



Modified submandibular mandibulotomy approach versus lip-splitting approach in tongue cancer surgery: a retrospective paired-cohort study

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Abstract

Objectives The surgical approach for resection and reconstruction of tongue cancer (TSCC) with or without the lip-splitting incision is controversial. This study introduced a modified approach without lip-splitting and the clinical results were assessed.

Methods Sixty-eight TSCC patients underwent surgery using the modified submandibular mandibulotomy (MSMM) approach without lip-splitting, and another matched 68 patients using lip-splitting mandibulotomy (LSM) approach were enrolled in this study. The clinical results including intraoperative relevance and surgical morbidities, survival status, facial appearance and scar scores, function of lower lip, and quality of life (QOL) were evaluated.

Results The primary tumors were en bloc resected through the MSMM approach with excellent tumor exposure and R0 resection margins as LSM approach. The survival status and complications were similar in both groups. The function of lower lip was better in patients of MSMM group at 1 month after surgery. The MSMM approach was associated with significantly better facial appearance and recreation compared to LSM approach by scar scores and QOL assessment.

Conclusion The MSMM approach without lip-splitting achieves similar tumor control, better aesthetic results, and QOL compared to LSM approach. It is a safe and effective surgical approach for patients with TSCC.

Clinical relevance The MSMM approach without lip-splitting is oncological safety in tongue cancer surgery and is scrutinized as one part of the treatment concept for better aesthetic results.

Keywords Tongue cancer · Mandibulotomy · Lip split · Esthetic outcome · Quality of life · Prognosis

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Introduction

Oral cavity and pharynx cancers account for around 4% of all sites of cancer, and oral cavity cancer accounts for approximately 28% of all head and neck malignancies in recent years [1–3]. The tongue cancer is the most common type of oral cancer. Surgery remains the mainstream treatment for the tongue cancer, along with radiotherapy or chemoradiotherapy. In recent years, the immunotherapy is becoming a new treatment strategy for advanced oral cavity cancers [4]. Besides, the younger adult patients with oral cavity cancer may be used standard guidelines as treatment strategy, and the treatment improvement and patient care should be advanced together due to long-term toxicity [3, 5]. Good surgical access to the tumor for adequate three-dimensional resection is the key surgical procedure for good survival of the patient with tongue cancer. The lip-splitting mandibulotomy (LSM) approach is the most common incision which

allows the proximal mandible to be swung outwards to gain full access to all sites of the oral cavity and oropharynx [6]. However, LSM approach inevitably leads to facial scar and other complications. In 1990s, the mandibular lingual releasing (MLR) and visor flap (VF) techniques had been becoming alternative approaches for resection of oral cavity and oropharynx cancers, which avoided facial scar and other morbidities associated with lip-splitting mandibulotomy [7, 8]. It was difficult to balance the need for adequate margins with the goal of minimizing facial scar and preserving oral functions. The applying of surgical approaches may depend on the surgeon's preference and experiences of the surgical procedure. Nevertheless, most surgeons appreciated not lip-splitting approach in resection of oral cancer because it achieved both good tumor control and aesthetic outcomes [7, 9, 10].

Traditionally, survival rate had been the only clinical outcome used to measure the success or failure of cancer treatment [8]. In this point, the LSM approach provided a safe and efficient mean of curative surgery [6, 11]. However, it is increasingly recognized that the prolong survival gains may be offset by a substantial loss in quality of life (QOL). Facial disfigurement following surgery is considered to be the most distressing aspect of QOL in oral cancer patients. Thus, the assessment of QOL of these patients after surgery, especially the aesthetic results, has a profound effect on measuring success or failure of treatment [12, 13].

So far, there are no guidelines regarding the surgical approach for oral cavity and pharynx cancers. Any method that gains adequate access to the tumor and provides optimal margin clearance is acceptable [14]. In order to balance the need for margin clearance with the goal of better aesthetic outcomes, we applied submental incision for mandibulotomy instead of lip-splitting incision in resection of tongue cancers and in reconstruction of following defects with free flaps. Furthermore, we evaluated clinical outcomes including survival status, QOL, aesthetic, and functional outcomes of the patients with tongue cancer in two cohorts: modified submandibular mandibulotomy (MSMM) approach without lip-splitting and traditional lip-splitting mandibulotomy (LSM) approach.

