Patterns of growth of lingual carcinoma on magnetic resonance imaging and correlations with clinicopathologic outcomes

Khyati Jani, MS,[a] Deepak Balasubramanian, MCh,[a] Sandya Jayasankaran, MD,[b] Samskruthi Murthy, MCh,[a] Sivakumar Vidyadaran, MCh,[a] Krishnakumar Thankappan, MCh,[a] and Subramania Iyer, MCh[a]

Objective. The aim of this study was to identify patterns of tumor growth as revealed on magnetic resonance imaging (MRI) and to evaluate the correlation of these patterns with histopathologic features and rates of recurrence, disease-free survival (DFS), and overall survival (OS).

Study Design. In a retrospective analysis of patients with tongue carcinoma, tumor advancing margins, patterns of tumor enhancement, and enhancement beyond tumor margins were studied on MRI. Histopathologic findings included differentiation, margin status, perineural invasion (PNI), and lymphovascular invasion (LVI). MRI and histopathologic features were correlated with outcomes.

Results. Ill-defined tumor margins and enhancement beyond tumor margins were associated with recurrences ($P \leq .001$) regardless of perineural invasion or LVI. DFS and OS were adversely affected by ill-defined tumor margins ($P \leq .010$). DFS was also affected by enhancement beyond the tumor margins ($P < .001$). A heterogeneous pattern of enhancement showed a trend toward a decrease in DFS and OS ($P = .088$ and .092, respectively). Advancing tumor margins on MRI were independent predictors of overall survival. MRI characteristics exhibited significant associations with histopathologic margins, PNI, and LVI.

Conclusions. Ill-defined advancing tumor margins, a heterogeneous pattern of enhancement, and enhancement beyond the tumor margins on MRI adversely affect outcomes and prognosis in tongue carcinoma. (Oral Surg Oral Med Oral Pathol Oral Radiol 2020;130:731−740)

Squamous cell carcinoma (SCC) of the tongue forms a major subset in head and neck cancers.[1] Data from the SEER (Surveillance, Epidemiology, and End Results) registry indicate the 5-year disease specific survival for tongue SCC has shown only marginal improvement over the recent decades.[2] Tongue cancers are considered aggressive tumors because of their high propensity for local invasion. Surgical excision with adequate margins forms the standard management of these neoplasms.[3] Various pathologic features of SCC, such as perineural invasion (PNI), certain patterns of invasion, and lymphovascular emboli, are proven prognostic factors in recurrent and primary oral squamous cell carcinoma (OSCC).[4,5] Accurate preoperative assessment and staging are essential in guiding treatment and establishing the prognosis for these patients. The recent update to the American Joint Committee on Cancer (AJCC) staging system includes the pathologic depth of invasion (DOI), which has helped accurately stage OSCC.[6]

Magnetic resonance imaging (MRI) is the imaging modality of choice to ascertain the size and extent of tongue SCC. However, no studies pertaining to MRI patterns of invasion in tongue cancer and their relationship to the behavior and prognosis of tongue tumors have been published.

The objective of this investigation was to identify the characteristics of tumor growth as revealed on MRI and evaluate the correlation of these characteristics with histopathologic findings and rates of recurrence, disease-free survival (DFS), and overall survival (OS). We hypothesize that some growth patterns detected on MRI are significantly correlated with histologic features and outcomes of treatment.

MATERIALS AND METHODS

Consecutive patients with newly diagnosed tongue SCC who presented to the Department of Head and Neck Surgery at the Amrita Institute of Medical Sciences (AIMS; Kochi, India) between January 2015 and December 2016 were included in the study. Patient demographic characteristics, tumor and imaging characteristics, and management and outcome data were retrieved from a prospectively maintained database. The study was approved by the institutional ethics board. Patients with prior treatment, distant metastasis at presentation, or recurrent tumors were excluded.

Statement of Clinical Relevance

Analysis of the correlations of magnetic resonance imaging characteristics of lingual carcinoma with recurrence, disease-free survival, and overall survival, as well as with histopathologic characteristics, may help establish the prognosis of the lesion.

[a]Department of Head and Neck Surgery, Amrita Institute of Medical Sciences, Amrita Vishwa Vidyapeetham University, Kochi, India.
[b]Department of Radiology, Amrita Institute of Medical Sciences, Amrita Vishwa Vidyapeetham University, Kochi, India.
Received for publication Jan 5, 2020; returned for revision Jun 8, 2020; accepted for publication Jun 13, 2020.

2212-4403/$-see front matter
https://doi.org/10.1016/j.oooo.2020.06.012

All patients underwent preoperative MRI, which was performed on a GE System Discovery 750 3 Tesla MRI system (GE Healthcare, Milwaukee, WI) using an 8-channel head and neck coil. The MRI sequences recorded were coronal T1-weighted images (T1WI), T2-weighted images (T2WI), T2WI with fat saturation, sagittal T2WI, and axial T2WI. For contrast-enhanced images, gadolinium contrast-enhanced T1WI with fat saturation acquired in 3-dimensional (3-D) axial sequences and reformatted in coronal and sagittal sections were used. The MRI slice thickness was 3 mm. Analysis was performed on the first postcontrast image immediately after contrast injection to avoid washout, which could obscure lesion characteristics. The MRI T1WI parameters were echo time 3.18 ms and repetition time 6.93 ms. The T2WI parameters were echo time 85 ms and repetition time 4890 ms. The number of excitations was 2 for both types of images. The flip angle was 12 degrees for T1WI and 111 degrees for T2WI. All MRI scans were reported by a single radiologist and 2 head and neck surgeons.

