 2000 Hills 2016 Ghavi 2000 Hills 2016 Hills 2016 Ghavi 2000 Hills 2016 Hills 2016 Hill	20 2 17 14 19 53 6 36 11 8 9 2 2 21 4 2 22 22 17	23 2 17 19 21 53 6 56 56 56 51 1 1 8 10 2 21 4 2 23 17		- 0.87 (0.46, 0.46] - 0.97 (0.46, 0.46] - 0.00 (0.18, 0.46) - 0.00 (0.18, 0.46) - 0.00 (0.47, 0.47) - 0.00	4.1 0.8 0.1 5.2 3.1 1.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0
Kono 2016 Nano 2016 Nan 2007 Fakase 2003 Telescopensy: $t^* = 0.50, t^* = 30.34%, tt^* = 1.85$ Nano 2006 Telescopensy: $t^* = 0.50, t^* = 30.34%, tt^* = 1.85$ Nano 2007 Sublingual gland skiloodenectomy Systels 2020 Sublingual gland skiloodenectomy Systels 2020 McGuk: 2008 Hala 2016 Charl 2009 McGuk: 2008 Hala 2016 Charl 2009 McGuk: 2008 Hala 2016 Charl 2009 McGuk: 2008 Hala 2016 Sublingual gland skiloodenectomy and pseudocyst wait removal Tes 2018 Sublingual gland skiloodenectomy and pseudocyst wait removal Thes 2020 Terres 2018 Sublingual gland Skiloodenectomy and pseudocyst wait removal Thes 2020 Sublingual gland Skiloodenectomy and pseudocyst wait removal Sublingual gland Skiloodenectomy and pseudocyst wait removal Skiloodenectomy and pseudocyst wait removal Skiloode	20 2 17 14 19 53 6 36 11 8 9 2 2 21 4 2 22 22 17	23 2 17 19 21 53 6 56 56 56 51 1 1 8 10 2 21 4 2 23 17		- 0.87 (0.46, 0.46] - 0.97 (0.46, 0.46] - 0.00 (0.18, 0.46) - 0.00 (0.18, 0.46) - 0.00 (0.47, 0.47) - 0.00	4.1 0.8 0.1 5.2 3.1 1.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0
Kono 2016 Apro17 2 Cauchiao 2014 Ruha 2003 Telescoperation 2014 Telescoperation 2014 Telescoperation 2014 Telescoperation 2015 Sublegual 2010 Sublegual 2010 Sublegual 2010 Sublegual 2010 Sublegual 2010 Course 2010 McGurt 2016 Course 2010 McGurt 2016 Course 2010 McGurt 2016 Course 2010 McGurt 2016 Course 2010 McGurt 2016 Course 2010 McGurt 2016 Course 2016 Course 2016 Course 2016 Course 2016 Course 2016 Course 2017 Tele of 9 = 0: $z = 5.60, p = 0.00$ Subleguag gland Bioloaderactomy and pseudocyst wall removal Them 2000 Torres 2016 Course 2016 Course 2016 Course 2016 Subleguag Bland Bioloaderactomy