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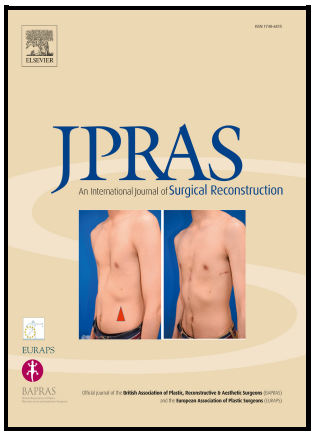
Use of the FAMM Flap in Oral Cavity and Tongue Defect Reconstruction: A Systematic Review and Meta-Analysis



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Use of the FAMM Flap in Oral Cavity and Tongue Defect Reconstruction: A Systematic Review and Meta-Analysis

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Summary

Background:

The Facial Artery Musculomucosal (FAMM) flap is a versatile flap based on the facial artery. It can be used for the reconstruction of the floor of the mouth, palate, tongue and alveolar ridge. The flap can be designed in various orientations and modified as an islanded or tunnelised flap. This study aims to review the use of the FAMM flap in the reconstruction of defects of the tongue and oral cavity, looking specifically at success rates and total complications.

Methods:

A literature search was conducted by two independent reviewers on PubMed, Dynamed, DARE, EMBASE, Cochrane and British Medical Journal (BMJ) electronic. (Registry CRD42024529989).

Results:

Twenty-seven studies fulfilled the search criteria and 407 FAMM flaps performed on 402 patients were extracted for analysis. 1.7% (n=7) of flaps failed with reasons being total necrosis (n=3), partial necrosis requiring surgical intervention and flap abandonment (n=2), total failure (n=1) and fistula formation (n=1). Overall, 26.0% (n=106) of patients experienced non-functional complications. Most commonly reported complications were partial necrosis (n=23, 5.7%), wound dehiscence (n=18, 4.4%) and venous congestion (n=13, 3.2%). The pooled success rate in all studies using FAMM flaps for oral cavity and tongue reconstruction was 99.47% (95% CI, 98.26 to 100.00, P = 1.00; I^2 = 0%;). Pooled total complication rates were 30.18% (95% CI, 16.97 to 43.38, P < 0.01; I^2 = 91%). Only thirty-five flaps required re-operation.

Conclusions:

Attracting low complication and failure rates, FAMM flaps are a safe and versatile option to consider in oral cavity and tongue reconstruction.

Key Words:

Oral Cancer; Reconstruction; Flap success; Facial Artery Musculomucosal Flap; Facial Artery; Tongue

Abbreviations:

FAMM = Facial Artery Musculomucosal Flap

BMJ = British Medical Journal

IARC = International Agency for Research on Cancer

OSCC = Oral Squamous Cell Carcinoma

RFFF = Radial Forearm Free Flap

ALT = Anterolateral Thigh Flap

AHRQ = Agency for Healthcare Research and Quality

SCC = Squamous Cell Carcinoma

FOM = Floor of Mouth

TORS = Transoral Robotic Surgery

Introduction

Oral cancer (predominantly squamous cell carcinoma) remains a significant global health issue. According to the 2022 International Agency for Research on Cancer (IARC) GLOBOCAN cancer statistics, lip and oral cavity cancers rank as the second most common type of cancer by new cases and the fourth leading type of cancer in terms of mortality in South-Central Asia.[1] Similarly, the 2022 State of Mouth Cancer UK Report shows that there has been a 34% rise in new cases over the last decade with a staggering 103% increase in the last 20 years within England alone.[2] There is almost one patient diagnosed with oral cancer every hour equating to 8,846 people in the UK in 2022.[2] Mortality rates have also surged with a 46% increase in oral-cancer-related deaths in the last 10 years.[2] 90% of oral cancers are oral squamous cell carcinoma (OSCC) with 377,713 new cases per year according to 2020 IARC GLOBOCAN data.[3] The management of oral cancers, alongside traumatic injuries, infection and congenital anomalies often requires complex reconstructive procedures posing significant challenges.

The mainstay of treatment for OSCC is surgery with or without adjuvant radiotherapy.[4] Tumour resections often result in large defects which can affect functional restoration and aesthetic outcomes. Therefore, a careful balance between tissue resection and functional preservation is required.[5] Reconstruction options for oral and tongue defects generally

fall into two main categories: microvascular free flaps and pedicled flaps.[6] Microvascular free flaps, such as the radial forearm free flap (RFFF) or anterolateral thigh (ALT) flaps, are considered the workhorse of free flap soft tissue oral reconstruction for larger defects. These flaps can be thin, pliable and versatile, allowing for extensive soft tissue or bone reconstruction.[7] However, they require microsurgical expertise and have prolonged operative times[8]. There is also variation in incidence of donor site complications seen in alternative reconstructive modalities such as RFFF (15%[9] - 40%[10]), and ALT (11%[11]-21.3%[12,13]). Commonly observed donor site complications are partial graft loss and paraesthesia in RFFF and ALT respectively[14,15]. In patients with existing comorbidities or with smaller defects, pedicled flaps such as the pectoralis major or submental island flaps should be considered.[16] However, as these are bulkier than the RFFF they can interfere with speech and swallowing thereby limiting their use in precise areas of the oral cavity.[7]

In recent years, the use of the facial artery musculomucosal (FAMM) flap, a regional pedicled flap, has emerged for the reconstruction of the floor of the mouth, palate and alveolar ridge defects.[17] It is supplied by the facial artery, originating from the cheek mucosa and it can be designed in various orientations - superiorly, inferiorly, or laterally base depending on the defect's location and size.[18] It emerges as a promising alternative due to its substantial versatility. The advantages of this flap are minimal donor site morbidity, a straightforward harvest technique, a reliable blood supply and obviating external scar formation.[19] This systematic review aims to critically evaluate the existing literature on the FAMM flap's efficacy, indications, and outcomes in reconstructing oral cavity and tongue defects.

Aims

This study reviews and evaluates the use of FAMM flap in the reconstruction of defects of the tongue and oral cavity, looking specifically at the success rates and total complications.

Methods

Database Registration

This systematic review and meta-analysis followed the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The review was registered with the University of

York's Centre for Reviews and Dissemination International Prospective Register of Systematic Reviews (PROSPERO) to reduce bias (Registry ID: CRD42024529989).