The patterns of tumor growth were recorded as follows (Figure 1):

1. Advancing tumor margins
   a. Smooth: Well-demarcated borders
      i. Uniform tumor advancement
      ii. Finger-like advancement
         - Single finger advancement
         - Multiple finger advancement
   b. Ill-defined: No definitive borders
2. Patterns of tumor enhancement
   a. Homogeneous: Uniform and consistent signal intensity across the tumor
   b. Heterogeneous: Non-uniform and variable signal intensity across the tumor
3. Enhancement beyond the tumor margins
   a. Present: Variable signal intensity beyond the margins of the tumor
   b. Absent

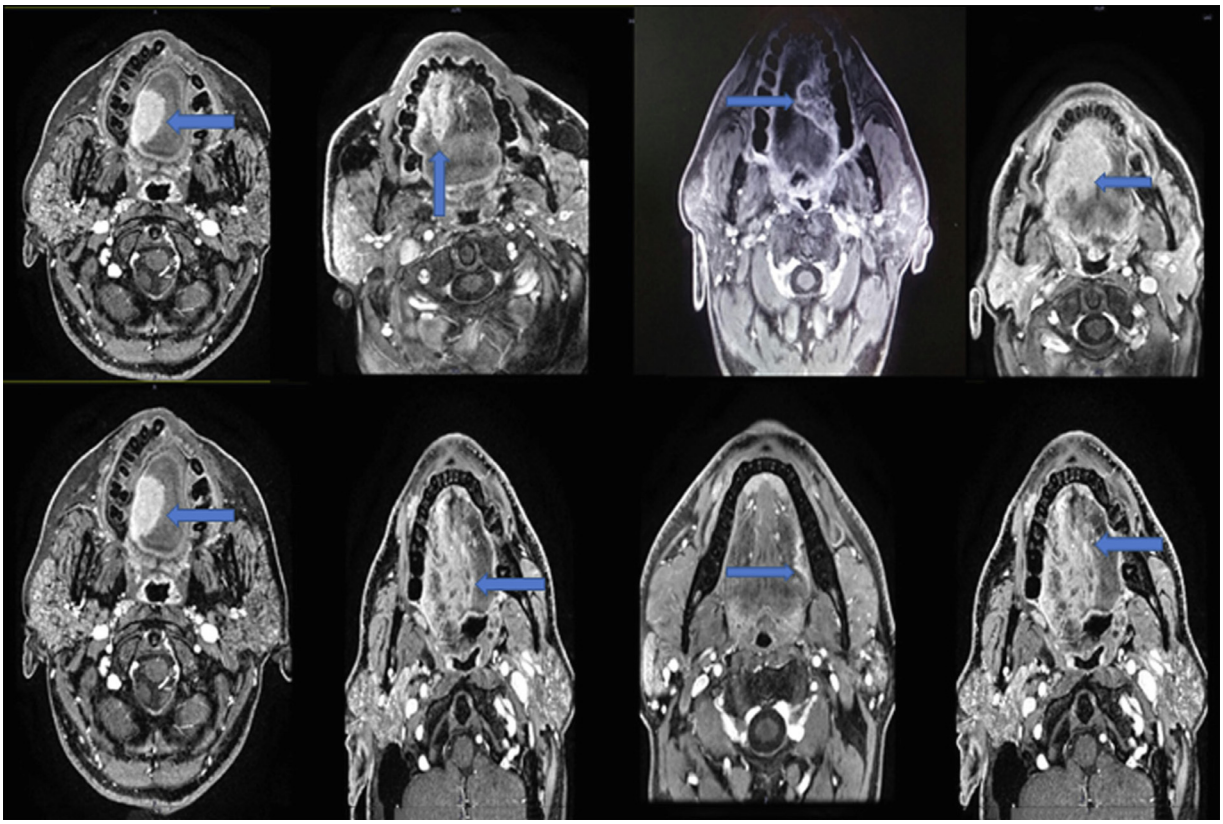

Fig. 1. Different magnetic resonance imaging (MRI) features in squamous cell carcinoma of the tongue. *Top row,* Advancing tumor margin. *Top left to right,* Tongue tumor, with arrow showing smooth margin, single-finger advancement, multiple-finger advancement, and ill-defined margin. *Bottom row,* Patterns of tumor enhancement and enhancement beyond the tumor margin. *Bottom left to right,* Homogeneous enhancement, heterogeneous enhancement, enhancement absent beyond the tumor margin, enhancement present beyond the tumor margin.

All patients underwent wide excision of the lesion (a gross margin of 1−1.5 cm, aiming for a minimum microscopic margin of 5 mm), selective neck dissection, and appropriate reconstruction.

The following histopathological characteristics were evaluated:

1. *Differentiation of the tumors*

   The lesions were histologically graded as well differentiated, moderately differentiated, or poorly differentiated.