Patients and methods

Nine hundred and eighty-nine consecutive patients of primary TSCC surgically treated from January 2016 to June 2021 were identified in oral and maxillofacial surgery database of Sun Yat-sen Memorial Hospital, Sun Yet-sen University. Patients were included as follows: primary tongue cancer with or without chemotherapy, tumors were resected via a MSMM approach or LSM approach, neck dissection, and free flap reconstruction. Patients were excluded

as follows: patients with previous head and neck cancers or recurrent tumors, patients with previous radiotherapy in head and neck regions, mandibulectomy, uncontrolled diabetes mellitus, and connective tissue diseases. Included patients were separated into two groups: MSMM approach or LSM approach. MSMM approach group included 68 patients. They were then paired into cohorts based on age, gender, and TNM stage. Then, another group of 68 patients that underwent LSM approach was the control. The only difference in aesthetic results between the cohorts was the lip-splitting incision or submandibular incision between the MSMM or LSM approach group. Appearance and life quality of the patients were assessed at 1 month, 6 months, 12 months, and 24 months after surgery. This study was approved by the Ethics Committee Board of Sun Yat-sen Memorial Hospital (KY-117). Informed consent was obtained from all of the TSCC patients.

Surgical procedure

Under general anesthesia, an incision is made from mastoid to submental for the MSMM approach of hemiglossectomy (Fig. 1 A and C). Following neck dissection, the attached points of mylohyoid muscle to hyoid bone and mandible are transected. The hyoglossal muscle to hyoid bone is transected, and the lingual artery is ligated. The oral floor mucosa outside the sublingual gland is incised, and the midline of the anterior tongue is split. Following the mandibulotomy is carried out; the posterior segment of the mandible is retracted in a lateral upward direction and digastric muscle in a lateral downward direction. The anterior-split tongue is pulled out to the submandibular space with excellent tumor exposure, and the tumor is safely resected with adequate margins (Fig. 1A, E). The primary tumor, the sublingual gland, the submandibular gland, the neck dissection tissue, and the mylohyoid, hyoglossal, and genioglossal muscles are en bloc removed. The surgical defect is reconstructed with a free flap. After inset of the flap, suture proceeded anteriorly from the area of the tongue base and oral floor when divided segment of the mandible is retracted upward. Then, the tongue with a flap is pushed up to the oral cavity. The mandibulotomy site is repaired with the pre-bent titanium internal fixation plates. The anterior tongue and lingual frenum is sutured with the flap to completely repair oral incision (Fig. 1G). For the MSMM approach of subtotal glossectomy and glossectomy, the incision is made from mastoid to mastoid and bilateral digastric muscles are transected. The tongue is pulled out and is en bloc resected through the similarly previous procedure. The reconstruction with free flap and incision closed are similar to previous procedure.

For the LSM approach, the lower lip and anterior mandibular labial sulcus are incised, in continuity with the neck dissection incision under general anesthesia (Fig. 1 B and