Literature Search

A literature search was conducted in April 2024 by two independent reviewers (LM and DR), with any disagreements resolved by a third reviewer (UR). The search was performed using PubMed, DynaMed, DARE, EMBASE, Cochrane, and British Medical Journal (BMJ) electronic databases for articles published between January 1970 and April 2024. The following search parameters were used to retrieve the relevant articles: "FAMM", "facial artery musculomucosal flap", "tongue", "orofacial defects", "oral cavity" "tongue base" "craniofacial", "head and neck" and "facial reconstruction"

Only original research articles were considered. The following study types were reviewed: randomised control trials, prospective cohort studies, retrospective cohort studies, case studies and case series. Two independent reviewers (LM and DR) screened titles and abstracts for eligibility and inclusion. The same reviewers then screened relevant full papers before inclusion.

Inclusion

For this article, all completed clinical studies focussing on the use of FAMM flaps in reconstructing tongue and/or oral cavity defects were included. All causes of tongue and oral cavity defects were included (trauma, oncology and congenital).

Exclusion

For this article, studies focusing on FAMM flap use for non-tongue or oral cavity defect reconstruction and those focusing on paediatric (<18) patients were excluded. Studies using alternative flaps for reconstruction were also excluded. Papers where the full text is not available in English, studies that did not report complications, and studies comparing flap types for oral cavity and tongue reconstruction with FAMM flap outcome data that could not be isolated were excluded.

Quality assessment and risk of bias

The Newcastle-Ottawa scale was used to assess studies individually for risk of bias. The results from the Newcastle Ottawa Tool were translated into the Agency for Healthcare Research and Quality (AHRQ) scores. Publication bias was assessed using R (version 4.4.0) to perform Egger's regression test, package meta version 7.0-0 to create funnel plots of success rates and complications of the use of FAMM flaps in oral cavity and tongue reconstruction.

Statistical Analysis

Pooled analysis estimates and 95% confidence intervals were calculated for the outcomes of successful reconstruction rates and total complications in all studies utilising the FAMM flap, with the application of a random effects model. Statistical analysis was performed using R (version 4.4.0), package meta version 7.0-0. Heterogeneity was assessed using R (version 4.4.0), package meta version 7.0-0 to determine the I^2 statistic (in percentage).

Results

As shown in the PRISMA Flow Diagram *(Figure 1*), the initial search yielded 716 results. After the removal of duplicates and ineligible studies, 61 articles were fully reviewed for the inclusion criteria. Grey literature searches identified three results. Two were removed on review of abstracts and one was fully reviewed. A total of 27 papers fulfilled the inclusion criteria and were included in the analysis.

Figure 1: PRISMA Flow Diagram

Study Characteristics

A total of 27 articles with 454 patients were reviewed in full text for extraction. Seven studies contained mixed data where only certain patients matched the inclusion criteria. Patients matching the inclusion criteria in these studies were included in the study if all individual data could be extracted. Fifty-two patients in these studies were excluded due to flap type/ location (n=32) and paediatric patients (n=20).

Overall, 407 FAMM flaps were performed on 402 patients for reconstruction of the oral cavity and tongue. Five patients had bilateral FAMM flaps. One paper with 20 patients did not disclose their sex[20], but the remaining studies

found 269 patients were male and 113 were female with a male-to-female ratio of 2.38:1. Mean age was 61.1 years, with a range of 18 to 90 years. The most common reason for reconstruction with a FAMM flap was malignancy (n=376, 92.4%). 19.7% (n=74) of malignancies were not described further. Squamous cell carcinoma was the most commonly described malignancy (n=292, 77.7%), followed by mucoepidermoid carcinoma (n=2, 0.5%). Other malignancies reconstructed with FAMM flaps are detailed in Table 1. 77.7% (n=292) of patients reconstructed due to malignancy underwent a neck dissection, 271 of which were concomitant and 16 previously underwent neck dissections during the primary resection. 1.1% (n=4) received a sentinel node biopsy and 7.7% (n=29) did not receive a neck dissection. Information regarding neck dissection was not reported in three studies involving 54 (14.2%) patients. Tumour staging was not consistently reported across studies as seen in Table 1. Level, side and timing of neck dissections as well as defect locations are described in Table 1. Other reasons for reconstruction included fistula (n=9, 2.2%), non-malignant tumour (n=7, 1.7%), cleft palate (n=6, 1.5%), osteonecrosis of the jaw (n=2, 0.5%), trauma (n=1, 0.2%), and iatrogenic (n=1, 0.2%). The location and size of defects can be seen in *Table 2.*[18,20-45]

Table 1: Study Characteristics

Table 2: Size and Location of Defects

Flap Outcomes

Flap failure was defined as a flap that required salvage surgery, repeat flap coverage or *complete* loss of flap viability (e.g. through total necrosis, venous congestion or wound dehiscence). Flap success was therefore defined as a flap which did not experience any of the aforementioned criteria. Total necrosis was defined as a flap that has turned black and no blood is observed on incision, whereas partial necrosis was defined as a flap with blisters and dark or purplish red discolouration.[46] Of the 407 FAMM flaps performed on 402 patients, 98.3% (n=400) were successful, while 1.7% (n=7) FAMM flaps experienced failure according to the definition used in this study. Reasons for flap failure were

total necrosis (n=3), venous congestion (n=1), partial necrosis requiring surgical debridement (n=1), partial necrosis requiring palatal swing flap coverage (n=1), total failure (n=1) and fistula formation (n=1).

Complication definitions varied within the studies. To standardise analysis, functional complications were separated from non-functional complications. Overall, 26.0% (n=106) of flaps experienced non-functional complications. The most commonly reported complications were partial necrosis (n=23, 5.7%), wound dehiscence (n=18, 4.4%) and venous congestion (n=13, 3.2%).

Twenty-three functional complications were reported in four studies containing 94 patients. Most functional complications describe dissatisfaction with the quality of speech/ swallowing, however, no standardised tools were consistently used for assessment across studies.

9.7% (n=35) of patients from 26 studies required further surgical procedures. Re-operations could not be extracted from the one study.[25] Pedicle sectioning (n=8, 2.2%) was the most described, followed by scar revision/ vestibuloplasty (n=5, 1.4%), and pedicle sectioning and scar revision/ vestibuloplasty (n=4, 1.1%). The revision procedure type was not described in nine patients.

