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A precise glossectomy for tongue cancer adjacent to or crossing the midline: a novel anatomical unit resection surgery

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Abstract. Previous studies have lacked a clear anatomical and functional definition of glossectomy for tongue cancer adjacent to or crossing the midline (TCML). The aim of this study was to provide a novel surgical approach based on anatomical unit resection surgery to treat TCML. A total of 120 patients with TCML who had undergone radical surgery were recruited retrospectively into the study. The patients who were treated with compartment surgery formed the control group; those treated with anatomical unit resection surgery formed the experimental group. The TCML was classified into cancer adjacent to the midline, cancer invading but not breaching the contralateral musculus verticalis linguae–genioglossus complex (MGC), and cancer breaching the contralateral MGC. No significant difference in the overall survival rate was found between the experimental and control groups overall ($P = 0.853$) or by TCML classification. In patients with cancer adjacent to the midline, the swallowing score ($P = 0.040$) and cosmetic outcome ($P = 0.015$) were significantly better in the experimental group than in the control group. For patients with cancer invading but not breaching the contralateral MGC, the speech intelligibility score ($P = 0.001$), swallowing score ($P = 0.002$), and cosmetic outcome ($P = 0.037$) were significantly better in the experimental group than in the control group. Anatomical unit resection surgery was found to provide a precise surgical treatment to address tongue cancer adjacent to or crossing the midline and maximally maintain tongue tissue and function.

Keywords: Tongue neoplasms; Surgical oncology; Glossectomy; Recovery of function; Prognosis.

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Oral cancer is one of the most common malignant lesions worldwide,[1] with approximately 350,000 new cases and 170,000 deaths in 2018.[2] Although there has been a slight decrease in the global incidence of oral cancer, the incidence of tongue cancer is increasing.[3] Tongue cancer remains the most common intraoral site for oral cancer, with high morbidity and mortality.[4] Despite continuous therapeutic advancements over the past several years, the overall 5-year survival rate of patients with advanced tongue cancer is estimated to be approximately 50%.[5,6]

Surgical treatment remains the mainstay for addressing tongue cancer.[7] To date, the universally accepted standard treatment is compartmental surgical resection of the tongue primary lesion.[5] Each half of the tongue includes its own intrinsic muscles (longitudinal and transverse), extrinsic muscles (hyoglossus, styloglossus, genioglossus, and palatoglossus), lingual veins, lingual artery, lingual nerve, and hypoglossal nerve.[8] From a functional surgery perspective, tongue resection leads to partial muscle defects in such a way that they cause function loss.[5] Based on compartment surgery, patients with tongue cancer adjacent to or crossing the midline (TCML) should be treated with a hemiglossectomy, subtotal glossectomy, or total glossectomy.[9] However, previous studies have lacked a clear anatomical and functional definition of glossectomy for TCML.

In a previous study performed by the present authors' group, it was found that primary tongue tumours can be divided into four types: I, pushing; II, sawtooth; III, spike; and IV, skipping.[10] The same author group has also described the use of anatomical unit resection surgery (AURS), which is the removal of the entire anatomical unit (or subunit) in which the tumour is involved.[10,12] This was found to significantly improve the overall survival (OS) rate in patients with buccal cancer[11] and posterior oral cavity cancer.[12] Each muscle structure is an individual anatomical unit. In AURS, each compartment of the tongue can be subdivided into several anatomical units. The subdivision of each half of the tongue compartment would be beneficial for performing a precise glossectomy for TCML and maintaining tongue function. Based on the anatomical characteristics of the tongue and AURS, the novel concept of the musculus verticalis linguae–genioglossus complex (MGC) has been developed, which includes the ipsilateral musculus verticalis linguae and genioglossus (Fig. 1). The MGC is shown in the sagittal plane in Fig. 1A and marked in green in the coronal plane in Fig. 1C. The MGC can serve as an anatomical marker for the evaluation of the relationship between the primary tumour and the bilateral MGC in order to determine the extent of the surgical resection. The principal aim of this study was to describe a novel surgical approach to address TCML and preserve tongue function.