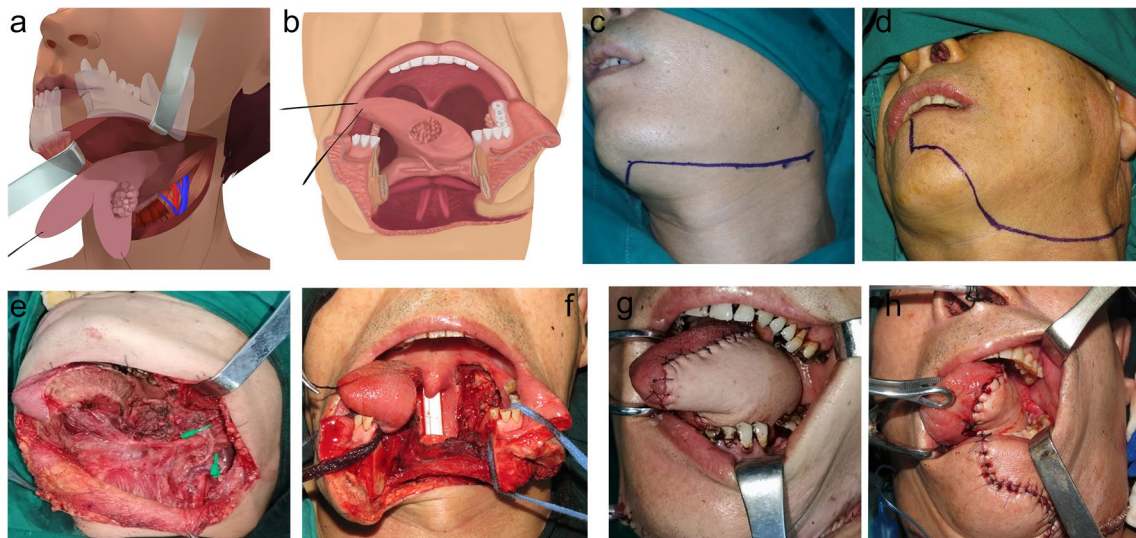


Fig. 1 Modified submandibular mandibulotomy (MSMM) approach and lip-splitting mandibulotomy (LSM) approach in resection and defect reconstruction of tongue squamous cell carcinoma (TSCC). Schematic diagram of modified submandibular mandibulotomy

approach (MSMM, **A**) and lip-splitting mandibulotomy approach (LSM, **B**). The incision of MSMM (**C**) and LSM (**D**) approaches. Oncologic resection and defect reconstruction of TSCC through MSMM (**E, G**) and LSM (**F, H**) approaches

D). Following neck dissection, the mandibulotomy is carried out and the divided segments of mandible are swung out to gain excellent tumor exposure (Fig. 1F). Then, the primary tumor, the sublingual gland, the submandibular gland, the neck dissection tissue, and the mylohyoid, hyoglossal, and genioglossal muscles are en bloc removed. The surgical defect is reconstructed with a free flap (Fig. 1G). After the vascular anastomosis is completed, the mandibulotomy site is repaired with the pre-bent titanium internal fixation plates. The lip and neck incision is repaired layer by layer. For the LSM approach of subtotal glossectomy and glossectomy, the incision is made from mastoid to mastoid in continuity with the lower lip and anterior mandibular labial sulcus.

Prognosis analysis

Clinical outcome evaluation consisted of tumor exposure, resection margin, and surgical morbidity. This study also evaluated tumor recurrence and survival status, including the number of patients with local/regional recurrence, and disease-free survival (DFS), alive with a disease (AWD), and died of a disease (DOD), which is often used to evaluate the survival status as a clinical outcome of cancer treatment.

Appearance analysis

Patients in the study were provided with a standardized, well validated, and objective scar evaluation tool, the Patient and Observer Scar Assessment Scale (POSAS), to assess aesthetic outcomes after surgery [12, 15, 16]. The POSAS, has an objective clinician-directed score (observer scar

assessment scale, OSAS) and a subjective patient-directed score (patient scar assessment scale, PSAS), have to be completed by the patient and the observer, respectively. For the scales, a lower score indicates a better result and a higher score means a worse appearance. The observer from our clinician team and the patient scored the overall scars of lip, chin, submental, and neck and then rated the overall disfigurement of the MSMM and LSM scars on a 10-point Likert scale. For this scale, a lower score indicates a better result. The patients in this study were followed-up, and the scales were completed at 1, 6, 12, and 24 months after surgery. OSAS of all patients was assessed by an observer, and data collection was performed by another observer in our team.

Lip function analysis

The sensation and movement function of lower lip were tested as described in previous study [15] at 1, 6, 12, and 24 months after surgery. Sensation was assessed at four points of vermillion border: 3 mm medial to commissure of lower lip of patients in LSM group and the mid-point of lower lip of patients in MSMM group. The other two points were 5 mm medial to those positions. The points of upper lip were used as a control. Pressure sensation and temperature sensation were tested for these points. Scores were given as (3) equivalent sensation, (2) decreased sensation, and (1) no sensation. The patients were also asked to say and hold “ee” and “oh” to assess lip movement [15]. The movements were shown to naive observer to rate as this scale: (2) symmetrical or (1) asymmetrical.