Operating Times

Further surgery was not consistently reported across studies and follow-up time was variable. Operating time was reported in three studies and was found to be variable in individual reporting.[20,35,39] Massarelli et al. 2017 reported individual flap harvesting time, which ranged from 40 to 75 minutes with a mean time of 48.9 minutes.[35] Benjamin et al. 2020 described a decrease in procedural time with experience in flap use from 181 minutes to 59 minutes by the end of the study.[39] Joseph et al. 2020 described a 56.5-minute average, compared to the 150.5-minute average of their comparator, the fasciocutaneous free flap.[20]

Quality Assessment and Publication Bias

Of the studies included in this paper, one was of fair quality, seven were of good quality and 18 were of poor quality according to the AHRQ rating (Table 3).[47] All studies (n = 26) had evidence of comparability bias, with (n=0) having selection bias and (n = 8) studies having evidence of outcome bias (Insert table number). Funnel Plot analysis was

conducted on the pooled survival and complication rates. Egger's regression test was used to assess potential publication bias in the included studies. For flap survival, the test yielded an intercept of -0.245 (95% CI: -0.49 – 0), p = 0.0616, suggesting unlikely publication bias (p > 0.05) (Figure 2). For complication rates, the test yielded an intercept of 2.333 (95% CI: 0.49 - 4.18), p = 0.0204 (Figure 3), indicating publication bias. This bias could lead to an overestimation of the effect size for complications due to the selective reporting of studies with more favourable results.

Table 3. Newcastle-Ottawa scores and Agency for Healthcare Research and Quality (AHRQ) rating of included studies.

Figure 2: Funnel plot of success rates in oral cavity and tongue reconstruction using FAMM flaps

Figure 3: Funnel plot of complication rates in oral cavity and tongue reconstruction using FAMM flaps

Meta-analysis

The random effects model was used, given the heterogeneity and inability to assume equal effects of each study. Overall, the pooled success rate for the use of FAMM flaps in oral cavity and tongue reconstruction was 99.47% (95% CI, 98.26 to 100.00, P = 1.00; I2 = 0%; Fig 3). The total complication rate for the use of FAMM flaps in oral cavity and tongue reconstruction was 30.18% (95% CI, 16.97 to 43.38, P < 0.01; I2 = 91%; Fig 4).

Figure 4: Forest plot of pooled meta-analysis of success rates in oral cavity and tongue reconstruction using FAMM flaps

Figure 5: Forest plot of pooled meta-analysis of complication rates in oral cavity and tongue reconstruction using FAMM flaps

Discussion

Our analysis has revealed a promising efficacy of the FAMM flap for the reconstruction of the oral cavity and tongue. Total success rates are high (98.28%) and total non-functional complications are relatively low (26.0%), highlighting the robustness of this surgical technique in the reconstruction of the oral cavity and tongue. The FAMM flap has demonstrated similar survival rates compared to the most commonly used flaps for oral cavity and tongue reconstruction, such as the anterolateral thigh flap (ALT) (96.4%[48]- 98.6%[49]), pectoralis major flap (94%[50]-98.6%[51])and radial forearm free flap (RFFF) (96.0%[48] - 97.4%[52]).

Advantages of the FAMM flap

The advantages of the use of FAMM flaps in oral cavity and tongue reconstruction are several. Primarily, these flaps are mucosal, allowing for tissue to be replaced like-for-like without hair. Additionally, the flaps are thin with a large axis of rotation, making the flap valuable for defects across the entire oral cavity and tongue. The flap can also be based superiorly or inferiorly, giving the flap additional function in reconstruction in both maxillary and mandibular regions. The FAMM flap has been modified in previous studies to increase length, and width and reduce the need for pedicle sectioning in dentate patients. High survival rates and low complication rates also make the flap a more reliable choice. The flap is also easily harvested and less time-consuming when compared to free flap reconstructions which are becoming increasingly common. However, there is also a case report in the literature describing a free microvascular FAMM flap to reconstruct the cheek mucosa, which may improve aesthetic outcomes.[53]

Despite the FAMM flap demonstrating pooled complication rates of 30.8% of cases within this review, this rate is comparable to alternative flaps such as the RFFF, ALT, and pectoralis major flaps used for tongue and oral cavity reconstruction. The pectoralis major flaps have a reported total complication rate between 21.4%[51] and 51.7%[54], RFFF complications varying between 18.1%[52] and 24.0%[48] and ALT complications ranging from 13.0%[55] to 44.7%[48] in the literature.

Disadvantages of the FAMM flap

Historically, FAMM flaps were limited by their width and the necessity of a two-stage procedure involving pedicle sectioning in dentate patients. With increased use, techniques to reroute Stensen's duct allowed for an increased width[24], and to create a one-stage procedure, the FAMM flap was tunnelised.[27]

Operating Time

The reporting of operating time varied across the studies given the varying definitions, reasons for procedures, additional flaps used in conjunction and the experience of the operating surgeon. In one included study, the mean flap harvesting time was 49 minutes, and the procedure length was 56 minutes in one study and 59 minutes in another study after increased experience with the procedure. Flap raising and inset times in the literature were reported to be between 20 and 60 minutes for the islanded variation of the FAMM flap.[56,57] It was demonstrated that between 60 and 110 minutes[58] is needed to harvest, and mean operative time is 76 minutes[59] for the pectoralis major myocutaneous flap. A comparative study between FAMM flaps and RFFF demonstrated shorter operating times (7.2 hours and 8.9 hours respectively).[60] These times likely included neck dissection and ablation. However, flap harvesting time is likely longer than the FAMM flap due to the free microvascular nature of the flaps.

Limitations

Since its original use, the nomenclature of FAMM flaps has varied due to numerous modifications and similarities with other local flaps, causing misunderstanding in the communication of surgical techniques. Literature reviews have been undertaken to attempt to standardise the language used[61] however a disparity still exists.

Studies included in the analysis varied in the reporting of patient characteristics and outcomes with varying follow-up times. Therefore, complete data is not available and actual outcomes may not be consistent with those reported in the literature. Reporting was particularly inconsistent with patient tumour staging, defect size, functional complications, actual complications, location of flap and flap size. Hence it is not possible to draw conclusions on specific defect sizes/types.

Few studies have compared the FAMM flap to other flaps that are commonly used to reconstruct the tongue and oral cavity.[20,60] Studies comparing these flaps with the FAMM flap in a controlled setting with consistent reporting of characteristics and outcomes will provide valuable information on its efficacy.

The results of the pooled complication rates should be interpreted with caution due to the high level of heterogeneity observed (I^2 = 91%, p <0.01). The high heterogeneity suggests considerable variability across included studies, which may be due to differences in study design, population characteristics, outcome measures, or other methodological factors. While random-effects models were used to account for this variability, the heterogeneity observed may limit the generalizability of the pooled estimates.

Two studies contained small sample sizes (n=6 and n=5 respectively) and experienced greater numbers of complications than study size (n=8 and n=9 respectively).[34,37] Continuity corrections were applied for the feasibility of meta-analysis within this study where the study complications were taken to estimate sample size, which suggests smaller pooled complication rates from its true estimate.