Materials and methods

This was a retrospective cohort study. A total of 120 patients with TCML who underwent radical surgery between March 2016 and May 2020 in the Department of Oral and Maxillofacial Surgery at the Second Xiangya Hospital were recruited. Patients with a history of preoperative radiotherapy or chemotherapy were excluded. This study was approved by the Institutional Review Board of the Second Xiangya Hospital (approval number 2011210), and informed consent was obtained

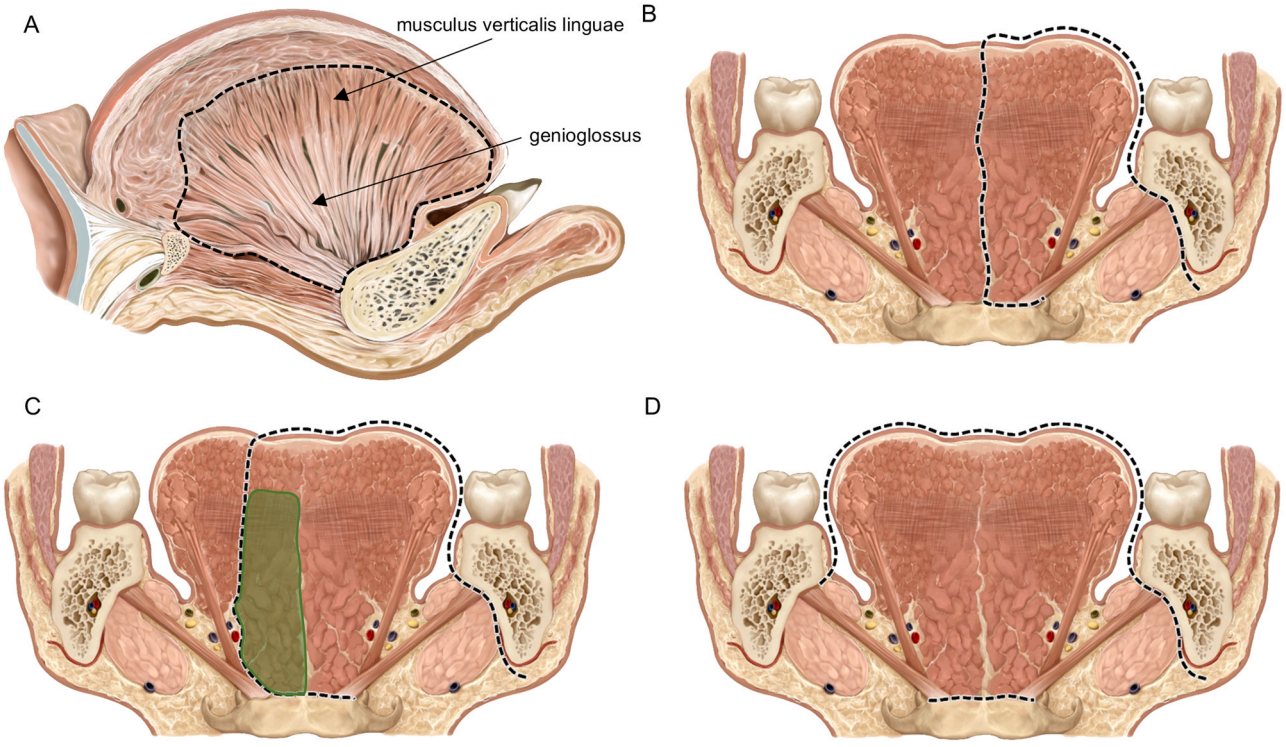

Fig. 1. Sub-classification of the anatomical unit resection surgery (AURS) procedures for treating tongue cancer adjacent to or crossing the midline. (A) Musculus verticalis linguae–genioglossus complex (MGC). (B) Type I, hemiglossectomy. (C) Type II, resection of the contralateral MGC and primary tumour, preserving the contralateral lingual veins, lingual artery, lingual nerve, and hypoglossal nerve. (D) Type III, subtotal or total glossectomy.

