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Analysis

# Nomograms predicting cancer-specific survival and overall survival of advanced salivary gland malignancy patients: a study based on the SEER database

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## Abstract

**Objective** To establish a clinical prediction model for specific and overall survival in advanced salivary gland malignant tumors, providing a potential reference tool for personalized clinical care and adjunct treatment decision-making.

**Methods** Retrospective data from the Surveillance, Epidemiology, and End Results (SEER) 8.4.3 version were utilized. Clinical variables collected included patient age, gender, race, diagnosis year, SERR historic stage A, histological types(The histological classification of advanced salivary gland malignant tumors in this study mainly include acinic cell carcinoma, adenoid cystic, mucoepidermoid carcinoma, salivary duct carcinoma, carcinoma ex pleomorphic adenoma, squamous cell carcinoma NOS, salivary gland carcinoma NOS and other histological types), T stage, N stage, M stage, treatment modalities (including surgery, radiotherapy, and chemotherapy), marital status, cancer-specific survival (CSS), overall survival (OS), and survival status. Patients diagnosed with TNM III/TNM IV stage salivary gland malignant tumors between 2010 and 2015 were allocated to the training set, while those diagnosed between 2004 and 2009 served as the test set. Chi-square test compared clinical variables between the training and test sets. Univariate and multivariate COX regression models identified prognostic factors, Kaplan–Meier analysis depicted survival curves, and predictive models for patient OS and CSS were constructed using R-studio environment, with calibration curves and C-index calculated. All statistical analyses were conducted using SPSS 25.0 and R-studio, with $P < 0.05$ considered significant.

**Results** A total of 1477 late-stage salivary gland malignant tumor patients were included. Independent prognostic factors for OS included age, tumor histology, histologic types, T stage, M stage, surgery, and radiotherapy. CSS shared similar prognostic factors with OS. Predictive nomograms based on clinical variables showed high accuracy for 1, 2, 3, 5, and 10-year OS and CSS, with C-indexes of 0.748 and 0.783, respectively. External validation confirmed the models' accuracy, with well-fitted calibration curves between predicted and observed survival rates.

**Conclusion** Nomograms constructed from clinical data can effectively predict OS and CSS for advanced salivary gland malignant tumor patients, providing a potential reference tool for personalized clinical care and adjunct treatment strategies.

**Keywords** Nomogram · Salivary gland malignancy · Cancer-specific survival (CSS) · Overall survival (OS)

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## 1 Introduction

Salivary gland cancer is a rare malignant tumor, accounting for approximately 1–3% of malignancies in the head and neck region [1]. While most head and neck malignancies are squamous cell carcinomas, salivary gland cancer exhibits greater histological diversity, with 21 different subtypes classified by the World Health Organization in 2017 [2, 3]. Surgery remains the primary treatment modality for salivary gland tumor, significantly impacting patient survival rates [4–6], radiotherapy has been shown to extend the survival of patients with salivary gland cancer [7, 8]. Current prognostic tools, such as the AJCC staging system, have limitations and fail to consider other potential risk factors that may affect patient prognosis. Therefore, there is an urgent need for a new predictive tool to individualize prognosis for advanced salivary gland malignancies.

Nomograms are graphical calculation tools used to predict cancer patient prognosis, aiding in better prognosis evaluation and treatment stratification. Research has shown that nomograms improve medical care for various cancers, including gastric cancer, liver cancer, small cell carcinoma, and non-Hodgkin's lymphoma of the salivary gland [9–12]. However, there is currently no similar nomogram available for predicting the survival status of advanced (TNM III/TNM IV) salivary gland malignancies. The Surveillance, Epidemiology, and End Results (SEER) database, a comprehensive registry of cancer cases in North America, provides valuable data for evidence-based clinical practice and medical research. Therefore, this study aims to collect clinical information from the SEER database for advanced salivary gland malignancy patients, conduct statistical analysis to identify clinical-pathological factors affecting patient prognosis, and develop a nomogram model for advanced salivary gland malignancies. This model could serve as a potential reference tool for personalized clinical care and the development of adjunct treatment strategies, ultimately improving patient outcomes and extending survival.