Conclusion

The facial artery musculomucosal flap (FAMM) appears to be a safe and versatile flap for the reconstruction of the oral cavity and tongue. It boasts numerous advantages such as “replacing like for like” and reduced operating times compared to commonly used microvascular free flaps, with comparable survival and complication rates. With its modifications for a larger defect cover and multiple pedicles to anchor from the FAMM flap can be considered as an effective alternative in oral cavity and tongue reconstruction.

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\\10.39.3.185\journalsworkarea\Elsevier\login\else\pras\9367\Quality Assessment Instruments: Appendix E,

Figure Legends

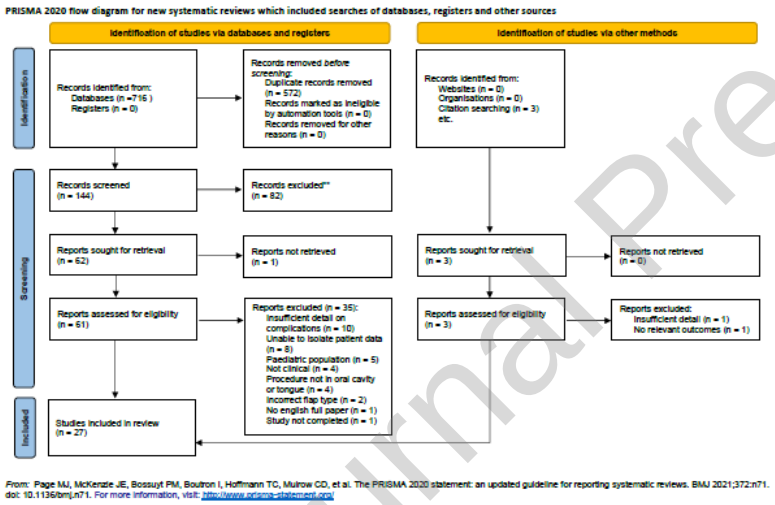

Figure 1. A PRISMA Flow Diagram demonstrating systematic search results

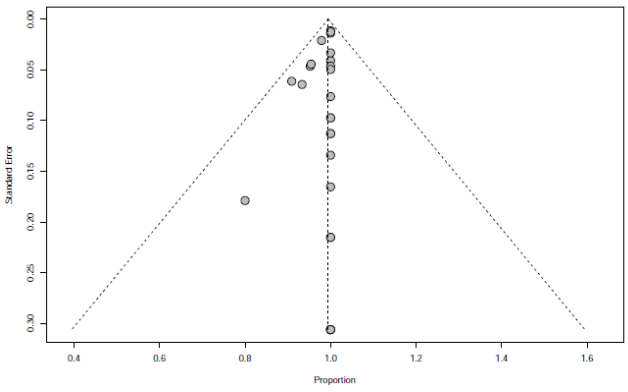

Figure 2: Funnel plot of success rates in oral cavity and tongue reconstruction using FAMM flaps

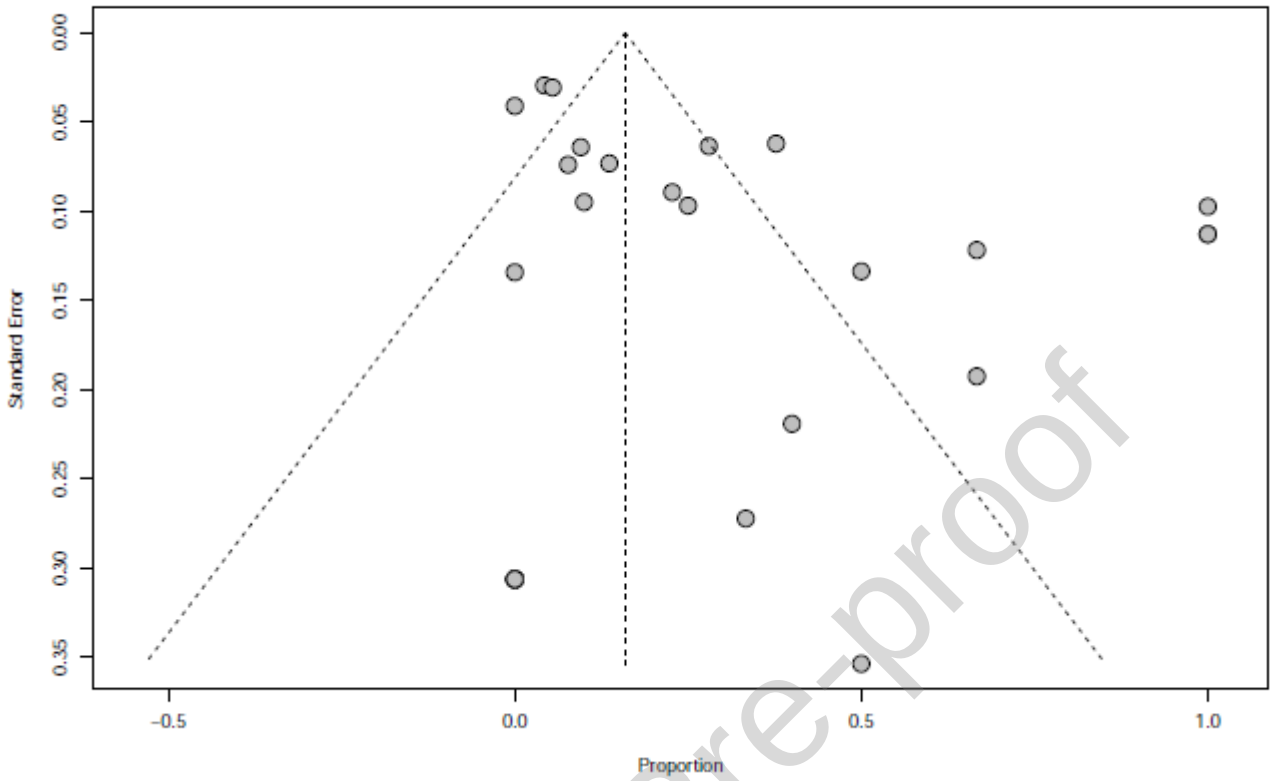

Figure 3: Funnel plot of complication rates in oral cavity and tongue reconstruction using FAMM flaps

