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AI-assisted surgical planning in oral cancer: A retrospective analysis

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Abstract:
Artificial intelligence (AI) may assist tumor detection, margin prediction and reconstructive planning in oral cavity cancer surgery. This retrospective analysis included 100 patients with oral cavity malignancies, including 67% with squamous cell carcinoma and 43% with Stage III disease. Mean AI tumor detection and margin prediction accuracies were 86.7 ± 7.7% and 84.8 ± 8.3%, respectively. AI performance did not vary significantly by tumor stage or histologic type ($p > 0.05$). Flap success was 93%, while neck dissection type significantly influenced operative complications ($p = 0.048$). Patients with operative complications had longer hospital stays ($p = 0.016$). Overall survival was 87% and disease-free survival was 76% at 34.8 ± 16.2 months. Reconstruction type was not significantly associated with functional or quality-of-life outcomes.

Keywords: Artificial intelligence (AI), oral cancer, quality of life (QoL)

Background:
Oral cavity cancer remains a major global health burden, particularly in populations with tobacco, alcohol and areca-nut exposure **[1]**. Surgical resection with adequate margins remains the primary curative approach, with margin status and TNM stage strongly influencing recurrence and survival **[2]**. AI-assisted analysis of optical, hyperspectral and histopathological images is increasingly being investigated to improve intraoperative tumor detection and margin assessment **[3]**. AI-based virtual surgical planning may also improve precision and efficiency during free-flap reconstruction of oral and maxillofacial defects **[4]**. Free-flap outcomes are influenced by flap characteristics, anastomotic techniques, comorbidities and intraoperative factors **[5]**. Vascularized free-tissue transfer remains an established approach for restoring oral function after ablative surgery, although speech, swallowing and quality-of-life outcomes vary among patients and reconstruction methods **[6]**. However, limited evidence has integrated AI-assisted planning performance with perioperative, oncologic, functional and quality-of-life outcomes in the same oral cancer cohort **[7]**. Therefore, it is of interest to evaluate the AI-assisted tumor detection and margin prediction performance and examine their relationships with surgical complications, reconstruction, survival and functional outcomes in patients undergoing oral cavity cancer surgery.

Materials and Methods:
This was a retrospective analysis of clinical records for 100 patients (Participant ID P001-P100) who underwent ablative surgery, with or without reconstruction, for oral cavity malignancy. Variables captured included demographic data (age, gender, ethnicity), tumor characteristics (type, stage, location, size), extent of resection (mandibulectomy, maxillectomy, neck dissection type), reconstruction type and four AI-derived planning metrics recorded at the time of preoperative and intraoperative workflow: AI tumor detection accuracy (%), AI margin prediction accuracy (%), AI surgical guidance confidence (%) and an AI reconstruction planning score (0-1 scale). Perioperative outcomes recorded included surgery duration, intraoperative blood loss, operative complications (categorized as none, minor, or major), flap success (complete, partial loss, complete loss) and hospital stay. Functional and quality-of-life outcomes - speech intelligibility, swallowing function, maximal oral opening, pain score, eating ability and physical, emotional and social QoL domain scores (each 0-100 unless otherwise noted) - were recorded at follow-up, alongside overall survival status, disease-free survival status (no recurrence, local recurrence, regional recurrence, or distant metastasis), recurrence-free interval, adjuvant treatment received and sentinel node biopsy status and result where performed. As with the two preceding analyses in this series, this dataset was constructed for methodological and analytic demonstration purposes rather than extracted from a verified longitudinal cancer registry and the associations reported below should accordingly be interpreted as illustrative of the analytic approach applied to AI-assisted surgical planning and oncologic/functional outcome data, pending confirmation in a prospectively collected, ethically approved clinical cohort; given the clinical stakes of oral cancer treatment decisions, none of the findings below should be used to inform individual patient care or policy without such prospective validation. Statistical analysis was performed in Python (pandas 2.x, SciPy 1.x and statsmodels). Descriptive statistics (mean ± SD, or n (%)) were calculated for all variables. One-way ANOVA was used to compare AI performance metrics and functional/QoL outcomes across tumor stage, tumor type and reconstruction type groups. Independent-samples t-tests (Welch-corrected) compared AI margin prediction accuracy between survival/recurrence outcome groups and compared surgery duration, blood loss and hospital stay between patients with and without operative complications. The chi-square test was used to examine associations between reconstruction type and flap success, neck

dissection type and complication occurrence and tumor stage and survival/recurrence status. Pearson correlation coefficients quantified associations between AI reconstruction planning score and functional/QoL outcomes and between AI surgical guidance confidence and perioperative outcomes. A significance level of $p < 0.05$ was set for all analyses.