2. *Histopathologic margins*
   a. Positive margins: presence of tumor at the surgical margin
   b. Close margins: Presence of tumor within 5 mm of the surgical margin
   c. Clear margins: Presence of tumor no closer than 5 mm from the surgical margin
3. *Perineural invasion (PNI)*
   a. Present: At least 1 tumor cell within any nerve layer
   b. Absent: No evidence of tumor cells within any nerve layer
4. *Lymphovascular invasion (LVI)*
   a. Present: tumor emboli in adjacent lymphatic and/or vascular channels
   b. Absent: no evidence of tumor emboli

T (size and depth of invasion) and N (presence of tumor cells in lymph nodes) stages were recorded for all cases. M (metastasis) stage evaluation was done by using computed tomography (CT) of the chest. Only those patients with no metastases were included in the study. Staging of patients was based on the staging criteria in the *American Joint Committee on Cancer Staging Manual*, 8th edition. The study patients received adjuvant treatment based on the histopathologic report and stage of disease. Adjuvant radiotherapy was administered for advanced stage (III or IV) cancer. Adjuvant chemoradiotherapy was administered for extranodal extension or close margins, as decided by the multidisciplinary tumor board. Patients were followed up in the Head and Neck Surgery out-patient department with monthly clinical examinations. In cases of suspected recurrence, positron emission tomography (PET) and biopsy were performed to confirm the diagnosis and plan further treatment.

The following outcomes were assessed:

1. *Recurrence*—defined as any histologically proven local, regional, or distant disease occurring at least 3 months after the date of surgery
2. *DFS*—defined as the time to relapse, second cancer, or all-cause death, whichever came first
3. *OS*—defined as the time from initial surgery to the date of death or last follow-up

Table I. Demographic characteristics

Age	*No. of patients*
Mean age	50.9 ± 11.5
Age range	18−74
Gender	
Male	62 (80.5%)
Female	15 (19.5%)

Statistical analysis was performed by using SPSS version 22 (SPSS Inc., Chicago, IL). Categorical data were analyzed by using the χ^2 test. For survival analysis, DFS and OS were analyzed by using the Kaplan-Meier method. Comparison of survival and MRI parameters was done by using the log rank analysis. Multivariate analysis was performed by using the Cox proportional hazards model. All statistics were 2-sided and a P value less than .05 was considered statistically significant.

RESULTS

Patient and treatment characteristics

The study included 77 patients (mean age 50.9 ± 11.5 years; age range 18−74 years). The patient population included 62 males (80.5%) and 15 females (19.5%) (Table I).

MRI characteristics

Advancing tumor margins were classified as smooth margins with uniform advancement in 13 patients (16.9%) and smooth margins with finger-like advancement in 48 patients (62.3%). Finger-like advancement was further subclassified into 2 categories—single finger advancement and multiple finger advancement—with 24 patients in each group. Tumors with ill-defined margins were identified in 16 patients (20.8%). Tumor enhancement was homogeneous in 7 patients (9.1%) and heterogeneous in 70 patients (90.9%). Presence of enhancement beyond the

Table II. Magnetic resonance imaging characteristics

Advancing tumor margins	
Smooth: Uniform tumor advancement	13 (16.9%)
Smooth: Finger-like advancement	48 (62.3%)
- Single finger advancement	24 (31.15%)
- Multiple finger advancement	24 (31.15%)
Ill-defined	16 (20.8%)
Patterns of tumor enhancement	
Homogeneous	7 (9.1%)
Heterogeneous	70 (90.9%)
Enhancement beyond the tumor margins	
Present	46 (59.7%)
Absent	31 (40.3%)

tumor margins was present in 46 patients (59.7%) and absent in 31 patients (40.3%) (Table II).

Histopathologic characteristics

On the final histopathologic evaluation, 9 cases (11.7%) were well differentiated; 56 (72.7%) were moderately differentiated; and 12 (15.6%) were poorly differentiated. Seven patients (9.1%) had close margins (mean distance from surgical margin = 3 mm); and 70 (90.9%) had clear margins. No patient had positive margins. PNI was present in 44 cases (57.1%) and absent in 33 (42.9%). Lymphovascular invasion was present in 41 (53.2%) patients and absent in 36 (46.8%). The above-mentioned details are shown in Table III.

Staging and treatment

T stage and N stage classification according to the AJCC 8th edition is listed in Table III. In total, 31 patients (40.2%) were treated by surgery only, whereas 33 patients (42.9%) received adjuvant radiotherapy (RT) and 13 (16.9%) received adjuvant chemoradiotherapy (see Table III). The minimum follow-up time was 2 years.

Association of MRI characteristics with recurrence

Of the 77 patients, 18 developed either local or locoregional recurrence. Association of MRI features of advancing tumor margins showed that patients who had smooth uniform advancement had no recurrence. Seven (14.6%) of the 48 cases with finger-like advancement from the tumor surface developed recurrence. Of the 16 lesions with ill-defined margins, 11 (68.8%) were associated with recurrence. When taken together, the association of advancing tumor margins and recurrence was statistically significant ($P < .001$). These patterns were significantly associated with recurrence irrespective of the microscopic presence of PNI ($P = .001$) or LVI ($P = .003$) (Table IV).

All 18 patients who experienced recurrence had a heterogeneous pattern of tumor enhancement (25.7% of the 70 cases with heterogeneous tumor enhancement), but this did not reach the level of statistical significance because of uneven distribution of cases ($P = .214$). Presence of enhancement beyond tumor margins had statistically significant association with recurrence, with all 18 recurrences arising in the 46 lesions (39.1%) with this type of enhancement ($P < .001$) (see Table IV).