## 2 Materials and methods

### 2.1 Study population

Retrospective data were obtained from the Surveillance, Epidemiology, and End Results (SEER) 8.4.3 version database. Patients diagnosed with salivary gland malignant tumors between 2004 and 2015 were screened, with AJCC 6th staging used as the pathological staging criteria. Inclusion criteria comprised patients pathologically confirmed with salivary gland malignant tumors, staged as TNM III or TNM IV, and possessing complete and accurate follow-up information. Exclusion criteria included missing key information, patients staged as TNM I or TNM II, and those with incomplete follow-up information. A total of 1447 patients were included in the study, with 766 patients in the training set (diagnosed between 2010 and 2015) and 681 patients in the test set (diagnosed between 2004 and 2009).

### 2.2 Collection of clinical features

Clinical variables included patient demographics, tumor characteristics, treatment modalities, marital status, overall survival (OS), cancer-specific survival (CSS), and survival status.

### 2.3 Construction of nomogram prognostic model

Using the clinical variables collected, a prognostic model was established in the R-Studio environment to predict the survival status of advanced salivary gland malignancy patients. The accuracy of the model was evaluated using the C-index and calibration curve.

### 2.4 External validation of the model

The predictive model was validated using the following methods: (1) calculating the risk scores for each patient based on the predictive model, dividing patients into four groups according to quartile values of risk scores, and plotting

Kaplan–Meier survival curves based on risk score levels; (2) plotting calibration curves of predicted and actual survival rates and calculating the C-index using data from the test set.

### 2.5 Statistical methods

Chi-square tests were used to examine differences in clinical variables between the training and test sets. Univariate and multivariate COX regression models were used to analyze risk factors affecting patient prognosis, and Kaplan–Meier models were used to plot survival curves. All statistical analyses were conducted using SPSS 25.0 and R-Studio, with $P < 0.05$ considered statistically significant.

## 3 Results

### 3.1 Clinical and pathological characteristics of patients with advanced salivary gland malignancies

The clinical and pathological characteristics of patients included in the study are shown in Table 1. Significant statistical differences were observed between patients in the training and test sets in terms of M staging and SEER Historic stage A ($P < 0.05$). However, other pathological characteristics such as age, gender, race, marital status, tumor type, histologic types, T staging, N staging, surgical treatment, and radiotherapy were similar between the two sets. Additionally, analysis of overall survival using Kaplan–Meier models for the training and test sets showed no statistically significant difference (Fig. 1) ($P = 0.915$).

### 3.2 Risk factors influencing CSS and OS of patients with salivary gland malignancies

Single-factor and multi-factor COX regression analysis models were established based on patients' clinical characteristics (Tables 2, 3). The results showed that age, T staging, N staging, M staging, Historic stage A, histologic types, surgical treatment, and radiotherapy were independent prognostic factors for cancer-specific survival (CSS) while age, T staging, M staging, Historic stage A, histologic types, surgical treatment, and radiotherapy were independent prognostic factors for overall survival (OS) of patients.

### 3.3 Nomograms for predicting CSS and OS of late-stage salivary gland malignancy patients

Based on the results of single-factor and multi-factor COX regression analysis of patients, nomograms were constructed to predict 1-year, 2-year, 3-year, 5-year, and 10-year CSS and OS of advanced salivary gland cancer patients (Fig. 2). The predictive factors for CSS mainly included T staging, N staging, M staging, Historic stage A, histologic types, surgical treatment, radiotherapy, and age (Fig. 2a). The predictive factors for overall survival of patients are also roughly the same (Fig. 2b).

### 3.4 Validation of nomograms for CSS and OS, predicting patient survival probability curves

Risk scores for predicting patient survival status were calculated based on the nomograms, ranging from 27.5 to 338.5 points for CSS and 20 to 317.5 points for OS in the training set. The quartile values were calculated as 128 and 117.5, respectively. Patients were divided into four groups accordingly. Kaplan–Meier survival curves were plotted in SPSS 25.0 (Fig. 3). Results showed that higher risk scores were associated with lower CSS (Fig. 3a) and OS (Fig. 3b).