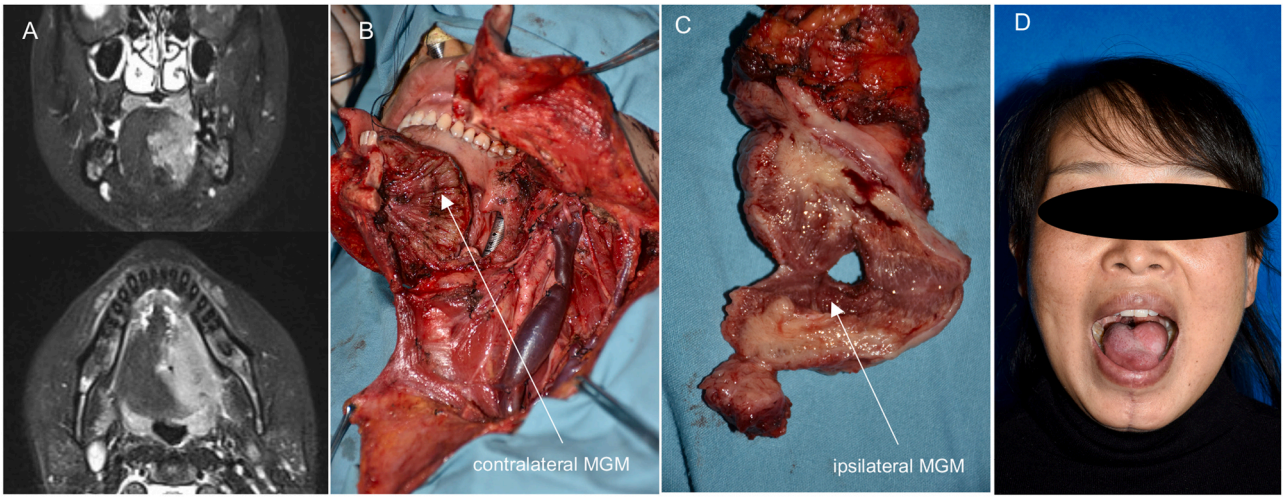

Fig. 2. Invasion of the ipsilateral MGC by the primary tumour. (A) MRI of the primary tumour. (B) The contralateral MGC was preserved after resection of the ipsilateral MGC. (C) Primary tumour specimen. (D) Appearance at 24 months after surgical treatment. (MGC, musculus verticalis linguae–genioglossus complex.).

from all participants. The study was performed in accordance with the principles of the Declaration of Helsinki.

Magnetic resonance imaging (MRI) and computed tomography (CT) were used to assess the location and size of the primary tumour and cervical lymph nodes. All patients underwent radical surgery and continuous en bloc excision, as well as reconstruction using an anterolateral thigh flap. The pathological resection margins were negative in these patients. Patients who were treated with compartment surgery were assigned to the control group, while those who were treated with AURS were assigned to the experimental group.

The relationship between the primary tumour and the bilateral MGC was determined by dissecting the primary tumour specimen. The inclusion criteria for TCML were as follows: a primary tumour invading the ipsilateral MGC, which was defined as 'tongue cancer adjacent to the midline'; a primary tumour invading or breaking through, i.e. breaching, the contralateral MGC, which was defined as 'tongue cancer crossing the midline'. Patients with TCML were classified as having tongue cancer adjacent to the midline, tongue cancer invading but not breaching the contralateral MGC, or tongue cancer breaching the contralateral MGC.

Surgical technique

Compartment surgery was performed as described previously.[5] AURS was performed as follows. After completion of the neck dissection, lip splitting and a mandibulotomy were performed. The intraoral incision began at the frenulum linguae, continued along the genial tubercles to cut off the ipsilateral genioglossus, and extended upward with blunt dissection to the lingual septum. In this space, the surgeon could precisely estimate whether the primary tumour had invaded the ipsilateral genioglossus, contralateral genioglossus, or extrinsic lingual muscles by intraoperative palpation. Conventional palpation of the tongue dorsum cannot fully assess the extent of the primary tumour in the underlying tongue tissue. It is more precise to estimate the relationship between the primary tumour and bilateral MGC using the aforementioned palpation procedure than palpation of the dorsum. The ipsilateral MGC served as an anatomical marker for determining the extent of the tongue cancer resection. For posterior tongue cancer, it is necessary to evaluate the relationship between the primary tumour and hyoglossus or styloglossus.

Depending on the extent of the tumour resection, the AURS procedure can be classified into three types: type I, resection of the ipsilateral MGC and primary tumour (hemiglossectomy, Fig. 1B), indicated for cancer adjacent to the midline (Fig. 2); type II, resection of the contralateral MGC and primary tumour, with preservation of the contralateral lingual veins, lingual artery, lingual nerve, and hypoglossal nerve (Fig. 1C), indicated for cancer invading but not breaching (breaking through) the contralateral MGC (Figs. 3 and 4); and type III, subtotal or total glossectomy (Fig. 1D), indicated for cancer breaching the contralateral MGC (Fig. 5).

An objective functional evaluation was performed postoperatively. Specifically, speech intelligibility, swallowing efficiency, and the cosmetic outcome were assessed using functional assessment.[13–15] Each of these outcomes was assessed on a four-point scale from 1 to 4, with a score of 1 indicating tracheostomy requirement, dysphagia, or a poor aesthetic outcome and a score of 4 indicating normal speech, near natural swallowing, or an excellent cosmetic outcome. The mean ± standard deviation scores were calculated.