Quality of life analysis

The University of Washington Quality of Life (UW-QOL) questionnaire is the most commonly used tool for patients' clinical outcomes with head and neck cancer, and we applied it to evaluate clinical outcomes of patients with head and neck cancer previously [17]. This study evaluated clinical outcomes including functional outcomes and appearance of patients based on UW-QOL questionnaire. The domains in the questionnaire are scored on a scale ranging from 0 (worst) to 100 (best). The patients in this study completed the UW-QOL version 4 questionnaire before surgery (baseline) and at the follow-up period (at 1, 6, 12, and 24 months after surgery). Data collection was performed by two examiners in the same maxillofacial team and was calibrated.

Statistical analysis

Data were recorded and analyzed using the SPSS version 16.0 statistical software (SPSS, Chicago, IL). Mean differences for continuous data were assessed using the *t*-test. Chi-square analysis or Fisher's exact test was used to compare the patient-reported symptoms, surgical complications, and assessments between the MSMM and LSM groups. Statistical significance was set at $p < 0.05$.

Results

Of 989 patients identified, 95 patients with a MSMM approach and 632 patients with a LSM approach were included. Eighty-five MSMM and 553 LSM patients were considered because other patients met exclusion criteria. The 76 most recent patients in each group were contacted for enrollment. Sixty-eight in each arm agreed to participate and became paired cohorts, whose characteristics were listed in Table 1. There was no statistically significant difference in age, gender, and tumor stage between the MSMM and LSM groups.

Both MSMM and LSM approach showed good tumor exposures, and all tumors were resected in an en bloc fashion with negative resection margins. The neck dissection of patients was similar in both groups, and they were received functional neck dissection, radical neck dissection, or bilateral neck dissection based on clinical imaging evaluation of cervical lymph node ($P > 0.05$). The defects were reconstructed with an anterolateral thigh free flap, a radial forearm free flap, or a posterior tibial artery free flap. There was no difference in application of free flaps between the MSMM group and LSM group ($P > 0.05$). The number of patients received postoperative tracheostomy was similar in the MSMM group and LSM group (88.4% vs. 90.7%, $P > 0.05$). The operation time was shorter in the

MSMM group than that in the LSM group (295 ± 93 vs. 323 ± 78 min, $P = 0.037$). The cases of patients stayed in ICU (intensive care unit) postoperatively were similar in both groups (16.3% vs. 16.3%, $P > 0.05$). The number of patients received tube feeding was similar in the MSMM group and LSM group (67.4% vs. 72.1%, $P > 0.05$), but the patients in the MSMM group return to oral feeds were earlier than in the LSM group (5.5 ± 2.1 vs. 7.1 ± 3.3 , $P = 0.023$). This result indicated that the function of lip was recovered faster in the MSMM group based on the lip function assessment. The two groups have similar durations of postoperative hospital stay (8.2 ± 2.5 vs. 8.9 ± 2.9 , $P > 0.05$). The perioperative characteristics were demonstrated in Table 1.

The median follow-up time was 39 months and 40 months in the MSMM group and LSM group, respectively. There was no significant difference in postoperative complications, including wound dehiscence, fistulae between the MSMM group and LSM group. The patients received postoperative radiotherapy or radiochemotherapy were comparable in both groups (41.9% vs. 39.5%, $P > 0.05$). In follow-up period, one and two patients were found to have osteoradionecrosis in the MSMM group and LSM group, respectively. There was no difference of recurrence, distant metastasis, and patient survival status in both groups ($P > 0.05$). DFS of patients were 36/43 (83.7%) and 37/43 (86%) in the MSMM group and LSM group, respectively. Patients of AWD and DOD were 5 (11.6%) and 2 (4.7%), 3 (7%), and 3 (7%) in the MSMM group and LSM group, respectively. Those data was demonstrated in Table 2.