### 3.5 High overlap between actual and predicted survival rates, demonstrating high accuracy of the predictive model

To further validate the accuracy of the predictive model, the fit between predicted and actual survival rates for CSS and OS was examined in R environment (Fig. 4). Calibration curves for CSS (Fig. 4a) and OS (Fig. 4c) showed satisfactory overlap between predicted and actual survival rates, with C-index values of 0.783 and 0.748, respectively, indicating high accuracy. External validation using the test set data also demonstrated a high fit between predicted and actual survival rates (Fig. 4b, d), with C-index values of 0.739 for CSS and 0.711 for OS. These results indicate that the predictive model

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**Table 1** Clinical and Pathological Characteristics of Patients with Salivary Gland Malignancies in the Training and Test Sets

| Characteristics | Total | | | *p* value |
|---|---|---|---|---|
| | | Training set | Testing set | |
| Year of diagnosis | 2004–2015 | 2010–2015 | 2004–2009 | |
| All of patients | 1447 | 766(52.9%) | 681(47.1%) | |
| Age | | | | 0.251 |
| < 50 | 223 | 112(14.6%) | 111(16.3%) | |
| 50–79 | 854 | 445(58.1%) | 409(60.1%) | |
| > 80 | 370 | 209(27.3%) | 161(23.6%) | |
| Gender | | | | 0.237 |
| Female | 475 | 262(34.2%) | 213(31.3%) | |
| Male | 972 | 504(65.8%) | 468(68.7%) | |
| Race | | | | 0.919 |
| White | 1198 | 634(82.8%) | 564(82.8%) | |
| Black | 97 | 53(6.9%) | 44(6.5%) | |
| Other | 152 | 79(10.3%) | 73(10.7%) | |
| Marital status | | | | 0.216 |
| Married | 853 | 440(57.4%) | 413(60.6%) | |
| Unmarried | 594 | 326(42.6%) | 268(39.4%) | |
| Type of tumor | | | | 0.477 |
| Epithelial tumor of major salivary glands | 1397 | 742(96.9%) | 655(96.2%) | |
| Other | 50 | 24(3.1%) | 26(3.8%) | |
| Histologic Type | | | | 0.218 |
| Acinic cell carcinoma | 97 | 51(6.7%) | 46(6.8%) | |
| Adenoid cystic | 91 | 48(6.3%) | 43(6.3%) | |
| Mucoepidermoid carcinoma | 233 | 105(13.7%) | 128(18.8%) | |
| Carcinoma ex pleomorphic adenoma | 73 | 51(6.7%) | 22(3.2%) | |
| Salivary duct carcinoma | 55 | 36(4.7%) | 19(2.8%) | |
| Squamous cell carcinoma, NOS | 400 | 213(27.8%) | 187(27.5%) | |
| Salivary gland carcinoma, NOS | 164 | 89(11.6%) | 75(11.0%) | |
| Other | 334 | 173(22.6%) | 161(23.6%) | |
| SEER Historic stage A | | | | < 0.0001 |
| Localized | 102 | 63(8.2%) | 39(5.7%) | |
| Regional | 797 | 380(49.6%) | 417(61.3%) | |
| Distant | 548 | 323(42.2%) | 225(33.0%) | |
| AJCC 6th T-Stage | | | | 0.379 |
| T1 | 114 | 62(8.1%) | 52(7.6%) | |
| T2 | 167 | 87(11.4%) | 80(11.7%) | |
| T3 | 588 | 325(42.4%) | 263(38.6%) | |
| T4 | 535 | 274(35.8%) | 261(38.3%) | |
| Tx | 43 | 18(2.3%) | 25(3.7%) | |
| AJCC 6th N-Stage | | | | 0.334 |
| N0 | 595 | 324(42.3%) | 271(39.8%) | |
| N1 | 852 | 442(55.9%) | 410(57.1%) | |
| AJCC 6th M-Stage | | | | 0.010 |
| M0 | 1284 | 676(88.3%) | 608(89.3%) | |
| M1 | 138 | 83(10.8%) | 55(8.1%) | |
| Mx | 25 | 7(0.9%) | 18(2.6%) | |
| Surgery | | | | 0.228 |
| Performed | 1197 | 625(81.6%) | 572(84.0%) | |
| Unperformed | 250 | 141(18.4%) | 109(16.0%) | |
| Radiotherapy | | | | 0.188 |
| Yes | 920 | 475(62.0%) | 445(65.3%) | |
| None | 527 | 291(38.0%) | 236(34.7%) | |
| Chemotherapy | | | | 0.186 |
| Yes | 337 | 189(24.7%) | 148(21.7%) | |
| No/Unknown | 1110 | 577(75.3%) | 533(78.3%) | |