Association of MRI characteristics with DFS

The mean DFS was 34 months (range 29.8−38.2 months) for the entire cohort. Cases with advancement of smooth, uniform tumors had no recurrence at the time of the last follow-up. Smooth, finger-like advancement was associated with DFS of 38.4 months (range 33.9−45.7 months) but the DFS in cases ill-defined tumors was 21.6 months (range 15.3−30.2 months). Log rank survival analysis of DFS showed that the association with advancing tumor margins on MRI was statistically significant ($P < .001$), as shown

Table III. Histopathologic characteristics, staging, and treatment

Histopathologic characteristics	
Differentiation of tumors	
Well differentiated	9 (11.7%)
Moderately differentiated	56 (72.7%)
Poorly differentiated	12 (15.6%)
Histopathologic margins	
Positive margins	0 (0.0%)
Close margins	7 (9.1%)
Clear margins	70 (90.9%)
Perineural invasion	
Present	44 (57.1%)
Absent	33 (42.9%)
Lymphovascular invasion	
Present	41 (53.2%)
Absent	36 (46.8%)
T stage	
T1	11 (14.3%)
T2	3 (3.9%)
T3	23 (29.9%)
T4	40 (51.9%)
N stage	
N0	34 (44.1%)
N1	12 (15.6%)
N2 a	5 (6.5%)
N2 b	7 (9.1%)
N2 c	19 (24.7%)
N3	0
Treatment	
Surgery only	31 (40.2%)
Surgery + RT	33 (42.9%)
Surgery + CRT	13 (16.9%)

T1 = Tumor ≤ 2 cm in greatest dimension; ≤ 5 mm depth of invasion (DOI; not tumor thickness); OR tumor > 2 cm, but ≤ 4 cm; and ≤ 10 mm DOI.
T2 = Tumor ≤ 2 cm; DOI > 5 mm and ≤ 10 mm, OR tumor > 2 cm, but ≤ 4 cm; and ≤ 10 mm DOI.
T3 = Tumor > 4 cm OR any tumor > 10 mm DOI.
T4 = Moderately advanced or very advanced local disease.
N0 = No regional lymph node metastasis.
N1 = Metastasis in a single ipsilateral lymph node; ≤ 3 cm in greatest dimension and ENE (−).
N2 a = Metastasis in single ipsilateral lymph node > 3 cm, but ≤ 6 cm in greatest dimension and ENE (−).
N2 b = Metastasis in multiple ipsilateral lymph nodes; ≤ 6 cm in greatest dimension and ENE (−).
N2 c = Metastasis in bilateral or contralateral lymph nodes; ≤ 6 cm in greatest dimension and ENE (−).
N3 = Metastasis in a lymph node > 6 cm in greatest dimension and ENE (−); OR metastasis in any lymph node(s) with clinically overt ENE (+).
CRT, chemoradiotherapy; *ENE,* extranodal extension; *RT,* radiotherapy.

Table IV. Associations of magnetic resonance imaging characteristics with recurrence, disease-free survival, and overall survival

MRI Characteristics	*Recurrence*	*Disease-free survival in months (mean values)*	*Overall survival in months (mean values)*
Advancing tumor margins			
Smooth: Uniform tumor advancement (13)	0	–	39.8
Smooth: Finger-like advancement (48)	7 (14.6%)	38.4	35.4
Ill-defined (16)	11 (68.8%)	21.6	24.9
P value	< .001*	< .001*	.010*
Patterns of tumor enhancement			
Homogeneous (7)	0	No recurrence at follow-up	All alive at follow-up
Heterogeneous (70)	18 (25.7%)	34.7	33.1
P value	.214	.088	.092
Enhancement beyond the tumor margins			
Present (46)	18 (39.1%)	30.7	31.6
Absent (31)	0	–	36.7
P value	< .001*	< .001*	.079

MRI, magnetic resonance imaging.
*Significant difference.

in Table IV. Tumors with a homogeneous pattern of enhancement had no recurrences on follow-up, whereas DFS for patients with tumors of heterogeneous pattern was 34.7 months (range 30.8−38.3 months) (P = .088) (see Table IV). Cases with presence of enhancement beyond tumor margins had a mean DFS of 30.7 months (range 25.8−35.2) whereas there were no recurrences of lesions with absence of this type of