Scar assessment was performed at 1, 6, 12, and 24 months after surgery for patients of DFS. The scale scores of scar assessment and disfigurement were shown in Table 3. The scores of both OSAS and PSAS were significant higher in the LSM group than in the MSMM group. The scores about overall disfigurement based on 10-point Likert scale from both patients and clinician observers were higher in the LSM group than in the MSMM group (Table 3; $P < 0.05$). These data indicated that the subjective and objective scar was better in the MSMM group and they have better facial appearance after surgery (Table 3; Fig. 2, $P < 0.05$). Both the sensation and movement of low lip were better in patients in the MSMM group than in the LSM group 1 month after surgery. However, there were no difference of lip function between patients in the LSM group and MSMM group 6, 12, and 24 months after surgery. The lip functional assessments were shown in Table 3.

All patients of DFS in this study were completed the UW-QOL version 4 questionnaires at 1, 6, 12, and 24 months after surgery. The scores of questionnaires were shown in Table 4. There were no differences in the baseline scores of all domains between the MSMM group and LSM group. The patients in both groups scored similarly for pain, activity, speech, swallowing, chewing, taste, shoulder, and saliva at

Table 1 Demographic, clinical characteristic, and perioperative data of patients with tongue cancer in MSMM and LSM groups

	MSMM (<i>n</i> = 68)	LSM (<i>n</i> = 68)
Gender, female/male	26/41	29/39
Age, mean \pm SD, year	54.2 \pm 17.8	55.8 \pm 15.9
T classification, <i>n</i>		
T1	0 (0%)	0 (0%)
T2	33 (48.5%)	35 (51.5%)
T3	21 (30.9%)	18 (26.5%)
T4a	14 (20.6%)	15 (22.1%)
N classification, <i>n</i>		
N0	40 (58.8%)	41 (60.3%)
N1	13 (19.1%)	14 (20.6%)
N2a	7 (10.3%)	7 (10.3%)
N2b	5 (7.4%)	3 (5.9%)
N12c	3 (5.9%)	3 (5.9%)
N3	0 (0%)	0 (0%)
Induction therapy	8 (11.8%)	10 (14.7%)
Hemiglossectomy, <i>n</i>	43 (63.2%)	45 (66.2%)
Subtotal or total glossectomy, <i>n</i>	25 (36.8%)	23 (33.8%)
Resection margin, <i>n</i>		
Negative	68 (100%)	68 (100%)
Positive	0 (0%)	0 (0%)
Neck dissection, <i>n</i>		
FND	57 (83.8%)	55 (80.9%)
RND	11 (16.2%)	13 (20.1%)
Bilateral neck dissection, <i>n</i>	11 (16.2%)	10 (14.7%)
Flaps for reconstruction, <i>n</i>		
ALTF	39 (57.4%)	47 (69.1%)
RFF	4 (5.9%)	4 (5.9%)
PTAF	25 (36.8%)	17 (25.0%)
Flap lost, <i>n</i>	1 (1.5%)	1 (1.5%)
Tracheostomy, <i>n</i>	59 (86.8%)	61 (89.7%)
Operation time, mean \pm SD, minute*	289 \pm 61	312 \pm 68
ICU stay, <i>n</i>	12 (17.6%)	10 (14.7%)
Tube feeding, <i>n</i>	56 (82.4%)	59 (86.7%)
Return to oral feeds, mean \pm SD, day**	6.1 \pm 2.7	8.9 \pm 3.8
Postoperative hospital stay, mean \pm SD, day	7.1 \pm 2.3	7.9 \pm 2.7

Abbreviations: *MSMM* modified submandibular mandibulotomy, *LSM* lip-splitting mandibulotomy, *FND* functional neck dissection, *RND* radical neck dissection, *ALTF* anterolateral thigh flap, *RFF* radial forearm flap, *PTAF* posterior tibial artery flap, *ICU* intensive care unit

*The *P* value was 0.032 between two groups. **The *P* value was 0.025 between two groups

every time point in follow-up period. However, there was significant difference between the MSMM group and LSM group for the appearance at every time point in follow-up period. The scores of appearance from patients in MSMM group were much higher than that in the LSM group. The findings for recreation, mood, and anxiety were better in the MSMM group than that in the LSM group at 1 month, but there was no difference at 6, 12, and 24 months. The overall QOL of the patients in the MSMM group was better than that in the LSM group at 1 and 6 months based on the

questionnaire scores. These data indicated that the MSMM approach achieved better QoL.