Statistical analysis

Overall survival, disease-free survival, and local disease control rates were determined from the date of surgical treatment to the date of the event or latest follow-up. Death was identified as a competing event. Survival was analysed using Kaplan–Meier curves. The χ^2 test or Fisher's exact test was used to compare the categorical variables between the two groups. The *t*-test or non-parametric Mann–Whitney *U*-test was used to compare quantitative variables between the two groups. Statistical analyses were performed using SPSS Statistics version 17.0 software (SPSS Inc., Chicago, IL, USA). All values were two-sided, and statistical significance was set at $P < 0.05$.

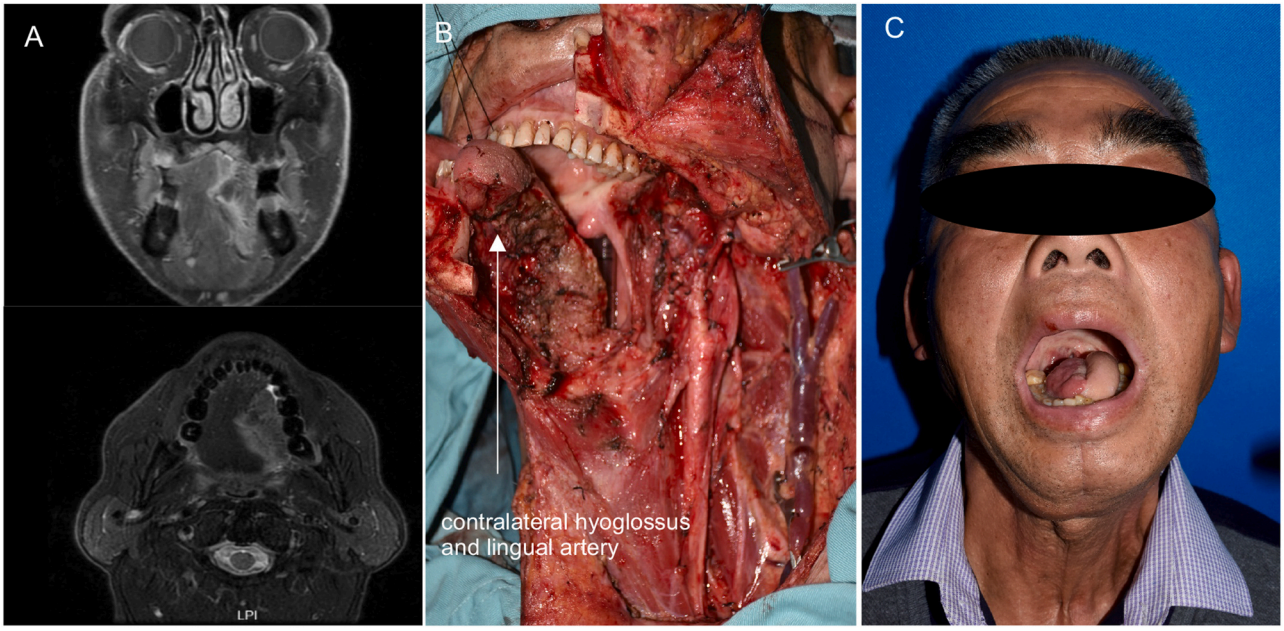

Fig. 3. Primary tumour suspected to have invaded the contralateral MGC. (A) MRI of the primary tumour. (B) The contralateral hyoglossus and lingual artery were preserved after resection of the contralateral MGC. (C) Appearance at 24 months after surgical treatment. (MGC, musculus verticalis linguae–genioglossus complex.).