and pseudocyst wall removal Them 2015 Save 2009 Photospensity: $z^{+} = 0.00, z^{+} = 0.00, z^{+} = 1.00$ Them 2015 Save 2009 Photospensity: $z^{+} = 0.00, z^{+} = 0.00, z^{+} = 1.00$ Theorem 2015 Save 2009 Photospensity: $z^{+} = 0.00, z^{+} = 0.00, z^{+} = 1.00$ Theorem 2015 Save 2009 Photospensity: $z^{+} = 0.00, z^{+} = 0.00$ Theorem 2015 Save 2009 Photospensity: $z^{+} = 0.00, z^{+} = 1.00$ Theorem 2015 Save 2019 Photospensity: $z^{+} = 0.00, z^{+} = 1.00$ Theorem 2015 Save 2019 Photospensity: $z^{+} = 0.00, z^{+} = 1.00$ Theorem 2015 Save 2019 Photospensity: $z^{+} = 0.00, z^{+} = 1.00$ Theorem 2014 Save	20 2 17 14 19 53 6 36 11 8 9 2 2 21 4 2 22 22 17	23 2 17 19 21 53 6 56 56 56 51 1 1 8 10 2 21 4 2 23 17		- 0.87 (c.68, c.64) - 0.87 (c.68, c.64) - 0.03 (1.6, 0.67) - 0.	4.1 0.8 0.1 5.2 3.1 1.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0
$\label{eq:second} \\ $$ We constructed $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$$	20 2 17 14 19 53 6 36 11 8 9 2 2 21 4 2 22 22 17	23 2 17 19 21 53 6 56 56 56 51 1 1 8 10 2 21 4 2 23 17		- 0.87 (c.68, c.64) - 0.87 (c.68, c.64) - 0.03 (1.6, 0.67) - 0.	4.1 0.8 0.5 5.2 3.1 1.0 0.9 1.0 0.9 1.7 0.8 1.0 0.9 1.7 0.8 1.0 0.9 1.7 0.8 1.0 0.9 1.7 0.8 1.0 0.9 1.7 0.8 1.0 0.9 1.7 0.8 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
Kono 2016 Nano 2016 Nano 2007 Fakase 2000 Fakase 2000 Fakase 2000 Fakase 2000 Fakase 2000 Fakase 2000 Fakase 2000 Fakase 2000 Sublingual gland sialoadenectomy Systels 2020 Gaudia Sublingual Subloadenectomy Systels 2020 McGuk. 2006 Hana: 2009 McGuk. 2006 Hana: 2009 Hana: 2009 Hana: 2009 McGuk. 2006 Hana: 2009 Hana: 2009 Hana: 2009 McGuk. 2006 Hana: 2009 McGuk. 2007 Hana: 2007 H	20 2 17 14 19 53 6 36 11 8 9 2 2 21 4 2 22 22 17	23 2 17 19 21 53 6 56 56 56 51 1 1 8 10 2 21 4 2 23 17		- 0.87 (c.68, c.64) - 0.87 (c.68, c.64) - 0.03 (1.6, 0.67) - 0.	4.1 0.8 0.5 5.2 3.1 1.0 0.9 1.0 0.9 1.7 0.8 1.0 0.9 1.7 0.8 1.0 0.9 1.7 0.8 1.0 0.9 1.7 0.8 1.0 0.9 1.7 0.8 1.0 0.9 1.7 0.8 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0