Discussion

The surgical approach for resection of tongue cancer is highly variable, and the optimal approach remains an open question [10, 15]. The anesthetic and functional outcomes about lip-splitting are still controversial [7, 15]. This study

Table 2 The postoperative complications and patient prognosis in the MSMM and LSM groups

	MSMM (n=68)	LSM (n=68)	P value
Median follow-up time, range, month	52, 24~89	53, 24~90	.845
Wound dehiscence, n	2 (2.9%)	3 (4.4%)	.824
Postoperative fistulae, n	4 (5.9%)	5 (7.4%)	.798
PORT/PORCT, n	35 (51.5%)	34 (50.0%)	.887
ORN, n	2 (2.9%)	3 (4.4%)	.824
Local recurrence, n	10 (14.7%)	11 (16.2%)	.865
Regional recurrence, n	7 (10.3%)	6 (8.8%)	.758
Distant metastasis, n	2 (2.9%)	3 (4.4%)	.824
Survival status, n			
DFS	49 (72.1%)	48 (70.6%)	.912
AWD	6 (8.8%)	8 (11.8%)	.815
DOD	13 (19.1%)	12 (17.6%)	.868

Abbreviations: MSMM modified submandibular mandibulotomy, LSM lip-splitting mandibulotomy, PORT postoperative radiotherapy, PORCT radiochemotherapy, ORN osteoradionecrosis, DFS disease-free survival, AWD alive with disease, DOD died of disease

performed a MSMM approach differed from previous non-lip-splitting approach for oncologic resection and defect reconstruction of different stage TSCC. The purpose of this retrospective paired-cohort study was to assess tumor recurrence, functional, and aesthetic outcomes of the MSMM approach versus LSM approach.

An adequate three-dimensional tumor exposure is crucial to extensive tongue tumor resection, and the en bloc R0 resection further affects patient's prognosis [18, 19]. The clinical application of non-lip-splitting incision for patient with TSCC is not widely accepted by surgeons. They worry that this incision cannot provide adequate tumor exposure which will lead to tumor recurrence and poor patient prognosis. However, some other surgeons appreciated non-lip-splitting incision for oral cancer because it achieved both good tumor control and aesthetic outcomes [7, 9–11]. The tumor recurrence and patient prognosis was similar in patients between non-lip-splitting incision and lip-splitting incision. The MSMM approach applied in this study is differed from previous non-lip-splitting approach. Firstly, the incision of lip is transfer to submental region which will increase the width of visor flap and expose the mandible. Secondly, the mandibulotomy is easy to apply with this incision. Thirdly, transoral incision of oral floor and semi-tongue-splitting is performed before mandibulotomy. The tongue is released for good tumor exposure, and negative margin is achieved for resection of tumor with different sites and sizes. As previous reports, this study also showed similar tumor recurrence and patient prognosis of patients with TSCC between MSMM and LSM approach. Thus, MSMM

Table 3 Scale scores of scar assessment, disfigurement, and lip function

	1 month			6 months			12 months*			4 months**		
	MSMM	LSM	P value	MSMM	LSM	P value	MSMM	LSM	P value	MSMM	LSM	P value
OSAS	12 (6–18)	20 (12–31)	.000	8(4–13)	18(9–26)	.000	7(4–12)	16(10–26)	.000	5(3–8)	10 (6–18)	.000
PSAS	10(5–16)	18(10–24)	.000	6(2–11)	15(7–19)	.000	6(4–9)	12(7–17)	.000	4(2–6)	9 (6–15)	.000
Clinician observer												
Perception of overall disfigurement	3(1–6)	5(2–7)	.025	2(1–3)	3(2–5)	.033	2(0–3)	3(2–5)	.034	1(0–2)	2(1–4)	.017
Patient												
Perception of overall disfigurement	3(1–4)	4 (2–6)	.019	2(0–3)	3(1–5)	.035	1(1–3)	2(1–4)	.033	1(1–2)	2(1–4)	.035
Lip sensation												
Pressure	12 (11–12)	10(8–12)	.032	12 (12–12)	12 (11–12)	.978	12 (12–12)	12 (12–12)	1	12 (12–12)	12(12–12)	1
Temperature	11 (10–12)	9 (7–11)	.016	12 (11–12)	12(11–12)	1	12 (12–12)	12(12–12)	1	12 (12–12)	12(12–12)	1
Lip movement	2 (1–2)	1 (1–2)	.042	2 (2–2)	2 (1–2)	.776	2(2–2)	2(2–2)	1	2(2–2)	2(2–2)	1