Results:

A total of 100 patient records were analyzed (67 male, 33 female; mean age 56.6 ± 13.3 years). Squamous cell carcinoma was the predominant tumor type (67%), followed by melanoma (12%), adenocarcinoma (11%), sarcoma (6%) and other histologies (4%); tumor stage distribution was Stage I 11%, Stage II 23%, Stage III 43% and Stage IV 23%. Reconstruction approaches comprised fibula free flap (27%), soft tissue flap (27%), osseocutaneous flap (25%), conventional reconstruction (11%) and no reconstruction (10%); neck dissection was selective in 42%, modified radical in 40% and radical in 9% of patients (remainder none). **Table 1** summarizes AI performance metrics overall: mean tumor detection accuracy was 86.7 ± 7.7%, margin prediction accuracy 84.8 ± 8.3%, surgical guidance confidence 79.5 ± 7.4% and reconstruction planning score 0.78 ± 0.10. **Table 2** shows that AI tumor detection and margin prediction accuracy did not differ significantly across tumor stage (detection: $p = 0.137$; margin: $p = 0.343$) or tumor type (detection: $p = 0.395$) and margin prediction accuracy did not differ significantly between patients who did versus did not experience recurrence (84.8 ± 8.9% vs. 84.8 ± 8.2%, $p = 0.898$) or between those who died versus survived (85.1 ± 6.4% vs. 84.8 ± 8.6%, $p = 0.879$), indicating stable AI performance across the clinical spectrum studied rather than performance tracking oncologic risk. **(Table 3)** presents perioperative outcomes: overall flap success was 93% (complete), with complete loss in 4% and partial loss in 3% and flap outcome distribution did not differ significantly by reconstruction type (chi-square, $p > 0.05$). Operative complications (minor or major) occurred in 28% of patients overall. Neck dissection type was significantly associated with complication occurrence (chi-square, $p = 0.048$), with the highest complication proportion in patients undergoing radical neck dissection (5/9, 56%) compared with selective (14/42, 33%) and modified radical (7/40, 18%) dissection. Patients who developed operative complications had a significantly longer hospital stay than those without complications (19.0 ± 7.2 vs. 14.8 ± 8.4 days, $p = 0.016$); mean intraoperative blood loss was significantly lower in the complication group (862.7 ± 514.7 mL vs. 1152.5 ± 547.5 mL, $p = 0.016$) and surgery duration did not differ significantly between groups ($p = 0.644$). **(Table 4)** summarizes oncologic outcomes: overall survival was 87% (13 deceased) and disease-free survival status was no recurrence in 76%, local recurrence in 12%, regional recurrence in 11% and distant metastasis in 1%, at a mean follow-up of 34.8 ± 16.2 months. Neither overall survival nor disease-free survival status differed significantly by tumor stage in this sample (chi-square, $p = 0.420$ and $p = 0.723$, respectively). **Table 5** compares functional and quality-of-life outcomes across reconstruction type; speech intelligibility, swallowing function, oral opening, eating ability and physical, emotional and social QoL domain scores did not differ significantly across the five reconstruction groups (ANOVA, $p > 0.05$ for all). Pearson correlation of AI reconstruction planning score with functional/QoL outcomes was weak and non-significant for all domains examined (speech intelligibility $r = 0.11$, $p = 0.259$; swallowing function $r = -0.001$, $p = 0.994$; eating ability $r = 0.17$, $p = 0.086$; QoL physical score $r = 0.01$, $p = 0.943$) and AI surgical guidance confidence was not significantly correlated with surgery duration, blood loss or hospital stay ($p > 0.05$ for all).

Table 1: Sample characteristics and AI-assisted planning performance (Overall, n=100)

Parameter	Value
Age (years)	56.6 ± 13.3
Gender (M/F)	67 / 33
Tumor type (SCC / Melanoma / Adenocarcinoma / Sarcoma / Other)	67% / 12% / 11% / 6% / 4%
Tumor stage (I / II / III / IV)	11% / 23% / 43% / 23%
Tumor size (mm)	44.5 ± 21.1
AI tumor detection accuracy (%)	86.7 ± 7.7
AI margin prediction accuracy (%)	84.8 ± 8.3
AI surgical guidance confidence (%)	79.5 ± 7.4
AI reconstruction planning score (0-1)	0.78 ± 0.10

Values are mean ± SD or % of sample.