Figure 3. Forest plot for treatment strategies for endoral (type 1) ranulas.

moderate, 5 as serious and 4 as critical. Risk of bias assessment for the only randomised controlled trial can be appreciated in Supplementary Table 3.

Classification for sublingual ranulas

To address the heterogeneity observed in the clinical presentations of sublingual ranulas, this review proposes a novel classification system for this condition. This system aims to further specify the extension of ranulas at three main anatomical levels: intraoral (Type 1), cervical (Type 2) and parapharyngeal space (Type 3). Each type is then divided into 'a' and 'b' categories, designating further specific extensions within these anatomical regions: Type 1a - simple endoral unilateral sublingual ranula; Type 1b - simple endoral sublingual ranula with extension to the contralateral oral floor; Type 2a - sublingual plunging ranula that reaches the cervical region from a hiatus

Study	Number of successes	Total	Proportion V with 95% CI	Weigh (%)
Pseudocyst wall excision and/or aspiration				
Torres 2018	0	1	0.00 [0.01, 0.89]	2.60
Ghani 2009	0	3	0.00 [0.01, 0.73]	2.82
Davison 1997	3	3	1.00 [0.27, 0.99]	2.82
Heterogeneity: $\tau^2 = 1.96$, $I^2 = 44.90\%$, $H^2 = 1.82$			0.41 [0.06, 0.88]	
Test of $\theta_i = \theta_i$: Q(2) = 3.63, p = 0.16			A DEFENSION DEFENSION DEFENSION DEFENSION DEFENSION	
Test of $\theta = 0$: z = -0.29, p = 0.77				
Sclerosing agents				
Li-Jen 2020	3	11 -	0.27 [0.09, 0.59]	4.84
Ohnta 2022	8	8	1.00 [0.50, 1.00]	2.93
Manna 2021	3	14 —	0.21 [0.07, 0.49]	4.91
Wendt 2021	1	4 —	0.25 [0.03, 0.76]	3.60
Lyly 2017	6	6	1.00 [0.42, 1.00]	2.91
Ryu 2017	7	18	0.39 [0.20, 0.62]	5.31
Garofalo 2014	3	3	1.00 [0.27, 0.99]	2.82
Roh 2006	6	7	0.86 [0.42, 0.98]	3.79
Roh 2009	5	9	0.56 [0.25, 0.82]	4.86
Heterogeneity: $\tau^2 = 0.94$, $I^2 = 57.35\%$, $H^2 = 2.34$			0.54 [0.33, 0.74]	
Test of $\theta_i = \theta_j$: Q(8) = 18.76, p = 0.02				
Test of $\theta = 0$: $z = 0.38$, $p = 0.70$				
Sublingual gland sialoadenectomy				
Roh 2022	37	42		5.32
Syebele 2022	37	37		3.00
Bachesk 2021	1	1 -	1.00 [0.11, 0.99]	2.60
Than 2020	7	7		2.92
Lyly 2017	19	19		2.98
Chen 2018	20	21		3.93
Liu 2016	14	14		2.97
Ghani 2009	2	2		2.75
Zhi 2009	129	129		3.01
Heterogeneity: $\tau^2 = 0.27$, $I^2 = 16.95\%$, $H^2 = 1.20$			🔷 0.94 [0.88, 0.97]	
Test of $\theta_i = \theta_j$: Q(8) = 9.63, p = 0.29 Test of $\theta = 0$: z = 6.63, p = 0.00				
Sublingual gland sialoadenectomy and pseudocyst wall removal				
Yang 2014	23	23	1.00 [0.74, 1.00]	2.99
Hills 2016	10	10	1.00 [0.55, 1.00]	2.95
O'Connor 2013	5	5	1 .00 [0.38, 0.99]	2.89
Heterogeneity: $\tau^2 = 0.00$, $I^2 = 0.00\%$, $H^2 = 1.00$			0.96 [0.81, 0.99]	
Test of $\theta_i = \theta_j$: Q(2) = 0.50, p = 0.78				
Test of $\theta = 0$: $z = 3.72$, $p = 0.00$				
Transcervical approaches				
Than 2020	1	3	0.33 [0.04, 0.85]	3.44
Lyly 2017	4	7	0.57 [0.23, 0.86]	4.61
Patel 2009	4	9	0.44 [0.18, 0.75]	4.86
Davison 1997	10	12		4.59
Heterogeneity: $\tau^2 = 0.25$, $I^2 = 26.93\%$, $H^2 = 1.37$			0.59 [0.36, 0.78]	
Test of $\theta_i = \theta_j$: Q(3) = 4.11, p = 0.25				
Test of $\theta = 0$: z = 0.73, p = 0.47				
Overall			0.79 [0.65, 0.88]	
Heterogeneity: $\tau^2 = 2.10$, $I^2 = 69.49$ %, $H^2 = 3.28$				
Test of $\theta_i = \theta_j$: Q(27) = 88.48, p = 0.00				
Test of $\theta = 0$: z = 3.69, p = 0.00				
Test of group differences: $Q_b(4) = 29.33$, p = 0.00		0.00	0.50 1.00	
Random-effects DerSimonian-Laird model				

Figure 4. Forest plots for treatment strategies for plunging (type 2) ranulas.

of the mylohyoid muscle; Type 2b - sublingual plunging ranula that reaches the cervical region from the posterior margin of the mylohyoid muscle; Type 3a - extended sublingual ranula

involving the parapharyngeal space; Type 3b - extended sublingual ranula involving the parapharyngeal space, masticatory space and/or the infratemporal fossa.

Discussion

Treatments for plunging ranulas showed an overall effect size of 0.80 (95 per cent CI 0.65-0.89; I2 = 73.96 per cent), while treatments for endoral ranulas showed a slightly higher effect size of 0.88 (95 per cent CI 0.83-0.91; I2 = 35.87 per cent). This indicates that, although both treatment approaches are effective, those for endoral ranulas may be marginally superior, suggesting that treatments may yield better outcomes when the ranula's extent is more limited. For the treatment of plunging ranulas, we observed high effect sizes for sublingual sialoadenectomy with or without sialoadenectomy, respectively, 0.96 (95 per cent CI 0.81-0.99; I2 = 0.00 per cent) and 0.94 (95 per cent CI 0.88-0.97; I2 = 16.95 per cent), suggesting efficacious, consistent and predictable treatment outcomes.