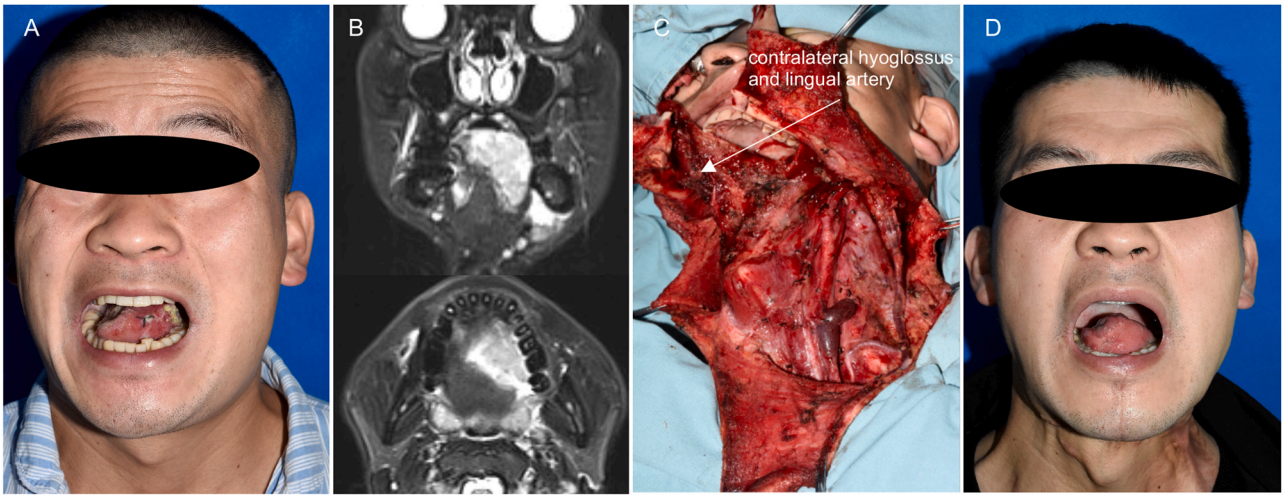

Fig. 4. Invasion of the contralateral MGC by the primary tumour. (A) Preoperative photograph. (B) MRI of the primary tumour. (C) The contralateral hyoglossus and lingual artery were preserved after resection of the contralateral MGC. (D) Appearance at 18 months after surgical treatment. (MGC, musculus verticalis linguae–genioglossus complex.).

Results

A total of 120 patients with TCML were recruited into this study, with 60 patients in each group. The clinical data are reported in Table 1; no significant difference in any of the clinical characteristics, except pathological margin, was found between the experimental and control groups.

The follow-up duration ranged from 1 to 69 months and the follow-up rate was 100%. All surviving patients were followed up for 2 years or more; those with a short follow-up such as 1 month were non-survivors who died of their disease. The OS rate was 66.7% in the experimental group and 65% in the control group (Table 1, $P = 0.853$). The disease-free survival rate was 66.7% in the experimental group and 60% in the control group (Table 1, $P = 0.673$), while the local disease control rate was 86.7% in the experimental group and 76.7% in the control group (Table 1, $P = 0.356$). Moreover, the OS rate of cancer adjacent to the midline was 68.6% (24/35) in the experimental group and 63.6% (21/33) in the control group (Supplementary Material Table S1, $P = 0.574$). The OS rate of cancer invading but not breaching the contralateral MGC was 71.4% (10/14) in the experimental group and 70.6% (12/17) in the control group (Supplementary Material Table S1, $P = 0.885$). The OS rate of cancer breaching the contralateral MGC was 54.5% (6/11) in the experimental group and 60% (6/10) in the control group (Supplementary Material Table S1, $P = 0.563$).

Fig. 5. Primary tumour breaching the contralateral MGC. (A) Preoperative photograph. (B) MRI of the primary tumour. (C) The operation area after resection of the bilateral MGC. (D) Primary tumour and lymph nodes specimen. (E) Appearance at 18 months after surgical treatment. (MGC, musculus verticalis linguae–genioglossus complex.).

The surgical margins of all 60 patients in the control group were ≥ 5 mm. In the experimental group, the surgical margin was < 5 mm in 13 of the 60 patients. Of these 13 patients, three had cancer adjacent to the midline and 10 had cancer invading but not breaching the contralateral MGC. The local disease control rate for the 13 patients with margins < 5 mm was 84.6% (11/13), while the local disease control rate for the 47 patients with margins ≥ 5 mm was 87.2% (41/47) ($P = 0.831$).

Functional assessment at 12 months

Of the included patients, 44 in the experimental group and 42 in the control group survived for more than 12 months and underwent the functional assessment (Table 2). The results of the functional assessment were compared between the experimental and control groups for each separate TCML classification.

Regarding cancer adjacent to the midline, no significant difference in pronunciation score was found between the experimental (3.38 ± 0.70) and control group patients (3.18 ± 0.73; $P = 0.321$). However, the swallowing score in the experimental group (3.65 ± 0.48) was significantly higher

Table 1. Clinical characteristics of the patients treated with anatomical unit resection surgery (AURS; experimental group) and compartment surgery (control group).