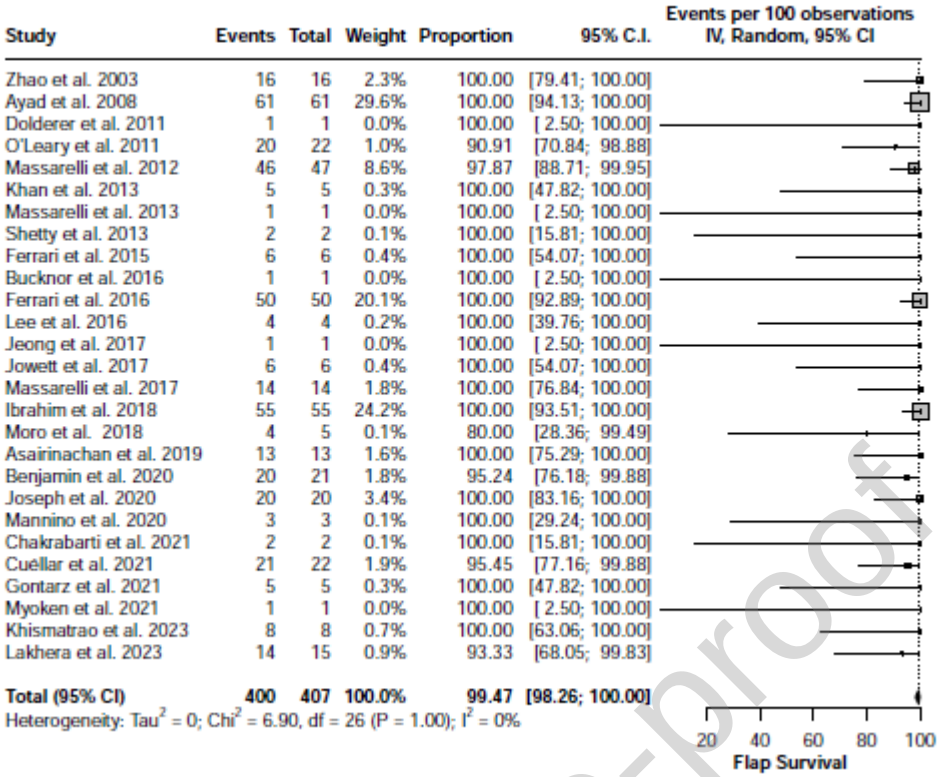

Figure 4: Forest plot of pooled meta-analysis of success rates in oral cavity and tongue reconstruction using FAMM flaps

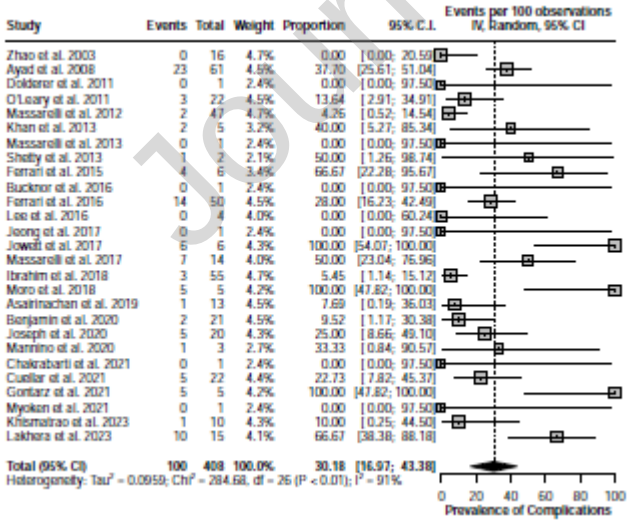

Figure 5: Forest plot of pooled meta-analysis of complication rates in oral cavity and tongue reconstruction using FAMM flaps

Table 1: Study Characteristics

Author, Year and Country	Number of Patients/ Flaps (n)	Mean (range) age	Gender ratio (M: F)	Reason for reconstruction (n)	Type of malignancy (n)	Staging (n)	Procedure for resection	Neck dissection (Y/N, n)	Level, side and timing of neck dissection (n)	Pre or post operative radiotherapy (n)	Type of FAMM flap (n)	Type of pedicle (n)	Flap Failure and Reason (n)	Complications (n)	Functional Complications (n)	Re-operations (n)
Zhao et al. 2003. China[14]	16	51.63 (38 - 70)	10: 6	Cancer (16)	SCC (16)	T1N0M0 (1), T2N0M0 (1). Others not stated	Partial glossectomy (16)	Y (16)	Not stated	Post (12)	Islanded (16)	Superior (16)	0	Nil	Nil	Nil
Ayad et al. 2008. France[15]	57 (61 flaps)	(35 - 82)	50: 7	Cancer (57)	SCC (56), Liposarcoma (1)	T1 (12), T2 (32), T3 (8), T4a (5)	Ablative surgery (57), Marginal mandibulectomy (26), Partial glossectomy (28)	Y (51), Sentinel node biopsy (4), N (2)	Previous (12), Concomitant ipsilateral (20), Concomitant bilateral (19)	Post (7), Pre (10)	Traditional (61)	Inferior (61)	0	Partial necrosis (15), Infection (1), Abscess (2), Haematoma (1), Tongue tethering by scar formation (3), Trismus (1)	Non-functional/ understandable speech (3)	Revision surgery (6)
Doldere r et al.2011. Australia[16]	1	75	1:0	Cancer (1)	SCC (1)	Not stated	Resection 4 years previously with no repair (1)	Not stated	N/A	Not stated	Islanded (1)	Inferior (1)	0	Nil	Nil	Nil
O'Leary et al. 2011. Denmark[17]	22	(35-85)	17: 5	Cancer (22)	SCC (18), Muco-epidermoid carcinoma (1), Cases of adenomatous carcinoma, malignant melanoma not specified (3).	Not stated	Tumour ablation no specifics stated	Y (12), N(10)	Not stated	Pre (4)	Traditional (22)	Inferior (16), Superior (6)	Total failure (1) Partial necrosis requiring palatinal swing flap (1)	Partial necrosis (1), Trismus (1), Bleeding due to manipulation of flap by patient (1)	Nil	Nasolabial flap (1), Re-operation, not stated (1), Palatinal swing flap (1)