Abbreviations: MSMM, Modified submandibular mandibulotomy; LSM, Lip-splitting mandibulotomy; OSAS, Observer scar assessment scale; PSAS, Patient scar assessment scale

*There were 63 patients in each group completed the assessments excluding the patients with recurrent and metastasis tumor in 12 months follow-up period

**There were 55 patients in MSMM group and 54 patients in LSM group completed the assessments excluding the patients with recurrent and metastasis tumor in 24 months follow-up period

Data were shown as median (range)

Fig. 2 Facial appearance (A, B) and appearance of reconstructed tongues (C, D) at 2 years after surgery through MSMM and LSM approaches



approach without lip-splitting is safe for oncologic resection of patients with TSCC.

The mandibulotomy in surgical treatment of oral and oropharyngeal cancer is controversial. The tumor control and frequency of complications associated with this procedure varies in many studies [14, 20, 21]. A meta-analysis showed that no significant difference was found regarding the surgical margins, overall survival rate, total and local recurrence rates, and speech and tongue movement between the mandibular preservation approach and the mandibulotomy approach in oral and oropharyngeal cancer patients. The mandibular preservation approach showed a lower complication rate after surgery [20]. However, another study showed that mandibulotomy approach provided superior local control and disease-free survival compared to transoral resection without mandibulotomy in pT2 tongue cancers [14]. In this study, mandibulotomy approach was applied in both groups and this method gained adequate access to the tumor and provided optimal margin clearance. The complication rate of fistula and osteoradionecrosis of mandible was low in this study, and adequate soft-tissue closure with free flaps and reliable fixation was important for prevention of complications after surgery.

Besides survival rate, QOL has been considered to be one of the most important outcomes in oral cancer treatment [22]. Facial disfigurement, especially the scar of lower lip following lip-splitting incision, is considered to be the most distressing aspect of QOL. We applied the

modified mandibulotomy with submental incision instead of lip-splitting incision in resection of tongue cancers. In this study, the days of tube feeding were shorter and the time of return to oral feeds was earlier after surgery in patients of the MSMM group. This superior function may result from the better sensation and movement of low lip in patients of in patients of the MSMM group one month after surgery. As previous studies [7, 9, 10, 22], we found aesthetic and functional outcomes and other QOL domains were superior through this modified approach without lip-splitting based on the results of the POSAS and UW-QOL questionnaire in this study.

There are also some limitations in this study. A prospective study need to be conducted to confirm the results of this study, because another study concluded that scarring and facial disfigurement were no statistically significant differences between lip-splitting and non-lip-splitting approach based on their results of the POSAS [12]. They showed that the lip-splitting mandibulotomy approach also provided satisfactory scarring and low self-perception of disfigurement for oral cancer patients after surgery [12]. Secondly, the gender and age of patients may affect the results of objective scales and questionnaire. We found that female patients with age under than 40 years old in the LSM group showed lower scores of patient scar scale and decreased QOL for the lip-splitting incision caused high levels of patient anxiety, self-consciousness of oral cancer patients after surgery.

Table 4 The scores of QOL for patients in MSMM group and LSM group at follow-up time