Group	Number of patients (%)		*P*-value
	AURS ($n = 60$)	Compartment surgery ($n = 60$)	
Age (years), mean ± SD	50.9 ± 11.1	49.8 ± 8.6	0.522
Sex			0.999
Male	56 (93.3)	56 (93.3)	
Female	4 (6.7)	4 (6.7)	
Pre-existing disease			0.897
Hypertension	9 (15)	5 (8.3)	
Diabetes mellitus	5 (8.3)	2 (3.3)	
Coronary heart disease	3 (5)	1 (1.7)	
Smoking history			0.298
Yes	53 (88.3)	54 (90)	
No	7 (11.7)	6 (10)	
Alcohol history			0.471
Yes	51 (85)	48 (80)	
No	9 (15)	12 (20)	
T status			0.605
T2	7 (11.7)	10 (16.7)	
T3	39 (65)	34 (56.7)	
T4	14 (23.3)	16 (26.7)	
N status			0.056
N(−)	27 (45)	16 (26.7)	
N(+)	33 (55)	44 (73.3)	
Neck dissection			0.855
Unilateral	31 (51.7)	30 (50)	
Bilateral	29 (48.3)	30 (50)	
Re-exploration			0.223
Yes	8 (13.3)	4 (6.7)	
No	52 (86.7)	56 (93.3)	
Flap size (cm^2), mean ± SD	71.0 ± 24.8	67.6 ± 24.9	0.451
Type of tongue cancer adjacent to or crossing the midline			0.820
Adjacent to the midline	35 (58.3)	33 (55)	
Invading but not breaching the contralateral MGC	14 (23.3)	17 (28.3)	
Breaching the contralateral MGC	11 (18.3)	10 (16.7)	
Postoperative radiotherapy and chemotherapy			0.648
Yes	2 (3.3)	3 (5)	
No	58 (96.7)	57 (95)	
Pathological margin			< 0.001*
< 5 mm	13 (21.7)	0 (0)	
≥5 mm	47 (78.3)	60 (100)	
Overall survival rate	40 (66.7)	39 (65)	0.853
Disease-free survival rate	40 (66.7)	36 (60)	0.673
Local disease control rate	52 (86.7)	46 (76.7)	0.356

MGC, musculus verticalis linguae–genioglossus complex; SD, standard deviation. *Significant, $P < 0.05$.

than that in the control group (3.18 ± 0.85; $P = 0.040$). The cosmetic outcome was also significantly better in the experimental group than in the control group (3.58 ± 0.50 vs 3.04 ± 0.78; $P = 0.015$).

For patients with cancer invading but not breaching the contralateral MGC, the pronunciation score in the experimental group (3.73 ± 0.47) was significantly higher than that in the control group (2.58 ± 0.67; $P = 0.001$). The swallowing score in the experimental group (3.64 ± 0.67) was also significantly higher than that in the control group (2.33 ± 0.89; $P = 0.002$). Moreover, the cosmetic outcome was significantly better in the experimental group than in the control group (3.54 ± 0.69 vs 2.83 ± 0.72; $P = 0.037$).

For patients with cancer breaching the contralateral MGC, there was no significant difference in pronunciation score (experimental group, 2.71 ± 0.76 vs control group, 2.25 ± 0.46; $P = 0.281$), swallowing score (experimental group, 2.57 ± 0.98 vs control group, 1.50 ± 0.93; $P = 0.072$), or cosmetic outcome (experimental group, 2.43 ± 0.79 vs control group, 2.00 ± 0.93; $P = 0.379$) between the experimental and control groups.

To further examine the functional differences between the patients undergoing AURS and those undergoing compartment surgery, the types of TCML and surgical procedures performed in each were investigated (Table 3). Regarding the patients with

Table 2. Functional and aesthetic outcomes at 12 months for the different types of tongue cancer (adjacent to or crossing the midline) in the anatomical unit resection surgery group (AURS; experimental group) and compartment surgery group (control group).