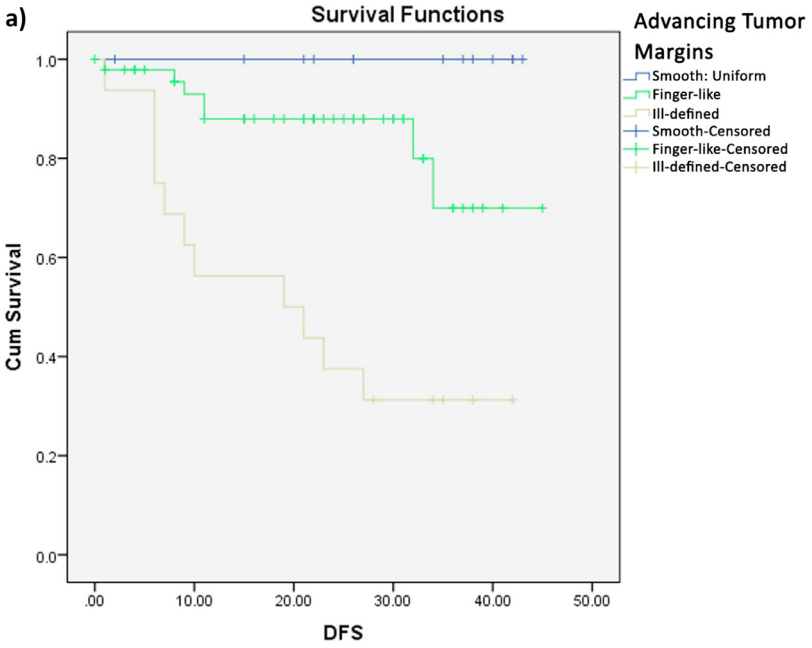

Fig. 2. Disease-free survival (DSF) **A**, Kaplan-Meier curve disease free survival analysis and comparison with various MRI advancing tumor margins on MRI in tongue carcinoma; significantly poorer disease-free survival was discovered in cases with ill-defined advancing tumor margins ($P < 0.001$). The steps indicate the cumulative DFS at each period. The vertical check marks indicate individuals with recurrence of disease (the censored population). **B**, Kaplan-Meier disease-free survival analysis and comparison with homogeneous and heterogeneous patterns of enhancement on MRI in tongue carcinoma; slightly poorer disease-free survival was discovered in cases with a heterogeneous pattern of enhancement. ($P = 0.088$). The steps indicate the cumulative DFS at each period. The vertical check marks indicate individuals with recurrence of disease (the censored population). **C**, Kaplan-Meier disease-free survival analysis and comparison with present and absent enhancement beyond tumor margins on MRI in tongue carcinoma; significantly poorer disease-free survival was discovered in cases with presence of enhancement cases. ($P < .001$). The steps indicate the cumulative DFS at each period. The vertical check marks indicate individuals with recurrence of disease (the censored population).

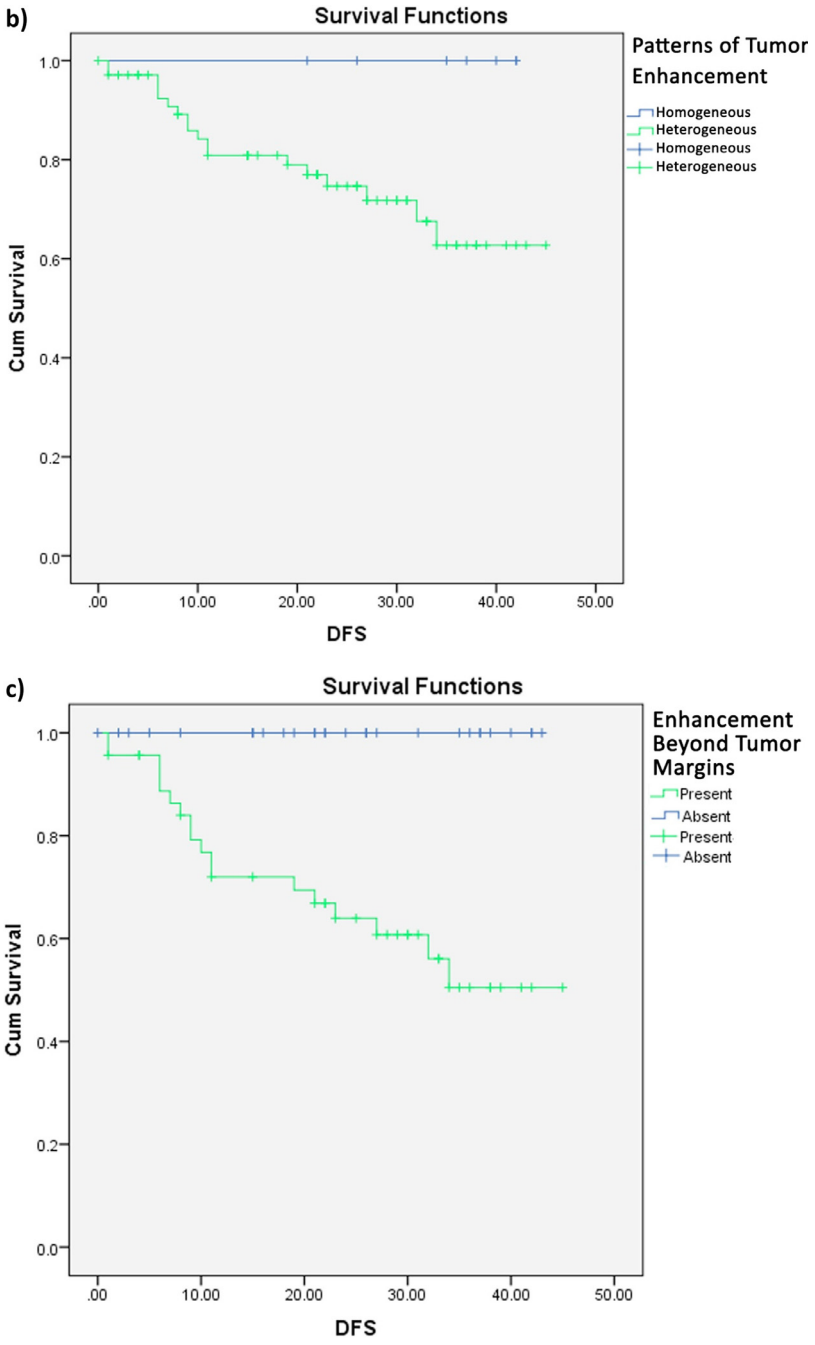

Fig. 2. Continued

enhancement ($P < .001$). However, although the P values for the relationship of advancing tumor margins and enhancement beyond the tumor margins were significant on univariate analysis, multivariate analysis did not reveal a significant association of MRI parameters with DFS (see Table IV; Figure 2).

Association of MRI characteristics with OS

The mean OS was 39.8 months (range 33.9−45.8 months) in tumors with smooth, uniform advancement; 35.4 months (range 30.6−40.1 months) in lesions with finger-like advancement; and 24.9 months (range 17.2 to 32.6 months) in tumors with ill-defined advancing margins. Log rank analysis of OS in comparison with MRI tumor advancing margins was statistically significant ($P = .010$), with significantly shorter OS times in cases with ill-defined lesions (see Table IV; Figure 3). On stepwise multivariate regression analysis, the smooth uniform advancement of tumor margins was an independent predictor of OS after adjusting for the effect of confounding variables, such as PNI, LVI, T stage, and N stage (P = .023) (Table V).