The use of sclerosing agents, particularly for plunging ranulas (0.64; 95 per cent CI 0.37-0.88; I2 = 79.32 per cent), was not supported by our findings as an effective treatment modality; therefore, despite the ongoing research,^{24,28,33,36,38} the use of sclerosing agents does not seem to be recommended in the treatment of this pathology. The same applies to transcervical treatments that showed a low effect size of 0.59 (95 per cent CI 0.36-0.78; I2 = 26.93) and are in line with current literature.^{1,18,19} Concerning the array of minimally invasive treatment options for endoral ranulas, marsupialisation techniques also showed less satisfactory outcomes (0.80; 95 per cent CI 0.72-0.87; I2 = 7.77 per cent), emphasising the need for careful selection of treatment based on individual patient scenarios, particularly when general anaesthesia poses a risk.

As confirmed in this meta-analysis, effective treatment of intraoral and plunging ranulas is primarily based on sublingual sialadenectomy, which yields excellent results and grants favourable outcomes.

In current literature, there are reports of extensive sublingual ranulas that not only invade the cervical region,⁶⁹ through a hiatus of the mylohyoid muscle or its posterior margin,¹⁵ but also extend into the parapharyngeal space⁵⁰ and against gravity, towards the cranial base⁷⁰ or the infratemporal fossa.⁷¹ Our results suggest that success rates of treatments for sublingual ranulas are not statistically different in relation to the extension of pathology from the oral floor (Figure 2); however, the analysis revealed considerable overall heterogeneity (I2 = 63.73 per cent), with treatments for cervical ranulas showing slightly lower success rates.

The challenge in treating ranulas arises especially in the complex cases mentioned earlier, where literature is still lacking, and further contributions are needed to confidently determine the best treatment in an evidence-based medicine perspective. Considering the variability in disease presentation and treatment options, we believe that it may be time for a new, comprehensive classification of this pathology. Classification attempts are always subject to a certain imprecision, yet proposing a terminology that comprises all the possible clinical presentations of this condition could prove useful for education, sharing information and comparing results.

The limitations of this study include the potential presence of significant heterogeneity among the included studies. The relatively high I2 values of the present meta-analysis may reflect substantial variations in study protocols, sampled populations and treatment modalities. These factors could affect the results of the present work and impose caution in their interpretation. More studies on extensive ranulas, classified as Type 3 according to the present classification, are needed to assess the safety and efficacy of different treatment modalities.

Conclusion

The present study has synthetised the different success rates of treatments for sublingual ranulas. Surgical interventions, particularly sublingual gland resection, have been confirmed as the most effective, demonstrating high success rates with low heterogeneity. The limited data precluded subgroup analysis for parapharyngeal space involvement, indicating a need for further research. The proposed new classification aims to standardise treatment approaches and facilitate clearer communication among clinicians, ultimately improving patient care. Future studies should focus on extensive ranulas to determine the safety and efficacy of different treatment modalities within an evidence-based framework.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0022215124001464.

Competing interests. The authors declare none.