Statistical differences between clinical variables in the training and test sets were examined using chi-square tests, with $P < 0.05$ considered statistically significant

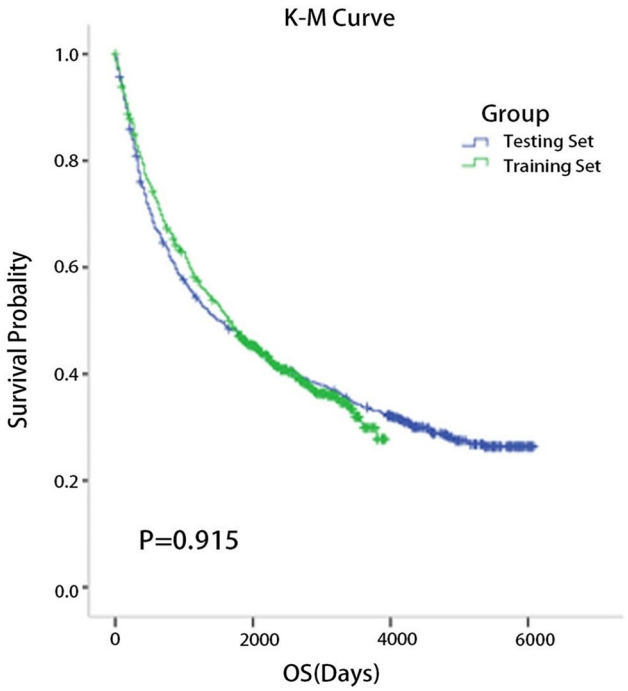


**Fig. 1** Survival curves of patients in the training and test sets showed no significant differences in survival rates

based on clinical data has high accuracy and can be used to predict 1-year, 2-year, 3-year, 5-year, and 10-year overall survival and cancer-specific survival of patients.

## 4 Discussion

In this study, we included clinical and pathological data from 1447 patients diagnosed with late-stage salivary gland malignancies between 2004 and 2015, and established nomograms for predicting patient-specific survival rates and overall survival rates. The results of this study may provide a comprehensive new perspective on the pathological characteristics and prognosis of advanced salivary gland malignancies.

The clinical characteristics of advanced salivary gland malignancies identified in our study are consistent with previous findings, including tumors originating from salivary gland epithelium, predominance in male patients, common lymph node infiltration metastasis, and extensive infiltration, with T3 and T4 staging dominating [8, 13, 14]. In this study, the most common histological type of advanced salivary gland malignancies was mucoepidermoid carcinoma, followed by salivary gland carcinoma, NOS and acinic cell carcinoma in sequence. This finding is consistent with the results of a retrospective study on salivary gland tumors by Long-Jiang Li [15].

In terms of survival rates, the 5-year cancer-specific survival rate and overall survival rate for late-stage salivary gland malignancies were 53.5% and 46.1%, respectively. The 10-year cancer-specific survival rate and overall survival rate were even lower, at 4.8% and 3.9%, respectively, indicating a poor prognosis for advanced malignant salivary gland tumors that warrants further attention.

Surgery remains the main treatment modality for late-stage salivary gland malignancies, with 82.7% of patients undergoing surgical treatment in our study. Results from single-factor and multi-factor COX regression analysis showed that patients undergoing surgical treatment had a nearly 70% and 50% reduction in the risk of death ($P < 0.01$), indicating that surgical treatment significantly reduces the risk of death and is a favorable factor for cancer-specific survival and overall survival, consistent with previous studies [4–6](. Additionally, a significant proportion of patients received radiotherapy (920/1447, 63.6%), and prognosis analysis showed that radiotherapy can reduce the risk of death and is an independent prognostic factor for overall survival, contributing to the extension of patients' overall survival ($P = 0.013$), which is consistent with previous reports [7, 8].