Massarelli et al. 2012. Italy[18]	47 (n=1 excluded for age, n=4 excluded for locaition of defect, n=14 excluded for flap type)	63 (32 - 90)	39:8	Cancer (39), Fistula (4), ONJ (1), Non-malignant tumour (3 - Peripheral ossifying fibroma (1), Pleomorphic adenoma (1), Giant cell granuloma (1))	Squamous Cell Carcinomas (SCC) (39)	T1N0M0 (3), T2N0M0 (27), T3N0M0 (5), T2N1M0 (1), T2N2bM0 (1), T3N2bM0 (1), T4N2bM0 (1)	Not stated	Y (42)	Not stated	Timing not specified (4)	Traditional (18), Islanded (6) Islanded-arterialised (4), Islanded-tunnelised (19)	Superior (4), Inferior (43)	Total necrosis (1)	Venous congestion (2)	Nil	Data not extractable from subgroup (n=6 required z-plasty but indiscernible)
Khan et al. 2013. UK[19]	5	Not stated	4:1	Cancer (5)	SCC (5)	Lymph node metastasis (3), Metastatic disease (3)	Not stated	Y (3), N (2)	II (2), II+III (1)	Not stated	Island flap n=5	Inferior (5)	0	Mild trismus (2)	Nil	Nil
Massarelli et al. 2013. Italy[20]	1	67	0:1	Cancer (1)	SCC (1)	cT2N0M0 (1)	Total soft palate resection (1)	Y (1)	I-IV (1)	Not stated	island free flap	N/A	0	Nil	Nil	Nil
Shetty et al. 2013. India[21]	2 (n=9 excluded due to age)	31 (23 - 39)	1:1	Fistula (2)	N/A	N/A	N/A	N/A	N/A	Not stated	Pedicle n=2	Superior (1), Inferior (1)	0	Partial necrosis (1)	Nil	Nil
Ferrari et al. 2015. Italy[22]	6 (n=6 excluded due to location of defect)	59.7 (38 - 79)	4:2	Cancer (2), Cleft palate (2), Fistula (2)	SCC (2)	Not stated	Not stated	Not stated	N/A	Not stated	traditional FAMM n=6	Superior (6)	0	Partial necrosis (1) Wound dehiscence (3)	Nil	Nil
Buckner et al. 2016. UK[23]	1	45	0:1	Fistula (1)	N/A	N/A	Not stated	N/A	N/A	Not stated	Not stated	Superior (1)	0	Nil	Nil	Nil
Ferrari et al. 2016. Italy[24]	50	62.2 (33 - 86)	33:17	Cancer (50)	SCC (50)	T1N0 (5), T2N0 (38), T3N0 (7)	Not stated	Y (50)	Unilateral supraomohyoid I-III (39), Bilateral Supraomohyoid I-III (11)	Post (14)	Inferior based FAMM n=36, Buccinator island flap (Zhao flap) n=14	Inferior (36), Superior (14)	0	Wound dehisence (12) Neck infection (2)	Nil	Nil

Lee et al. 2016. USA[25]	4 (n=10 excluded due to age)	20.5 (18 - 24)	3:1	Cleft palate (4)	N/A	N/A	N/A	N/A	N/A	Not stated	Spacer FAMM (single stage FAMM)	Not stated	0	Nil	Nil	Nil
Jeong et al. 2017. South Korea[26]	1	59	0:1	Cancer (Reconstructing secondary soft palatal defect due to flap necrosis following two-flap palatoplasty) (1)	Epithelial myoepithelial carcinoma (1)	pT2N0M0 (1)	Simple mass excision with safety margin (1)	Y (1)	IB + II (1)	Post (1)	Tunnelised islanded FAMM flap n=1	Not stated	0	Nil	Nil	Nil
Jowett et al. 2017. Germany[27]	6	60.3 (41 - 75)	3:3	Cancer (6)	SCC (5), Adenoid cystic carcinoma (1)	Pre/post op staging: cT2cN2bM0/pT2pN0M0 (2), cT2cN2cM0/pT2pN2cM0 (1), cT2cN2bM0/pT3pN1M0 (1), cT2cN0M0/pT3pN0M0 (1), cT2cN1M0/pT2pN2bM0 (1)	Not stated	Y (6)	Ipsilateral II-IV (1), Concomitent bilateral I–IV, with preservation of facial vessels/ipsi (4) Prior ipsilateral I–III with sacrifice of facial art + vein/contra (intact vessels) (1)	70Gy 1 year prior n=1. Adjuvant not stated	Single pedicle n=6	Inferior (6)	0	Ipsilateral upper lip anaesthesia (3), Muscular dysfunction causing loss of lip height (5)	Nil	Nil
Massarelli et al. 2017. Italy[28]	14 (n=3 excluded for flap type)	63.2 (50 - 75)	10:4	Cancer (14)	SCC (14)	pT2N0M0 (5), pT1N0M0 (1), pT4N2bM0 (1), pT3N0M0	Ablation (14)	Y (14)	Bilateral (14)	Post (4)	tunnelised island n=14	Not stated	0	Venous congestion (1), Wound dehisence (1), Unabl	Nil	Nil

						(5), pT3N2bM0 (2)								e to discriminate between sharp and blunt stimuli (3), No thermal sensitivity (2)		
Ibrahim et al. 2018. Canada[29]	55	66.8	38:17	Cancer (51), Non-malignant tumour (4)	Not stated (51)	Total T in situ (3), T1 (20), T2 (14), T3 (3), T4 (10). Traditional Group T in situ (2), T1 (7), T2 (11), T3 (1), T4 (5) Modified Group T in situ (25), T1 (13), T2 (3), T3 (2), T4 (5)	Not stated	Not stated	N/A	Not stated	Traditional FAMM n=29, modified FAMM n=26.	Inferior (55)	0	Haematoma (2), Partial necrosis (1)	Nil	Pedicle sectioning and scar revision/ vestibuloplasty (4), Pedicle sectioning only (4), scar revision/ vestibuloplasty (5)
Moro et al. 2018. Italy[30]	5	67.8 (55 - 83)	3:2	Cancer (5)	SCC (5)	T2N2aM0 (1), T1N0M0 (2), T2N0M0 (1), T2N1M0 (1)	Wide tumour resection (1), Tumour resection (2), Surgical excision of lesion (1), Partial glossectomy	Y (3), N (2)	I-III (3)	Post (3)	Arterialized Tunnelized FAMMIF	Inferior (5)	Total necrosis (1)	Trismus (1), Partial necrosis (2), Venous congestion (5), Transient weakness of mandibular branch of CNVII (1)	Speech problems with loss of intelligibility after 12 months (1)	Nil