Financial support. This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

References

- Harrison JD. Modern management and pathophysiology of ranula: literature review. *Head Neck* 2010;32:1310–20
- 2 Harrison JD, Garrett JR. An ultrastructural and histochemical study of a naturally occurring salivary mucocele in a cat. J Comp Pathol 1975;85:411–16
- 3 Gaffuri M, Torretta S, Pignataro L, Capaccio P. The piercing-stretching suture technique for the treatment of simple oral floor ranula. J Laryngol Otol 2022;136:68–72
- 4 Harrison JD, Garrett JR. Histological effects of ductal ligation of salivary glands of the cat. J Pathol 1976;118:245-54
- 5 McGurk M, Eyeson J, Thomas B, Harrison JD. Conservative treatment of oral ranula by excision with minimal excision of the sublingual gland: histological support for a traumatic etiology. *J Oral Maxillofac Surg* 2008;**66**:2050–7
- 6 Loney WW Jr, Termini S, Sisto J. Plunging ranula formation as a complication of dental implant surgery: a case report. J Oral Maxillofac Surg 2006;64:1204–8
- 7 Baurmash HD. Implant surgery and a plunging ranula. J Oral Maxillofac Surg 2007;65:1901-2
- 8 Borkar NB, Mohanty D, Hussain N, Dubey R, Singh S, Varshney A. A rare case of congenital ranula. *Afr J Paediatr Surg* 2021;18:106–8
- 9 Rao AR, Parakh H, Rao PMM, Kumar KY, Qadeer E. Unusual presentation of a congenital ranula cyst in a newborn. *Cureus* 2023;15:e38749
- 10 Papadopoulou E, Pettas E, Gkoutzanis L, Katoumas K, Georgaki M, Vardas E, et al. Co-existence of congenital epidermoid cyst and ranula in a newborn. Report of a unique case. J Oral Maxillofac Res 2023;14:e5
- 11 Chowdhary U, Phatak S, Dhok A, Potdukhe P. A rare case of congenital plunging ranulas: diagnosis with intraoral and extraoral ultrasound and magnetic resonance imaging. *Cureus* 2023;15:e37049
- 12 Hills A, Holden A, McGurk M. Evolution of the management of ranulas: change in a single surgeon's practice 2001-14. Br J Oral Maxillofac Surg 2016;54:992-6
- 13 Lomas J, Chandran D, Whitfield BCS. Surgical management of plunging ranulas: a 10-year case series in South East Queensland. ANZ J Surg 2018;88:1043–6
- 14 Morton RP, Ahmad Z, Jain P. Plunging ranula: Congenital or acquired? Otolaryngol Head Neck Surg 2010;142:104–7
- 15 Koch M, Mantsopoulos K, Leibl V, Müller S, Iro H, Sievert M. Ultrasound in the diagnosis and differential diagnosis of enoral and plunging ranula: a detailed and comparative analysis. J Ultrasound 2023;26:487–95
- 16 Jain P. Plunging ranulas and prevalence of the "Tail Sign" in 126 consecutive cases. J Ultrasound Med 2020;39:273–8
- Song T, Chiu W, de Paiva Leite S, Ahmad Z, Mahadevan M, Harrison JD, et al. Amylase as a diagnostic tool for plunging ranula: clinical series and description of the technique. *Laryngoscope* 2023;133:535–8
- 18 Harrison JD. The persistently misunderstood plunging ranula. Am J Otolaryngol 2022;43:103276
- 19 Chung YS, Cho Y, Kim BH. Comparison of outcomes of treatment for ranula: a proportion meta-analysis. Br J Oral Maxillofac Surg 2019;57:620-6