**Table 2** Results of Single-Factor COX Regression Analysis for Cancer-Specific Survival (CSS) and Overall Survival (OS) of Salivary Gland Malignancy Patients

| Characteristics | CSS Exp 95%CI p | OS Exp 95%CI p |
|---|---|---|
| Age | | |
| < 50 | Reference | Reference |
| 50–79 | 3.835 2.331–6.310 < 0.01 | 3.795 2.478–5.812 < 0.01 |
| > 80 | 9.689 5.771–16.266 < 0.01 | 8.962 5.790–13.871 < 0.01 |
| Gender | | |
| Female | Reference | Reference |
| Male | 1.447 1.124–1.862 0.004 | 1.380 1.132–1.682 < 0.01 |
| Race | | |
| White | Reference | Reference |
| Black | 0.612 0.379–0.988 0.045 | 0.587 0.389–0.887 < 0.01 |
| Other | 0.569 0.365–0.888 0.013 | 0.684 0.492–0.950 < 0.01 |
| Marital status | | |
| Married | Reference | Reference |
| Unmarried | 0.939 0.743–1.186 0.597 | 0.929 1.688–7.561 0.433 |
| Type of tumor | | |
| Epithelial tumor | Reference | Reference |
| Other | 1.617 0.801–3.268 0.180 | 1.709 1.066–2.740 0.026 |
| Histologic Type | | |
| Acinic cell carcinoma | Reference | Reference |
| Adenoid cystic | 1.331 0.611–2.898 0.471 | 1.060 0.556–2.019 0.860 |
| Mucoepidermoid carcinoma | 1.359 0.677–2.730 0.389 | 1.279 0.739–2.213 0.379 |
| Carcinoma ex pleomorphic adenoma | 1.756 0.797–3.868 0.162 | 1.810 1.005–3.518 0.048 |
| Salivary duct carcinoma | 2.142 0.972–4.718 0.059 | 1.874 0.999–3.518 0.051 |
| Squamous cell carcinoma, NOS | 3.700 1.976–6.929 < 0.01 | 3.144 1.930–5.122 < 0.01 |
| Salivary gland carcinoma, NOS | 3.741 1.951–7.171 < 0.01 | 2.776 1.647–4.680 < 0.01 |
| Other | 2.807 1.483–5.312 < 0.01 | 2.603 1.582–4.281 < 0.01 |
| SEER Historic stage A | | |
| Localized | Reference | Reference |
| Regional | 1.008 0.585–1.736 0.997 | 0.935 0.643–1.359 0.723 |
| Distant | 2.854 1.683–4.840 < 0.01 | 1.954 1.350–2.826 < 0.01 |
| AJCC 6th T-Stage | | |
| T1 | Reference | Reference |
| T2 | 3.949 0.902–8.200 < 0.01 | 2.385 1.471–3.866 < 0.01 |
| T3 | 2.431 1.228–4.813 < 0.01 | 1.693 1.096–2.615 0.018 |
| T4 | 4.994 2.543–9.811 < 0.01 | 2.785 1.808–4.290 < 0.01 |
| Tx | 6.475 2.629–15.950 < 0.01 | 3.452 1.775–6.712 < 0.01 |
| AJCC 6th N-Stage | | |
| N0 | Reference | Reference |
| N1 | 1.850 1.440–2.376 < 0.01 | 1.495 1.238–1.805 < 0.01 |
| AJCC 6th M-Stage | | |
| M0 | Reference | Reference |
| M1 | 4.763 3.550–6.391 < 0.01 | 3.386 2.634–4.352 < 0.01 |
| Mx | 5.525 2.260–13.502 < 0.01 | 3.573 1.688–7.561 < 0.01 |
| Surgery | | |
| Unperformed | Reference | Reference |
| Performed | 0.243 0.188–0.3.15 < 0.01 | 0.280 0.227–0.344 < 0.01 |
| Radiotherapy | | |
| None | Reference | Reference |
| Yes | 0.485 0.385–0.612 < 0.01 | 0.505 0.421–0.606 < 0.01 |
| Chemotherapy | | |
| No/Unknown | Reference | Reference |
| Yes | 1.397 1.091–1.789 0.008 | 1.202 0.980–1.474 0.077 |