All patients with a homogeneous pattern of tumor enhancement were alive at the 2-year follow-up, but patients with a heterogeneous pattern had a mean survival of 33.1 months (range 29.4−37.5 months) (P = .092), as listed in Table IV. The mean OS was 31.6 months (range 26.6−36.7 months) in lesions with enhancement beyond tumor margins and 36.8 months (range 31.8−41.8 months) in cases without this enhancement. The difference was not significant (P = .079). The association of patterns of enhancement, enhancement beyond tumor margins, and OS with multivariate analysis was not statistically significant.

Association of MRI characteristics with differentiation, histopathologic margin status, PNI, and LVI

The association of MRI characteristics with differentiation was not statistically significant ($P \geq .214$). The association of MRI characteristics with margin status was statistically significant for advancing tumor margins and enhancement beyond tumor margins ($P < .001$ and .023, respectively). Of the 77 patients, 44 had PNI, and 41 had LVI. The association of MRI imaging features with PNI was significant only for patterns of tumor enhancement (P = .043). The association of MRI characteristics with LVI was significant for all categories (advancing tumor margins P = .005; patterns of tumor enhancement P = .032; and enhancement beyond the tumor margins P = .010) (Table VI).

DISCUSSION

Tongue carcinomas comprise the majority of oral cancers. These tumors have a guarded prognosis, with even early stages showing a recurrence rate of 25% to 30%.[7-10] Tongue cancers are routinely evaluated with preoperative imaging with CT and MRI. These modalities offer anatomic details regarding the size and extent of the tumor, thus aiding in the clinical staging of the lesion. However, prognostication of these cancers with current imaging guidelines is difficult, especially because the recent AJCC recommendations include DOI, which is difficult to interpret on imaging. True tumor prognostication is possible only on final histopathologic examination. Apart from DOI, the behavior of tongue carcinomas correlates with certain adverse pathologic features. These include PNI, LVI, and extracapsular extension. In addition to the above-mentioned features, certain pathologic scoring systems, such as the Brandwein-Gensler scoring system, have been used to prognosticate in cases of tongue cancers.[5] However, these systems are not part of the AJCC staging

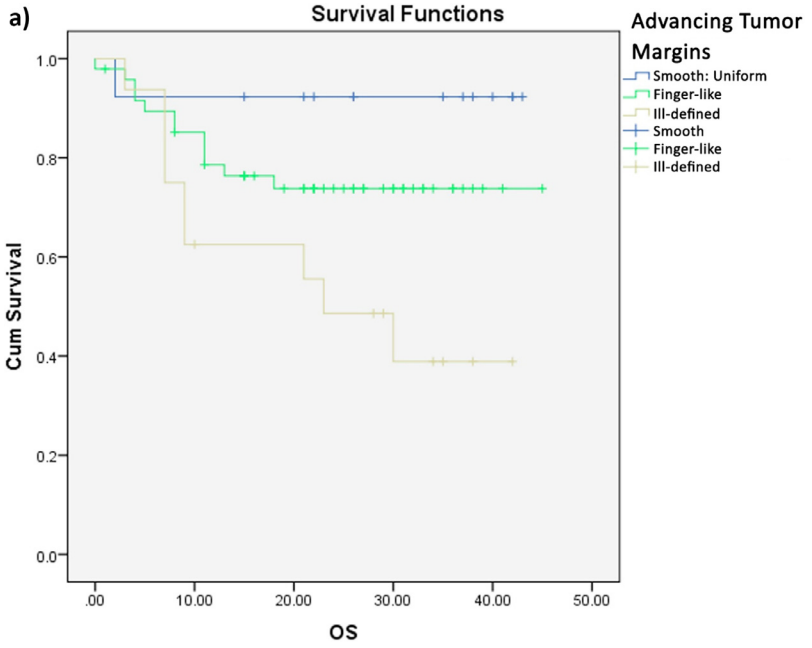

Fig. 3. Overall survival (OS). **A**, Kaplan-Meier OS analysis and comparison with various advancing tumor margins on magnetic resonance imaging (MRI) in tongue carcinoma; significantly poorer OS was discovered in cases with ill-defined advancing tumor margins (P = .010). The steps indicate the cumulative OS at each period. The vertical check marks indicate death of the individuals (the censored population). **B**, Kaplan-Meier curve OS analysis and comparison with homogeneous and heterogeneous patterns of enhancement on MRI in tongue carcinoma; slightly poorer OS was discovered in cases with heterogeneous pattern of enhancement. (P = .092). The steps indicate the cumulative OS at each period. The vertical check marks indicate death of the individuals (the censored population). **C**, Kaplan-Meier curve OS analysis and comparison with the presence and absence of enhancement beyond tumor margins on MRI in tongue carcinoma; slightly poorer OS was discovered in cases where enhancement was present (P = .079). The steps indicate the cumulative OS at each period. The vertical check marks indicate death of the individuals (the censored population).