- 20 Goodson AMC, Payne KFB, George K, McGurk M. Minimally invasive treatment of oral ranulae: adaption to an old technique. Br J Oral Maxillofac Surg 2015;53:332–5
- 21 Talmor G, Nguyen B, Mir G, Badash I, Kaye R, Caloway C. Sclerotherapy for benign cystic lesions of the head and neck: systematic review of 474 cases. *Otolaryngol Head Neck Surg* 2021;**165**:775–83
- 22 Packiri S, Gurunathan D, Selvarasu K. Management of paediatric oral ranula: a systematic review. J Clin Diagn Res 2017;11:ZE06–9
- 23 Elnager M, Udeabor SE, Elfadeel ASA, Onwuka CI, Hamid MMM, Alsubaie YMA. Modified micromarsupialization technique as an alternative primary treatment for ranulas: a case series in a resource-challenged economy. *Clin Exp Dent Res* 2022;**8**:1434–9
- 24 Ohta N, Shirane S, Fukase S, Kawata R, Sato T, Satani N, *et al.* OK-432 treatment of ranula intruding into the cervical region. *Clin Pract* 2022;**12**:215–18
- 25 Chow T-L, Chan SWW, Lam S-H. Ranula successfully treated by botulinum toxin type A: report of 3 cases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;105:41-2
- 26 Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med 2009;151:264–9 W64
- 27 Cumpston M, Li T, Page MJ, Chandler J, Welch VA, Higgins JP, et al. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. *Cochrane Database Syst Rev* 2019;**10**:ED000142
- 28 Liao L-J, Wang C-T, Huang T-W, Cheng P-W, Lo W-C. Ultrasound-guided-fine-needle aspiration drainage and percutaneous ethanol injection for benign neck cysts. J Med Ultrasound 2020;28:225–9
- 29 Roh J-L. Transoral complete vs partial excision of the sublingual gland for plunging ranula. *Otolaryngol Head Neck Surg* 2022;**167**:479–83
- 30 Syebele K, Munzhelele TI. The anatomical basis and rational for the transoral approach during the surgical excision of the sublingual salivary gland for the management of plunging ranula. *Am J Otolaryngol* 2020;**41**:102371
- 31 Bachesk AB, Bin LR, Iwaki IV, Iwaki Filho L. Ranula in children: retrospective study of 25 years and literature review of the plunging variable. *Int J Pediatr Otorhinolaryngol* 2021;148:110810
- 32 Ohta N, Shirane S, Fukase S, Kawata R, Sato T, Satani N, *et al.* OK-432 Treatment of ranula intruding into the cervical region. *Clin Pract* 2022;**12**:215–18
- 33 Manna S, Bageac DV, Berenstein A, Sinclair CF, Kirke D, De Leacy R. Bleomycin sclerotherapy following doxycycline lavage in the treatment of ranulas: a retrospective analysis and review of the literature. *Neuroradiol* J 2021;34:449–55
- 34 Elnager M, Udeabor SE, Elfadeel ASA, Onwuka CI, Hamid MMM, Alsubaie YMA. Modified micromarsupialization technique as an alternative primary treatment for ranulas: a case series in a resource-challenged economy. *Clin Exp Dent Res* 2022;**8**:1434–9
- 35 Than JK, Rosenberg TL, Anand G, Sitton M. The importance of sublingual gland removal in treatment of ranulas: a large retrospective study. *Am J Otolaryngol* 2020;**41**:102418
- 36 Wendt M, Papatziamos G, Munck-Wikland E, Marklund L. Sclerotherapy of ranulas with OK-432 - a prospective, randomized, double-blinded placebo-controlled study. *Acta Otolaryngol* 2021;**141**:531–6
- 37 Kono M, Satomi T, Abukawa H, Hasegawa O, Watanabe M, Chikazu D. Evaluation of OK-432 injection therapy as possible primary treatment of intraoral ranula. J Oral Maxillofac Surg 2017;75:336–42
- 38 Lyly A, Castrén E, Aronniemi J, Klockars T. Plunging ranula patient characteristics, treatment, and comparison between different populations. Acta Otolaryngol 2017;137:1271–4
- 39 Ryu KH, Lee JH, Lee JY, Chung SR, Chung MS, Kim HW, et al. Ethanol ablation of ranulas: short-term follow-up results and clinicoradiologic factors for successful outcome. AJNR Am J Neuroradiol 2017;38:1794–8
- 40 Aluko-Olokun B, Olaitan AA. Ranula decompression using stitch and stab method: the Aluko Technique. J Maxillofac Oral Surg 2017;16:192–6
- 41 Zhao Q, Li M, Lai R, Wang S. Treatment of intraoral ranulas with a two-incision fistula technique: the management of recurrence. Br J Oral Maxillofac Surg 2018;56:129–33
- 42 Capaccio P, Canzi P, Gaffuri M, Occhini A, Benazzo M, Ottaviani F, *et al.* Modern management of paediatric obstructive salivary disorders: longterm clinical experience. *Acta Otorhinolaryngol Ital* 2017;**37**:160–7
- 43 Chen JX, Zenga J, Emerick K, Deschler D. Sublingual gland excision for the surgical management of plunging ranula. Am J Otolaryngol 2018;39:497–500
- 44 Torres Y, Brygo A, Ferri J. A 17-year surgical experience of the intraoral approach for ranulas. J Stomatol Oral Maxillofac Surg 2018;119:172-6