CI, confidence interval; HR, hazard ratio

Based on the SEER database, Sun et al. [16] developed nomograms for predicting overall survival of salivary gland mucoepidermoid carcinoma in 2019, which included age, grade, surgical treatment, and chemotherapy in addition to T, N, and M staging. Wang et al. [17] constructed nomograms for predicting overall survival and cancer-specific survival of salivary gland adenocarcinoma patients in 2021, with C-index values of 0.747 and 0.780, respectively. Building upon previous work, this study developed nomograms for predicting cancer-specific survival and overall survival of advanced salivary gland malignancy patients. By calculating patient risk scores and grouping patients to plot Kaplan–Meier curves for validation, it was found that patients with higher scores had lower cancer-specific survival and overall survival ($P < 0.01$). Additionally, calibration curves plotted in the R environment and external validation demonstrated satisfactory fit between predicted and actual survival rates, further confirming the accuracy of the model.

T, N, and M classifications are independent risk factors for OS and CSS. The larger the tumor extension, the more lymph nodes involved, or the further the distant metastasis, the shorter the survival time. It is well known that the American Joint Committee on Cancer (AJCC) staging is a commonly used prognostic tool for malignant tumors [18]. However, this method has certain limitations and does not consider many independent factors affecting patient prognosis, such as age, tumor differentiation, and treatment received, resulting in significant limitations in personalized prediction. Nomograms incorporate many risk factors affecting patient prognosis and visually predict individual patient survival rates [19, 20]. Therefore, based on factors influencing patient prognosis, nomograms were constructed for predicting 1-year, 2-year, 3-year, 5-year, and 10-year cancer-specific survival and overall survival of advanced salivary gland malignancies to help clinicians better assess the prognosis of different patients.

Based on the model constructed in this article, it can be seen that under the same conditions, acinic cell carcinoma has the lowest risk score and is the histological type with the best prognosis in advanced malignant salivary gland tumors. Other studies have also shown that acinar cell carcinoma is often classified as a low-grade cancer [21], and its prognosis is relatively good [22].

Conversely, among the known histological subtypes of malignant salivary gland tumors, salivary duct carcinoma has the highest risk of death. The results of multivariate regression analysis reveal that its risk of death is approximately 1.5 times that of acinic cell carcinoma, with the poorest prognosis. Previous studies have also demonstrated that SDC has a propensity for early metastasis to regional lymph nodes and distant sites, and has a high recurrence rate [23–30], as well as a very poor survival rate. The majority of patients survive for only approximately three years after diagnosis [26, 30] [31–33]

Through the column chart established in this article, we can easily obtain score comparisons between other advanced malignant salivary gland tumors (such as mucoepidermoid carcinoma, adenoid cystic carcinoma, and malignant mixed tumor, etc.) in addition to the two pathological tissue types mentioned above. This can further study the differences in 1-year, 2-year, 3-year, 5-year, and 10-year survival rates between different pathological types of advanced malignant salivary gland tumors, providing a potential reference tool for the treatment of different pathological types of salivary malignant tumors and helping us further investigate their differences.

Certainly, there are limitations to this study. Firstly, in case selection, patients with unclear pathological staging and grading were excluded, which may affect the accuracy of patient CSS and OS. Secondly, certain clinical factors that may affect patient prognosis were not considered, such as patient pathological types, smoking history, and other personal histories. In addition, the SEER database does not contain detailed information on some clinically relevant variables and adjuvant therapy, such as the patient's own physical condition and comorbidities, as well as adjuvant therapy regimens and doses. Therefore, the results should be interpreted with caution. Although we have established a column chart model based on classic clinical pathological features to predict the specific survival rate and overall survival rate of patients with advanced salivary gland malignancies, molecular biology prognostic indicators and external validation are still needed to further improve its reliability. Despite these limitations, the model demonstrated good accuracy and predictability, which may help improve patient treatment outcomes and extend patient survival.