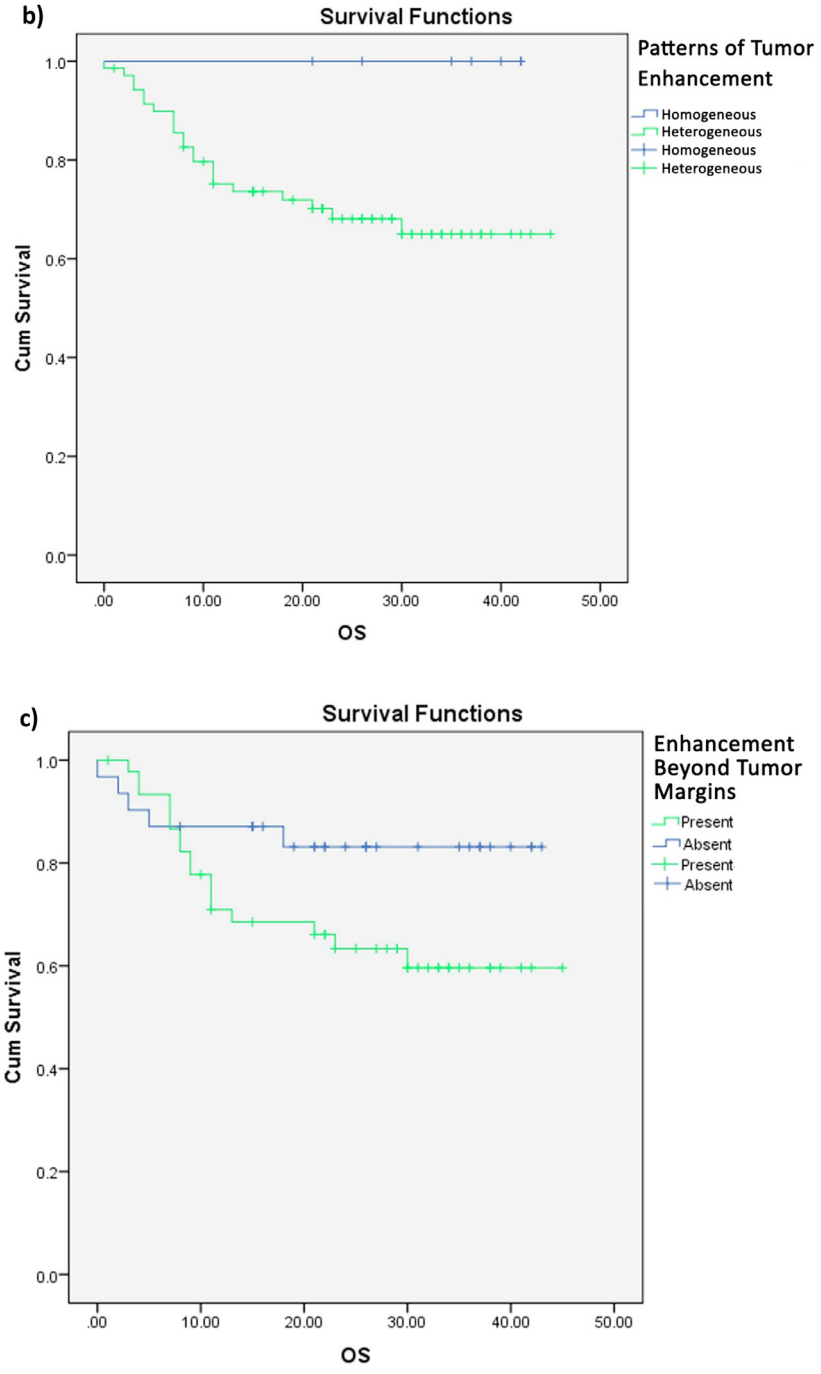

Fig. 3. Continued

system, and there is uncertainty with regard to treatment escalation for early tongue cancers with adverse features.

MRI is increasingly being used to stage oral cancers. Its superior soft tissue characterization, good contrast delineation, and high-resolution images make it the preferred imaging modality. The tumors are classified on the basis of focus, mass enhancement, and non-mass−like enhancement. The mass enhancement is further studied by shape; edge (smooth, speculated, irregular); and internal enhancement pattern (homogeneous, heterogeneous, rim enhancement, internal septations). The non-mass−like enhanced pattern includes the distribution pattern and the internal enhancement pattern. These patterns have correlations with the risk of malignancy in breast lesions. Similarly, MRI features have been used in the Liver Imaging Reporting and Data System.[11]

Table V. Multivariate analysis for overall survival

MRI Characteristics	*Hazard ratio*	*95% Confidence interval*	*P value*
Smooth			
Uniform	–	–	.023
Finger-like	2.307	0.286−18.59	.432
Ill-defined	7.004	0.870−56.37	.067

MRI, magnetic resonance imaging.

In this investigation, we were able to identify various features of tongue carcinomas on MRI that were correlated with disease outcomes. The presence of ill-defined advancing tumor margins, a heterogeneous pattern of tumor enhancement, and enhancement beyond tumor margins were associated with higher rates of locoregional recurrence and lower DFS and OS rates. Histopathologic differentiation, margin status, PNI, and LVI are known parameters that predict the outcome of treatment.[5] Association of MRI characteristics with these features shows a promising complementary role in risk determination that can be done preoperatively. Differentiation of the tumors did not show any statistically significant association with MRI characteristics. Statistically significant associations of histopathologic margin status with advancing tumor margins and enhancement beyond tumor margins suggest that these MRI characteristics can be predictive of postoperative positive margins, which, in turn, can aid in resection planning. PNI was associated only with patterns of tumor enhancement. However, the presence of LVI might be predicted by the pattern of advancing tumor margins, enhancement patterns in the tumor, and enhancement beyond the tumor margins. Despite highly significant *P* values of the association of the MRI characteristics of advancing tumor margins and enhancement beyond the tumor margins with DFS on univariate analysis, multivariate analysis was not significant for DFS. As a result, MRI characteristics were not independent significant predictors for DFS, which probably was caused by the effect of other confounding factors. The pattern of advancing tumor margins also showed a statistically significant association with OS and was found to be an independent significant predictor on multivariate analysis. One drawback to note is that these patterns were classified qualitatively and not quantitatively. This could lead to differences among radiologists when attempts are made to classify lesions in this way. With further research, these patterns could be better described, and a uniform set of criteria could be proposed. Our intention was to identify and group these findings and study their impact on tumor control. Further work in this area could pave the way for the development of a tongue imaging reporting system that would allow for more accurate preoperative prognostication in tongue cancers. This may prompt surgeons to treat patients with