							(1)									
Asairinachan et al. 2019. Australia[31]	13	61	9:4	Cancer (13)	SCC (13)	T1 (5), T2 (7), T4 (1)	Transoral robotic surgery resection (13)	Y (5), N (8)	Previous ipsilateral (2), Previous bilateral (2), Concomitant unilateral (1)	Previous (8)	inferiorly pedicled n=13	Inferior (13)	0	Infection (1)	Severe dysarthria (1), Moderate dysarthria (2), Severe dysphagia / NG tube dependence (4)	Surgical haemostasis under general anaesthetic (1)
Benjamin et al. 2020. USA[32]	21	71.1 (46 - 90)	9:12	Cancer (21)	SSC (21)	All T1/T2. No mention of nodal or metastatic status.	Partial glossectomy (21)	Y (21)	Selective - I-III or I-IV (21)	Not stated	Not specified	Not stated	Fistula formation (1)	Haemorrhage (1), Infection (1)	Nil	Minor revision and inset (1), Abscess drainage (1), Fistula revision with pectoralis muscle flap (1)
Joseph et al. 2020. India[13]	20	51.5	Not stated	Cancer (20)	Not stated (20)	T1 (5), T2 (15), N0 (12), N1 (3), N2a (1), N2b (4)	WLE (20)	Y (20)	Selective I-IV (20)	Post (4)	Island flap n=20	Inferior (20)	0	Venous congestion (1), Haematoma (1), Infection (3)	Nil	Re-operation, not stated (1)
Mannino et al. 2020. USA[33]	3 (n=3 excluded for location of flap)	55.7 (41 - 63)	0:3	Cancer (3)	clear cell carcinoma (1), SCC (1), Mucoepidermoid carcinoma (1)	Not stated (2), SCC T2N2b (1)	Partial maxillectomy (2), Radical tonsillectomy (1)	N (3)	N/A	Timing not specified (1)	Not specified	Inferior (3)	0	Trismus (1)	Nil	Z-plasty of scar at donor site (1)

Chakrabarti et al. 2021. India[34]	1 (2 flaps)	65	1:0	Cancer (1)	SCC (1)	pT2N0 (1)	Peroral resection including ventral tongue, floor of mouth, anterior marginal mandible with part of genioglossus and mylohyoid muscles (1)	Y (1)	Bilateral selective I-IV (1)	Not stated	Tunnelised islanded FAMM flap n=2	Not stated	0	Nil	Nil	Nil
Cuéllar et al. 2021. Spain[35]	22	62.4 (51 - 72)	15: 7	Cancer (22)	SCC (22)	T2N0M0 (9), pT2N1M0 (7), T2N2aM0 (3), T2N2bM0 (3)	Not stated	Y (22)	Selective - I-III or I-IV (22)	Post (13)	Pedicled n=22	Inferior (22)	Partial necrosis requiring surgical debridement (1)	Venous congestion (2), Heamatoma (1), Wound dehiscence (2)	Nil	Surgical debridement (1)
Gontarz et al. 2021. Poland[36]	5	69.8 (49 - 83)	2:3	Cancer (5)	SCC (5)	Clinical: T2N1M0 (2), T3N2cM0 (1), T3N0M0 (1), T3N1M0 (1). Pathological: T3N0 (2), T3N1 (1), T3N2b (1), T3Nx (1)	Intraoral excision with adequate margins (5), Distal part of floor of mouth excised (4)	Y (5)	Level I-IV ipsilateral and I-III contralateral (4), Previous (1)	Post (4)	double pedicled n=5	Double (5)	0	Restriction in protrusion of tongue and deviation towards operated side (5)	Nil	Nil
Myoken et al. 2021. Japan[37]	1	81	0:1	ONJ (1)	N/A	N/A	N/A	N/A	N/A	Not stated	Traditional FAMM flap	Superior (1)	0	Nil	Nil	Nil

Khismatrao et al. 2023. India[11]	8 (n=2 excluded due to location of flap)	(40 - 54)	7:1	Cancer (6), Trauma (1), Iatrogenic (1)	SCC (2), Plexiform ameloblastoma (1), Polymorphous adenocarcinoma (1), Pleomorphic adenocarcinoma (1), Ameloblastoma (1)	cT4aN0Mx (2)	WLE (6), Subtotal maxillectomy (2)	Y (4), N(2)	Not Stated	Not Stated	single pedicle n=8	Superior (6), Inferior (2)	0	Marginal mandibular nerve and hypoglossal nerve weakness (1)	Nil	Pedicle release (4)
Lakhera et al. 2023. India[38]	15	46.5 (28 - 60)	10:5	Cancer (15)	SCC (15)	T1N0M0 (4), T2N0M0 (5), T1N1M0 (1), T2N1M0 (3), T2N2aM0 (2)	WLE (15)	Y (15)	I-IV (15)	Post (6)	Pedicle n=15	Inferior (15)	Total necrosis following venous congestion (1)	Partial flap necrosis (2), Fistula formation (3), Infection (2), Venous congestion (2), Heamatoma (1)	Restricted tongue mobility (3); n=2 of these unable to protrude beyond incisors, Patient dissatisfaction with quality of speech (4); n=2 partially unintelligible speech; n=1, unintelligible speech; n=1 almost normal speech, Slight difficulty in	Re-operation, not stated (2)

															opening mouth (5)	

Table 2: Size and Location of Defects

Author, Year and Country	**Location of Defect**	**Defect Size**
Zhao et al. 2003. China[14]	Body of tongue n=2 Left body of tongue n=1 Right side of tongue n=4 Left side of tongue n=8 Left side of tongue base n=1	4x4mm n=5 4x3mm n=1 half of tongue n=9 total body of tongue n=1
Ayad et al. 2008. France[15]	FOM n=53 Gingiva n=2 Tongue n=2	Small to medium
Dolderer et al. 2011. Australia[16]	Left side of soft palate n=1	2cm
O'Leary et al. 2011. Denmark[17]	Floor of mouth n=16 Palate n=4 Retromolar trigonum n=1 Palatoglossal arch n=1	Not stated