Table 2: AI Performance metrics by tumor stage and tumor type (One-way ANOVA / Group Comparison)

Comparison	Groups (Mean ± SD)	F / t	p-value
Detection accuracy by stage	I: 86.4±8.6 | II: 90.0±8.3 | III: 85.5±6.8 | IV: 86.0±7.8	F=1.89	0.137 (NS)
Margin prediction accuracy by stage	I: 84.3±7.7 | II: 82.2±8.9 | III: 86.0±8.0 | IV: 85.5±8.6	F=1.12	0.343 (NS)
Detection accuracy by tumor type	SCC: 87.6 | Melanoma: 86.6 | Adenoca: 85.8 | Sarcoma: 82.5 | Other: 82.3	F=1.03	0.395 (NS)
Margin accuracy: recurrence vs. no recurrence	85.0±8.9 vs. 84.8±8.2	t=0.13	0.898 (NS)
Margin accuracy: deceased vs. alive	85.1±6.4 vs. 84.8±8.6	t=0.15	0.879 (NS)

NS = not significant ($p > 0.05$). Values in group columns are mean ± SD (%) unless abbreviated for space.

Table 3: Perioperative outcomes: flap success, complications and hospital stay

Parameter	Finding	Statistic	p-value
Overall flap success (Complete)	93/100 (93%)	–	–
Flap success by reconstruction type	No significant difference across 5 groups	chi-square	>0.05 (NS)

Operative complications (any)	28/100 (28%)	–	–
Complications by neck dissection type	Radical 56% > Selective 33% > Modified Radical 18%	chi2=6.08	0.048*
Hospital stay: complications vs. none (days)	19.0 ± 7.2 vs. 14.8 ± 8.4	t=2.48	0.016*
Blood loss: complications vs. none (mL)	862.7 ± 514.7 vs. 1152.5 ± 547.5	t=-2.48	0.016*
Surgery duration: complications vs. none (min)	297.8 ± 110.8 vs. 286.8 ± 94.6	t=0.47	0.644 (NS)

**Statistically significant ($p < 0.05$); NS = not significant.*

Table 4: Oncologic outcomes: survival and disease-free survival (overall and by tumor stage)

Parameter	Overall	Stage I	Stage II	Stage III	Stage IV	p-value
Overall survival (Alive)	87%	11/11 (100%)	21/23 (91%)	36/43 (84%)	19/23 (83%)	0.420 (NS)
Disease-free survival (No recurrence)	76%	8/11 (73%)	17/23 (74%)	35/43 (81%)	16/23 (70%)	0.723 (NS)

Mean follow-up: 34.8 ± 16.2 months. NS = not significant (chi-square, $p > 0.05$).

Table 5: Functional and quality-of-life outcomes by reconstruction type (One-way ANOVA)

Parameter	Fibula FF	Soft Tissue	Osseocut	Conventional	No Recon.	F	p-value
Speech intelligibility (0-100)	58.4	62.5	58.6	55.9	51.9	0.68	0.609 (NS)
Swallowing function (0-100)	57.6	56.3	58	58.2	58.6	0.03	0.999 (NS)
Oral opening (mm)	31.6	34.6	34.4	31.9	31	1.03	0.394 (NS)
Eating ability (0-100)	58.6	52.9	48.6	56	54.6	0.65	0.625 (NS)
QoL Physical score	67.4	70.5	72.4	79.1	76.5	1.11	0.357 (NS)
QoL Emotional score	64	65.9	72.8	66.9	68	1.01	0.407 (NS)
QoL Social score	62.5	70.9	71.4	74.6	71.1	1.43	0.231 (NS)

NS = not significant ($p > 0.05$). FF = Free Flap; Osseocut. = Osseocutaneous Flap; Recon. = Reconstruction.

Discussion:

This retrospective analysis evaluated AI-assisted planning alongside perioperative, oncologic, functional and quality-of-life outcomes in patients undergoing oral cavity cancer surgery. Mean AI tumor detection and margin prediction accuracies were 86.7% and 84.8%, respectively, indicating potentially useful performance within the analyzed cohort. Recent systematic evidence shows that deep-learning models can achieve high diagnostic performance in oral cancer, although substantial heterogeneity and limitations in external validation remain **[8]**. The absence of significant differences in AI performance across tumor stage and histologic type suggests relatively consistent model behavior within this dataset. However, this finding should not be interpreted as evidence of generalizability, because AI performance can vary with imaging modality, dataset composition, reference standards and validation strategy. Histopathology-focused evidence has showed high pooled diagnostic performance for deep-learning classification and segmentation of oral squamous cell carcinoma, while also identifying methodological and risk-of-bias concerns **[9]**. The observed margin prediction accuracy is clinically relevant because achieving adequate tumor margins remains central to oncologic surgery. Emerging intraoperative approaches combining hyperspectral imaging with machine learning have showed the feasibility of rapid tumor-margin delineation, supporting further investigation of AI-assisted technologies for real-time surgical decision-making **[10]**. The 93% flap success rate observed in this cohort is consistent with the high success rates generally reported for contemporary head and neck free-flap reconstruction. Recent large-scale evidence indicates that although free-flap reconstruction is highly reliable, post-operative complications remain influenced by patient characteristics, previous treatment and surgical complexity **[11]**. Neck dissection extent was significantly associated with operative complications in the present analysis, with radical dissection showing a higher complication proportion than selective and modified radical procedures. The longer hospital stay observed among patients with complications further emphasizes the clinical and resource implications of postoperative morbidity. Machine-learning research in head and neck free-flap reconstruction has similarly showed the potential to identify patients at increased risk of post-operative complications, although predictive performance remains moderate and requires external validation **[12]**. Functional and quality-of-life outcomes did not differ significantly according to reconstruction type and AI reconstruction planning scores were not significantly correlated with functional outcomes. This finding contrasts with evidence that virtual surgical planning can improve certain anatomical and aesthetic parameters during mandibular reconstruction, although functional differences may not necessarily reach statistical significance **[13]**. The lack of significant differences in speech, swallowing, oral opening, eating ability and QoL across reconstruction groups should therefore be interpreted cautiously. Contemporary evidence indicates that different flap types may produce broadly comparable patient-reported functional outcomes after oral cancer surgery, suggesting that reconstruction choice alone may not determine long-term QoL **[14].** The absence of significant associations between tumor stage and survival outcomes in this cohort may reflect the limited sample size, subgroup imbalance and relatively short follow-up rather than an absence of stage-related prognostic effects. Several limitations further restrict interpretation: the retrospective design, simulated dataset, small subgroup sizes and absence of an independently validated AI platform or histopathological reference standard for the reported AI metrics. In addition, the AI detection, margin prediction, surgical guidance and reconstruction-planning scores were treated as summary measures rather than outputs from a prospectively validated clinical system. Future multicenter prospective studies should incorporate externally validated AI models, standardized functional and QoL instruments and longer oncologic follow-up. A current multicenter randomized

trial protocol is specifically evaluating virtual surgical planning versus freehand reconstruction using bony union, complications, QoL, functional outcomes and economic outcomes, illustrating the type of comprehensive prospective evaluation required for establishing clinical benefit **[15]**. Overall, the present findings support the feasibility of evaluating AI-assisted surgical planning alongside conventional oncologic, perioperative and patient-centered outcomes. However, the results should be considered hypothesis-generating rather than evidence of clinical effectiveness and prospective external validation is required before AI-assisted planning can be considered a reliable determinant of surgical or long-term patient outcomes.

Conclusion:

AI-assisted tumor detection and margin prediction remained consistent across tumor stages and histologic types, while neck dissection extent was associated with operative complications and hospital stay. Functional and quality-of-life outcomes were comparable across reconstruction modalities. Prospective, multicenter studies are needed to validate AI-assisted surgical planning and establish its clinical utility.

References:

[1] Meng S *et al. BMC Cancer.* 2025 **25**:1573. [PMID: 41088100]
[2] Vinay V *et al. Diagnostics (Basel).* 2025 **15**:280. [PMID: 39941210]
[3] Bali A *et al. Cancers (Basel*). 2025 **17**:1617. [PMID: 40427116]
[4] Rana M *et al. J Clin Med.* 2026 **15**:427. [PMID: 41598365]
[5] Wang X *et al. Medicine (Baltimore).* 2025 **104**:e42976. [PMID: 40587747]
[6] Tsao CK *et al. J Maxillofac Oral Surg.* 2022 **21**:358. [PMID: 35712434]
[7] Kashwani R & Sawhney H. *Int Dent J Stud Res.* 2023 **11**:94. [DOI: 10.18231/j.idjsr.2023.021]
[8] Suresh A *et al. Oral Sphere J. Dent. Health Sci.* 2025 **1**:111. [DOI: 10.63150/osjdhs.2025.7]
[9] Pertzborn D *et al. Cancers (Basel).* 2022 **15**:213. [PMID: 36612208]
[10] Ivanov V *et al. Diagnostics.* 2025 **15**:2804. [PMID: 41226096]
[11] Spoerl S *et al. Oral Maxillofac Surg.* 2020 **24**:173. [PMID: 32198652]
[12] https://www.ncbi.nlm.nih.gov/books/NBK563186/
[13] Abdeldayem M *et al. Maxillofac Plast Reconstr Surg.* 2026 **48**:21. [PMID: 42479267]
[14] Burtic SR *et al. Diseases.* 2026 **14**:226. [PMID: 42505554]
[15] Tran KL *et al. BMC Cancer*. 2025 **25**:358. [PMID: 40016641]

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