Group	AURS ($n = 44$)	Compartment surgery ($n = 42$)	*P*-value
Adjacent to the midline	$n = 26$	$n = 22$	
Speech intelligibility			0.321
Tracheostomy required	0	0	
Unintelligible speech	3	4	
Acceptable intelligible speech	10	10	
Normal intelligible speech	13	8	
Swallowing efficiency			0.040 *
Dysphagia	0	1	
Moderate impairment	0	3	
Mild impairment	9	9	
Nearly natural	17	9	
Cosmetic outcome			0.015 *
Poor	0	0	
Fair	0	6	
Good	11	9	
Excellent	15	7	
Invading but not breaching the contralateral MGC	$n = 11$	$n = 12$	
Speech intelligibility			0.001 *
Tracheostomy required	0	0	
Unintelligible speech	0	6	
Acceptable intelligible speech	3	5	
Normal intelligible speech	8	1	
Swallowing efficiency			0.002 *
Dysphagia	0	2	
Moderate impairment	1	5	
Mild impairment	2	4	
Nearly natural	8	1	
Cosmetic outcome			0.037 *
Poor	0	0	
Fair	1	4	
Good	3	6	
Excellent	7	2	
Breaching the contralateral MGC	$n = 7$	$n = 8$	
Speech intelligibility			0.281
Tracheostomy required	0	0	
Unintelligible speech	3	6	
Acceptable intelligible speech	3	2	
Normal intelligible speech	1	0	
Swallowing efficiency			0.072
Dysphagia	1	6	
Moderate impairment	2	0	
Mild impairment	3	2	
Nearly natural	1	0	
Cosmetic outcome			0.379
Poor	1	3	
Fair	2	2	
Good	4	3	
Excellent	0	0	

MGC, musculus verticalis linguae–genioglossus complex. *Significant, $P < 0.05$.

cancer adjacent to the midline, all 26 patients in the experimental group were treated with a hemiglossectomy (type I), whereas in the control group, 15 of the 22 patients were treated with a hemiglossectomy (type I) and seven with a subtotal glossectomy (type III). For patients with cancer invading but not breaching the contralateral MGC, all 11 in the experimental group were treated with a resection of the contralateral MGC and primary tumour (type II), while all 12 in the control group were treated with a subtotal glossectomy (type III). For patients with cancer breaching the contralateral MGC, all seven patients in the experimental group and all eight patients in the control group were treated with a subtotal or total glossectomy (type III).

Discussion

The tongue is a complex muscular organ that is involved in speech, communication, articulation, chewing, and

Table 3. Surgical procedures in the patients with tongue cancer adjacent to or crossing the midline.

AURS – experimental group	Number	Type I Hemiglossectomy	Type II Resection of contralateral MGC and primary tumour[a]	Type III Subtotal or total glossectomy
Adjacent to the midline	26	26	–	–
Invading but not breaching the contralateral MGC	11	–	11	–
Breaching the contralateral MGC	7	–	–	7
Compartment surgery – control group	Number	Hemiglossectomy		Subtotal or total glossectomy
Adjacent to the midline	22	15		7
Invading but not breaching the contralateral MGC	12	–		12
Breaching the contralateral MGC	8	–		8

AURS, anatomical unit resection surgery; MGC, musculus verticalis linguae–genioglossus complex.
[a]Preserving the contralateral lingual veins, lingual artery, lingual nerve, and hypoglossal nerve.

swallowing. Defects in the tongue tissue can cause varying losses of tongue function. Depending on the type of compartment surgery, patients with TCML should be treated with a hemiglossectomy, subtotal glossectomy, or total glossectomy. In AURS, each compartment of the tongue is subdivided into several anatomical units. The principal aim of this study was to provide a novel surgical approach to more precisely resect TCML in order to preserve tongue function.

A previous study reported that the local disease control rate was 83.5% and the OS rate was 76.2% in tongue cancer patients treated with compartment surgery.[5] In the present study, the local disease control rate was 76.7% in the control group and 86.7% in the experimental group. The local disease control rate in the present study is therefore similar to that reported previously. However, the OS rate was 66.7% in the experimental group and 65% in the control group, which is lower than in the previous study. The worse OS in the present study when compared to previous studies may be explained by the advanced stage of the tongue cancer in the study patients and the limited sample size. The surgical margin was ≥ 5 mm in all 60 patients in the control group. In the experimental group, the surgical margin was < 5 mm in 13 of the 60 patients. Of these 13 patients, three had cancer adjacent to the midline and 10 had cancer invading but not breaching the contralateral MGC. The local disease control rate for the 13 patients with margins < 5 mm was similar to the rate for those with margins ≥ 5 mm. Moreover, no significant difference in the OS rate was found between the experimental and control groups for each of the different types of TCML. All surviving patients were followed up for 2 years or more and those with a short follow-up such as 1 month were non-survivors who died of their disease. These data indicate that AURS can offer an ideal local disease control rate and OS, similar to those obtained with compartment surgery.