	Baseline			1 month			6 months			12 months*			24 months**		
	MSMM	LSM	P value	MSMM	LSM	P value	MSMM	LSM	P value	MSMM	LSM	P value	MSMM	LSM	P value
Pain	75 (50–100)	75 (50–100)	.465	75 (50–75)	75 (50–75)	.587	100 (75–100)	100 (75–100)	.715	100 (75–100)	100 (75–100)	.892	100 (75–100)	100 (75–100)	.951
Appearance	100 (75–100)	100 (75–100)	.378	75 (50–100)	50 (25–75)	.000	100 (75–100)	50 (25–75)	.000	100 (75–100)	50 (50–75)	.003	100 (75–100)	50 (50–75)	.007
Activity	100 (50–100)	100 (50–100)	.652	75 (50–100)	75 (50–100)	.464	100 (75–100)	100 (75–100)	.356	100 (75–100)	100 (75–100)	.355	100 (75–100)	100 (75–100)	.414
Recreation	100 (75–100)	100 (75–100)	.743	75 (50–100)	75 (50–100)	.045	100 (75–100)	100 (75–100)	.112	100 (75–100)	100 (75–100)	.357	100 (75–100)	100 (75–100)	.598
Swallowing	100 (30–100)	100 (30–100)	.772	70 (30–100)	70 (30–100)	.772	100 (70–100)	100 (70–100)	.782	100 (70–100)	100 (70–100)	.823	100 (70–100)	100 (70–100)	.885
Chewing	100 (50–100)	100 (50–100)	.771	100 (50–100)	100 (50–100)	.713	100 (50–100)	100 (50–100)	.322	100 (50–100)	100 (50–100)	.722	100 (50–100)	100 (50–100)	.912
Speech	100 (70–100)	100 (70–100)	.673	70 (30–70)	70 (30–70)	.763	70 (30–100)	70 (30–100)	.273	70 (30–100)	70 (30–100)	.577	70 (30–100)	70 (30–100)	.842
Shoulder	100 (100–100)	100 (100–100)	1	70 (30–100)	70 (30–100)	.663	100 (30–100)	100 (30–100)	.724	100 (70–100)	100 (70–100)	.826	100 (70–100)	100 (70–100)	.853
Taste	100 (70–100)	100 (70–100)	.872	70 (30–70)	70 (30–70)	.851	70 (70–100)	70 (70–100)	.556	100 (70–100)	100 (70–100)	.755	100 (70–100)	100 (70–100)	.843
Salvia	100 (100–100)	100 (100–100)	1	70 (70–100)	70 (70–100)	.852	100 (30–100)	100 (30–100)	.524	100 (70–100)	100 (70–100)	.835	100 (70–100)	100 (70–100)	.924
Mood	50 (0–75)	50 (0–75)	.289	50 (25–100)	50 (25–75)	.042	75 (25–100)	75 (25–100)	.165	100 (50–100)	100 (50–100)	.532	100 (50–100)	100 (50–100)	.655
Anxiety	30(0–70)	30(0–70)	.438	30(30–100)	30(30–70)	.037	70(30–100)	70(30–100)	.448	70(70–100)	70(70–100)	.628	100(70–100)	100(70–100)	.525
Overall QOL	50 (25–75)	50 (25–75)	.674	75 (25–100)	50 (25–100)	.023	75 (25–100)	75 (25–100)	.044	75 (50–100)	75 (50–100)	.355	75 (75–100)	75 (75–100)	.662

Data were shown as median (range)

Abbreviations: MSMM modified submandibular mandibulotomy, LSM lip-splitting mandibulotomy, QOL quality of life

*There were 41 patients in each group completed the UW-QOL questionnaire excluding the patients with recurrent and metastasis tumor in 12 months follow-up period

**There were 39 patients in the MSMM group and 40 patients in the LSM group completed the UW-QOL questionnaire excluding the patients with recurrent and metastasis tumor in 12 months follow-up period

Conclusions

The MSMM approach without lip-splitting is safe, and effective in tongue cancer patients underwent oncologic resection and defect reconstruction. This study shows similar surgical morbidity and tumor control compared to LSM approach and achieves better QOL associated with lip function, facial appearance, and mood.

Author contribution Youyuan Wang: Study concepts, study design, manuscript preparation and review.

Min Fu: Statistical analysis and data acquisition.

Pingping Qiu: Figure preparation and data acquisition.

Bin Zhou: Quality control of data and algorithms.

Xianbei Zhu: Data acquisition.

Zhaoyu Lin: Data analysis and interpretation.

Chaobin Pan: Manuscript review.

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Declarations

Ethics approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the Ethics Committee Board of Sun Yat-sen Memorial Hospital, Sun Yat-sen University(KY-117) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent for publication Informed consent was obtained from each participant involved in the study.

Conflict of interests The authors declare no conflict of interests.

Competing interests The authors declare no competing interests.

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