- 45 Garofalo S, Mussa A, Mostert M, Suteu L, Vinardi S, Gamba S, *et al.* Successful medical treatment for ranula in children. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2014;**117**:e289–97
- 46 Lee DH, Yoon TM, Lee JK, Lim SC. Treatment outcomes of the intraoral approach for a simple ranula. Oral Surg Oral Med Oral Pathol Oral Radiol 2015;119:e223–5
- 47 Liu Z, Wang B. Anterograde excision of a sublingual gland: new surgical technique for the treatment of ranulas. Br J Oral Maxillofac Surg 2016;54:151–4
- 48 Jia T, Xing L, Zhu F, Jin X, Liu L, Tao J, et al. Minimally invasive treatment of oral ranula with a mucosal tunnel. Br J Oral Maxillofac Surg 2015;53:138–41
- 49 Woo SH, Chi JH, Kim BH, Kwon SK. Treatment of intraoral ranulas with micromarsupialization: clinical outcomes and safety from a phase II clinical trial. *Head Neck* 2015;37:197–201
- 50 Yang Y, Hong K. Surgical results of the intraoral approach for plunging ranula. *Acta Otolaryngol* 2014;**134**:201–5
- 51 Ohta N, Fukase S, Suzuki Y, Kurakami K, Aoyagi M, Kakehata S. OK-432 treatment of ranula extending to the parapharyngeal space. *Acta Otolaryngol* 2014;**134**:206–10
- 52 Hills A, Holden A, McGurk M. Evolution of the management of ranulas: change in a single surgeon's practice 2001-14. Br J Oral Maxillofac Surg 2016;54:992–6
- 53 Amaral MB, de Freitas JB, Mesquita RA. Upgrading of the micromarsupialisation technique for the management of mucus extravasation or retention phenomena. *Int J Oral Maxillofac Surg* 2012;**41**:1527–31
- 54 O'Connor R, McGurk M. The plunging ranula: diagnostic difficulties and a less invasive approach to treatment. Int J Oral Maxillofac Surg 2013;42:1469–74
- 55 Bonet-Coloma C, Minguez-Martinez I, Aloy-Prósper A, Galán-Gil S, Peñarrocha-Diago M, Mínguez-Sanz J-M. Pediatric oral ranula: clinical follow-up study of 57 cases. *Med Oral Patol Oral Cir Bucal* 2011;16:e158–62
- 56 Seo JH, Park JJ, Kim HY, Jeon S-Y, Kim JP, Ahn S-K, et al. Surgical management of intraoral ranulas in children: an analysis of 17 pediatric cases. Int J Pediatr Otorhinolaryngol 2010;74:202–5
- 57 Roh J-L. Primary treatment of ranula with intracystic injection of OK-432. *Laryngoscope* 2006;**116**:169–72
- 58 Ghani NA, Ahmad R, Rahman RA, Yunus MRM, Putra SP, Ramli R. A retrospective study of ranula in two centres in Malaysia. J Maxillofac Oral Surg 2009;8:316–19
- 59 Patel MR, Deal AM, Shockley WW. Oral and plunging ranulas: what is the most effective treatment? *Laryngoscope* 2009;119:1501–9
- 60 Zhi K, Wen Y, Zhou H. Management of the pediatric plunging ranula: results of 15 years' clinical experience. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009;**107**:499–502
- 61 McGurk M, Eyeson J, Thomas B, Harrison JD. Conservative treatment of oral ranula by excision with minimal excision of the sublingual gland: histological support for a traumatic etiology. J Oral Maxillofac Surg 2008;66:2050-7
- 62 Roh J-L, Kim HS. Primary treatment of pediatric plunging ranula with nonsurgical sclerotherapy using OK-432 (Picibanil). *Int J Pediatr Otorhinolaryngol* 2008;7**2**:1405–10
- 63 Choi T-W, Oh C-K. Hydrodissection for complete removal of a ranula. *Ear Nose Throat J* 2003;82:946–7 951
- 64 Haberal I, Göçmen H, Samim E. Surgical management of pediatric ranula. Int J Pediatr Otorhinolaryngol 2004;68:161–3
- 65 Yuca K, Bayram I, Cankaya H, Caksen H, Kiroğlu AF, Kiriş M. Pediatric intraoral ranulas: an analysis of nine cases. *Tohoku J Exp Med* 2005;**205**:151-5
- 66 Davison MJ, Morton RP, McIvor NP. Plunging ranula: clinical observations. *Head Neck* 1998;20:63–8
- 67 Fukase S, Ohta N, Inamura K, Aoyagi M. Treatment of ranula wth intracystic injection of the streptococcal preparation OK-432. *Ann Otol Rhinol Laryngol* 2003;**112**:214–20
- 68 Mintz S, Barak S, Horowitz I. Carbon dioxide laser excision and vaporization of nonplunging ranulas: a comparison of two treatment protocols. *J Oral Maxillofac Surg* 1994;52:370–2
- 69 Matayoshi A, Nakasone T, Makishi S, Goto S, Hirano F, Maruyama N, *et al.* Plunging ranula extended to the inferior lingular segment of the left lung. *J Oral Maxillofac Surg Med Pathol* 2021;**33**:169–72
- 70 Kumbul YÇ, Okur N, Çiriş IM, Okur E, Sivrice ME, Akin V. A giant diving ranula extending to the skull base in pediatric age. J Craniofac Surg 2021;32:e515–17
- 71 Karino M, Kanno T, Iwahashi T, Ide T, Kaneko I, Yoshino A, et al. A rare case of plunging ranula with local recurrence and wide spread to the infratemporal fossa treated successfully by an intraoral surgical treatment. J Oral Maxillofac Surg Med Pathol 2017;29:240–4