Massarelli et al. 2012. Italy[18]	Hard palate n=3 Right tongue mobile n=6 Post-lat maxillary alveolar edge n=1 Anterior mandibular alveolar ridge + FOM n=3 Left tongue mobile n=2 Lateral mandibular alveolar ridge + FOM n=2 Anterolateral FOM + Ventral tongue n=1 Anterior mandibular alveolar ridge n=1 Post-lat mandibular alveolar ridge n=1 Anterior mandibular alveolar ridge + FOM + ventral tongue n=1 Left FOM n=1, Anterolateral FOM n=3, Right hard palate n=3, Anterior FOM n=2 Uvula + left soft hemipalate n=1 Right retromolar trigone n=3 Right FOM + Ventral tongue n=1 Lateral maxillary alveolar ridge + right hard palate n=1 Anterior FOM + Ventral tongue n=1 Left soft hemipalate + tuber maxillae + retromolar trigone n=1 Lateral mandibular alveolar ridge + anterolateral FOM n=1 Uvual n=1 Soft palate + right and left tonsillar fossae n=1 Left hard palate n=1 Left anterolateral mandibular alveolar ridge + FOM n=1 Left tongue mobile + FOM n=1 Left soft hemipalate + hard palate n=1 Hard palate + posterolateral maxillary alveolar ridge n=1 2/3 hard palate + soft palate n=1	4-7cm n=62, individual sizes available on paper.
Khan et al. 2013. UK[19]	Lateral pharyngeal wall n=3 Tongue base n=2	Average flap size 3x5cm
Massarelli et al. 2013. Italy[20]	Uvula n=1	3.5x1.5cm n=1
Shetty et al. 2013. India[21]	Anterior palatal fistula n=2	1.2cm^2 n=1 1.8cm^2 n=1
Ferrari et al. 2015. Italy[22]	Anterior hard palate n=4 Superior alveolar crest and hard palate n=1 Palate n=1	Not stated
Bucknor et al. 2016. UK[23]	Hard palate n=1	3mm
Ferrari et al. 2016. Italy[24]	Tongue n=26 FOM n=18 FOM and tongue n=6	Not stated
Lee et al. 2016. USA[25]	Palate n=4	2.5 cm2 n=2 2cm2 n=1 3.75cm2 n=1
Jeong et al. 2017. South Korea[26]	Right posterior palate n=1	2x2.5x1cm n=1

Jowett et al. 2017. Germany[27]	Left anterior tongue with FOM extension n=1 Middle anterior FOM with ventral tongue extension n=1 Right anterior FOM with ventral tongue extension n=1 Right lateral oral tongue with lateral FOM n=1 Left submandibular gland with extra-glandular extension + positive margins previous surgery n=1 Right oropharynx extending to retromolar trigone, exposed inner mandibular angle post-TORS defect n=1	6.9 x 3.8 cm n=1 3.5x2.4 cm n=1 5.5x2.2 cm n=1 5.8x5.2 cm n=1 6.9x3.0cm n=1 3.0 x2.0cm n=1
Massarelli et al. 2017. Italy[28]	Uvula + left soft hemipalate n=1 Left soft hemipalate + maxillary tuberosity + retromolar trigone + left pharynx n=1 Uvula n=1 Right soft hemipalate + retromolar trigone n=2 Total soft palate n=2 Left soft hemipalate + hard palate n=1 Right 2/3 hard palate + soft palate n=1 Right soft hemipalate n=2 Right soft hemipalate + hard palate n=1 Left soft hemipalate n=2	4x3cm n=1 7x5cm n=3 6x3cm n=1 5x3cm n=1 6x4cm n=1 7x6cm n=1 6x5cm n=6
Ibrahim et al. 2018. Canada[29]	Oral cavity and oropharynx, not specified n=55	Not stated
Moro et al. 2018. Italy[30]	Left tongue n=3 Right tongue n=2	2.5x1cm n=1 Other defect sizes not specified. Flap sizes: maximum 4.5x3cm, mean 3x2.5cm
Asairinachan et al. 2019. Australia[31]	Base of tongue n=6 Tonsil n=6 Posterior pharyngeal wall n=1	Large n=13
Benjamin et al. 2020. USA[32]	Lateral/anterolateral tongue n=21	Small to Medium
Joseph et al. 2020. India[13]	Oral/ Tongue defects (not stated in paper)	Mean 6x4cm
Mannino et al. 2020. USA[33]	Tonsil n=1 Not stated in n=2 (oronasal fistula)	2.0 x1cm n=1 2.0 x1.5cm n=1 1.8x1.5cm n=1
Chakrabarti et al. 2021. India[34]	Floor of mouth encroaching on ventral Tongue n=1	3x2 n=1 2x2cm in n=1
Cuéllar et al. 2021. Spain[35]	FOM and tongue n=22	Medium sized defects Range3.7 x 2.1cm to 6.3 x 4.2cm.
Gontarz et al. 2021. Poland[36]	Tongue n=5	Moderate - type 2 according to Mannelli et al classification[31]
Myoken et al. 2021. Japan[37]	Maxillary defect n=1	Not stated
Khismatrao et al. 2023. India[11]	Lateral tongue and FOM n=1 Maxilla n=2 Lateral tongue n=1 Palate n=4	Size ranged from 1 x 0.8cm to 5.8 x 3.7cm
Lakhera et al. 2023. India[38]	Tongue n=9 FOM n=6	Small to Medium. Maximum width <3cm

Table 3: The Newcastle Ottawa Scale and AHRQ Scores for Risk of Bias of Included Studies

Author, Year and Country	Selection Score	Comparability Score	Outcome Score	AHRQ Rating
Zhao et al. 2003. China[14]	2	0	0	Poor
Ayad et al. 2008. France[15]	3	0	1	Poor
Dolderer et al. 2011. Australia[16]	2	0	2	Poor
O'Leary et al. 2011. Denmark[17]	3	0	1	Poor
Massarelli et al. 2012. Italy[18]	4	1	2	Good
Khan et al. 2013. UK[19]	3	0	1	Poor
Massarelli et al. 2013. Italy[20]	2	0	2	Poor
Shetty et al. 2013. India[21]	3	1	2	Good
Ferrari et al. 2015. Italy[22]	2	0	2	Poor
Bucknor et al. 2016. UK[23]	2	0	2	Poor
Ferrari et al. 2016. Italy[24]	3	1	2	Good
Lee et al. 2016. USA[25]	2	0	2	Poor
Jeong et al. 2017. South Korea[26]	2	0	2	Poor
Jowett et al. 2017. Germany[27]	2	1	2	Fair
Massarelli et al. 2017. Italy[28]	3	1	2	Good

Ibrahim et al. 2018. Canada[29]	3	1	2	Good
Moro et al. 2018. Italy[30]	2	0	0	Poor
Asairinachan et al. 2019. Australia[31]	3	0	2	Poor
Benjamin et al. 2020. USA[32]	3	0	0	Poor
Joseph et al. 2020. India[13]	4	1	2	Good
Mannino et al. 2020. USA[33]	3	0	2	Poor
Chakrabarti et al. 2021. India[34]	2	0	2	Poor
Cuéllar et al. 2021. Spain[35]	3	1	1	Poor
Gontarz et al. 2021. Poland[36]	3	1	0	Poor
Myoken et al. 2021. Japan[37]	2	0	2	Poor
Khismatrao et al. 2023. India[11]	3	1	2	Good
Lakhera et al. 2023. India[38]	3	1	2	Good