Table VI. Association of magnetic resonance imaging (MRI) characteristics with histopathologic findings

	Differentiation of the tumors (77)			*Histopathologic margins*			*PNI (44)*	*LVI (41)*
	Well differentiated	*Moderately differentiated*	*Poorly differentiated*	*Positive*	*Close*	*Negative*		
Advancing tumor margins								
Smooth	2 (2.57%)	11 (14.3%)	0	0	0	13 (16.9%)	5 (38.5%)	4 (30.8%)
Finger-like advancement	6 (7.75%)	33 (42.8%)	9 (11.6%)	0	0	48 (62.3%)	29 (60.4%)	23 (47.9%)
Ill-defined	1 (1.3%)	12 (15.6%)	3 (3.9%)	0	7 (9.1%)	9 (9.1%)	10 (62.5%)	14 (87.5%)
P value	.495			< .001*			.321	.005*
Patterns of enhancement								
Homogeneous	2 (2.57%)	5 (6.5%)	0	0	0	7 (9.1%)	1 (14.3%)	1 (14.3%)
Heterogeneous	7 (9.09%)	51 (66.25%)	12	0	7 (9.1%)	63 (81.9%)	43 (61.4%)	40 (57.1%)
P value	.214			.380			.043*	.032*
Enhancement beyond tumor margins								
Present	5 (6.5%)	22 (28.57%)	4	0	7 (9.1%)	39 (50.6%)	27 (58.7%)	30 (65.2%)
Absent	4 (5.19%)	34 (44.16%)	8	0	0	31 (40.3%)	17 (54.8%)	11 (35.5%)
P value	.566			.023*			.729	.010*

PNI, perineural invasion; *LVI,* lympovascular invasion.
*Statistically significant difference.

adverse MRI features more aggressively and maintain close follow-up to monitor for recurrence. Prognostic MRI biomarkers of tongue carcinoma could help in improving and optimizing the care provided to patients with tongue cancer.

CONCLUSIONS

SCCs of the tongue present with certain identifiable imaging characteristics on MRI. These can be correlated with known clinical outcomes and can be helpful in prognostication in these cases.

REFERENCES

1. Warnakulasuriya S. Global epidemiology of oral and oropharyngeal cancer. *Oral Oncol*. 2009;45:309-316.
2. National Cancer Institute. Surveillance, Epidemiology, and End Results (SEER). Available at: http://seer.cancer.gov/statistics.
3. National Comprehensive Cancer Network. NCCN clinical practice guidelines in oncology (NCCN guidelines): Head and neck cancers. Available at: http://www.NCCN.org.
4. Subramaniam N, Balasubramanian D, Low TH, et al. Factors affecting survival in surgically salvaged locoregional recurrences of squamous cell carcinoma of the tongue. *J Oral Maxillofac Surg*. 2018;76. 1133.e1-1133.
5. Brandwein-Gensler M, Teixeira MS, Lewis CM, et al. Oral squamous cell carcinoma: histologic risk assessment, but not margin status, is strongly predictive of local disease-free and overall survival. *Am J Surg Pathol*. 2005;29:167-178.
6. Lydiatt WM, Patel SG, O'Sullivan B, et al. Head and neck cancers—major changes in the American Joint Committee on Cancer eighth edition Cancer Staging Manual. *Cancer J Clin*. 2017;67:122-137.
7. Liu SA, Wong YK, Lin JC, Poon CK, Tung KC, Tsai WC. Impact of recurrence interval on survival of oral cavity squamous cell carcinoma patients after local relapse. *Otolaryngol Head Neck Surg*. 2007;136:112-118.
8. Koo BS, Lim YC, Lee JS, Choi EC. Recurrence and salvage treatment of squamous cell carcinoma of the oral cavity. *Oral Oncol*. 2006;42:789-794.
9. Agra IM, Carvalho AL, Kowalski LP, et al. Prognostic factors in salvage surgery for recurrent oral and oropharyngeal cancer. *Head Neck*. 2006;28:107-113.
10. Wong LY, Wei WI, Lam LK, Yuen APW. Salvage of recurrent head and neck squamous cell carcinoma after primary curative surgery. *Head Neck*. 2003;25:953-957.
11. Campos-Correia D, Cruz J, Matos AP, Figueiredo F, Ramalho M. Magnetic resonance imaging ancillary features used in Liver Imaging Reporting and Data System: an illustrative review. *World J Radiol*. 2018;10:9-23.

Reprint requests:

Deepak Balasubramanian
Associate Professor
Head and Neck Surgery
Amrita Institute of Medical Sciences
Kochi
Kerala
682041
India.
Deepakbala@live.com