In compartment surgery, the tongue is considered a median organ composed of two equal halves separated from each other by the lingual septum.[16,17] Bordoni et al.[18] reported that the lingual septum is composed of a vertical fibrous tissue layer, extending throughout the entire length of the median plane of the tongue, although it does not reach the dorsum, apex, and root. Our previous studies have shown that AURS can remove the entire anatomical unit (or subunit) in which the tumour is involved and can significantly improve the OS rate in patients with buccal and posterior oral cavity cancer.[11,12] In our experience, the key factors in tumour resection include the primary tumour location, primary tumour infiltration pattern, and adjacent anatomical units. Each muscle structure is an individual anatomical unit. The genioglossus is a fan-shaped extrinsic tongue muscle that is derived from the genial tubercles and can be inserted into the hyoid bone and the bottom of the tongue. The genioglossus combined with musculus verticalis linguae forms the majority of the half-tongue body. The mesial space of the MGC is the lingual septum space, and the outer space of the MGC contains the lingual artery and lingual veins, which highlights the MGC as an anatomical marker for the resection of tongue cancer.

An important advantage of AURS is that it estimates the relationship between the primary tumour and bilateral MGC, which is important for precise surgical resection of cancer adjacent to the midline or cancer invading but not breaching the contralateral MGC. Although preoperative imaging provides a vital basis for staging and surgical planning for oral cancer,[19] MRI has the potential to overestimate the tumour extent.[20] Oedema surrounding the tumour is a common simultaneous symptom that may influence the tumour information obtained from T2-weighted MRI.[21–23] Concerning conventional palpation, the tongue dorsum contains a large amount of tongue tissue and hence palpation through the dorsum is inefficient for assessing the extent of primary tumour invasion, especially for tumours in the underlying tongue tissue.

In the control group patients, inaccurate image information (oedema surrounding the tumour) and conventional palpation of the tongue dorsum in those with cancer adjacent to the midline may have resulted in the excessive surgical resection in this group. Regarding the experimental group patients with cancer adjacent to the midline, all 26 were treated with a hemiglossectomy (type I), whereas seven of the 22 patients in the control group with cancer adjacent to the midline were treated with a subtotal glossectomy (type III). For patients with cancer invading but not breaching the contralateral MGC, all 11 in the experimental group were treated with resection of the contralateral MGC and primary tumour (type II), while all 12 in the control group were treated with a subtotal glossectomy (type III). In patients treated with a subtotal glossectomy, the intraoral incision for compartment surgery always started from the tongue dorsum, and it is easy to injure the contralateral lingual artery

and hypoglossal nerve, leading to dysfunction.

Intraoperative palpation is a key factor in determining a surgical procedure based on AURS. With lip splitting, mandibulotomy, and cutting off of the genioglossus, the index finger can be inserted into the lingual septum space or outside space to accurately estimate whether the primary tumour has invaded the ipsilateral genioglossus, contralateral genioglossus, or extrinsic lingual muscles. Moreover, the oedema associated with tongue cancer can partially recede following incision of the mouth floor in AURS, which benefits the accuracy of intraoperative palpation. It is easier and more precise to estimate the relationship between the primary tumour and bilateral MGC in the aforementioned procedure than in conventional palpation. Thus, intraoperative palpation of the MGC can offer reliable information for determining surgical decisions.

Another important advantage of AURS is that it can be applied to patients with cancer invading but not breaching the contralateral MGC. These patients can be treated with resection of the contralateral MGC and primary tumour, while preserving the contralateral lingual veins, lingual artery, lingual nerve, and hypoglossal nerve. If these patients are treated with a compartment resection, it is impossible to preserve the contralateral lingual veins, lingual artery, lingual nerve, and hypoglossal nerve. Due to the precise resection of the primary tumour, the speech intelligibility, swallowing function, and cosmetic outcomes of patients with cancer invading but not breaching the contralateral MGC were better in the experimental group than those in the control group. For cancer adjacent to the midline, intraoperative palpation from the MGC offered reliable information for estimating the relationship between the primary tumour and the lingual septum. Proper surgical decisions then resulted in better functional and cosmetic outcomes in the experimental group than in the control group. For patients with cancer breaching the contralateral MGC, no significant difference in functional or cosmetic outcomes was observed between the experimental and control groups owing to the fact that the same surgical procedure was used in both groups.

AURS provided more precise resection of cancer adjacent to the midline and cancer invading but not breaching the contralateral MGC to maximally preserve tongue function. The ipsilateral MGC served as an anatomical marker for determining the resection of tongue cancer. In summary, glossectomy based on AURS can provide novel and precise surgical treatment. The use of glossectomy based on AURS appears to maximally preserve tongue tissue and function.

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Competing interests

None.

Ethical approval

This study was approved by the Institutional Review Board of the Second Xiangya Hospital (approval number 2011210).

Patient consent

Informed consent was obtained from all participants.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ijom.2022.11.014.

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