**Table 3** Results of Multifactor Cox Regression Analysis for Patients' Cancer-Specific Survival (CSS) and Overall Survival (OS)

| Characteristics | CSS Exp 95%CI p | OS Exp 95%CI p |
|---|---|---|
| Age | | |
| < 50 | Reference | Reference |
| 50–79 | 2.425 1.445–4.070 < 0.01 | 2.456 1.572–3.838 < 0.01 |
| > 80 | 6.182 3.550–10.763 < 0.01 | 5.517 3.466–8.780 < 0.01 |
| Gender | | |
| Female | Reference | Reference |
| Male | 1.139 0.873–1.486 0.337 | 1.068 0.868–1.313 0.535 |
| Race | | |
| White | Reference | Reference |
| Black | 0.844 0.513–1.391 0.507 | 0.960 0.626–1.472 0.850 |
| Other | 0.930 0.582–1.485 0.761 | 0.832 0.590–1.313 0.293 |
| Marital status | | |
| Married | | |
| Unmarried | | |
| Type of tumor | | |
| Epithelial tumor | | Reference |
| Other | | 0.934 0.554–1.576 0.799 |
| Histologic Type | | |
| Acinic cell carcinoma | Reference | Reference |
| Adenoid cystic | 1.066 0.480–2.368 0.876 | 0.843 0.436–1.627 0.610 |
| Mucoepidermoid carcinoma | 1.205 0.592–2.451 0.607 | 1.109 0.635–1.936 0.716 |
| Carcinoma ex pleomorphic adenoma | 1.319 0.589–2.957 0.501 | 1.487 0.818–2.705 0.194 |
| Salivary duct carcinoma | 1.590 0.703–3.598 0.266 | 1.360 0.711–2.601 0.353 |
| Squamous cell carcinoma, NOS | 2.197 1.139–4.237 0.019 | 1.823 1.094–3.037 0.21 |
| Salivary gland carcinoma, NOS | 2.270 1.149–4.485 0.018 | 1.822 1.060–3.133 0.030 |
| Other | 1.643 0.846–3.189 0.142 | 1.498 0.893–2.514 0.126 |
| SEER Historic stage A | | |
| Localized | Reference | Reference |
| Regional | 0.806 0.442–1.471 0.483 | 0.944 0.624–1.428 0.784 |
| Distant | 1.291 0.669–2.493 0.446 | 1.377 0.869–2.181 0.173 |
| AJCC 6th T-Stage | | |
| T1 | Reference | Reference |
| T2 | 3.372 1.594–7.131 < 0.01 | 2.207 1.351–3.605 < 0.01 |
| T3 | 3.927 1.934–7.973 < 0.01 | 2.395 1.525–3.762 < 0.01 |
| T4 | 5.018 2.489–10.116 < 0.01 | 2.752 1.754–4.317 < 0.01 |
| Tx | 2.212 0.828–5.905 0.113 | 1.206 0.591–2.460 0.606 |
| AJCC 6th N-Stage | | |
| N0 | Reference | Reference |
| N1 | 1.428 1.049–1.946 0.024 | 1.039 0.832–1.298 0.735 |
| AJCC 6th M-Stage | | |
| M0 | Reference | Reference |
| M1 | 2.177 1.465–3.236 < 0.01 | 1.579 1.138–2.191 < 0.01 |
| Mx | 1.703 0.658–4.409 0.273 | 1.943 0.898–4.027 0.092 |
| Surgery | | |
| Unperformed | Reference | Reference |
| Performed | 0.792 0.579–1.083 0.145 | 0.486 0.365–0.647 < 0.01 |
| Radiotherapy | | |
| None | Reference | Reference |
| Yes | 0.737 0.541–1.004 0.053 | 0.762 0.605–0.960 0.021 |
| Chemotherapy | | |
| No/Unknown | Reference | |
| Yes | 1.040 0.776–1.394 0.791 | |

CI, confidence interval; HR, hazard ratio

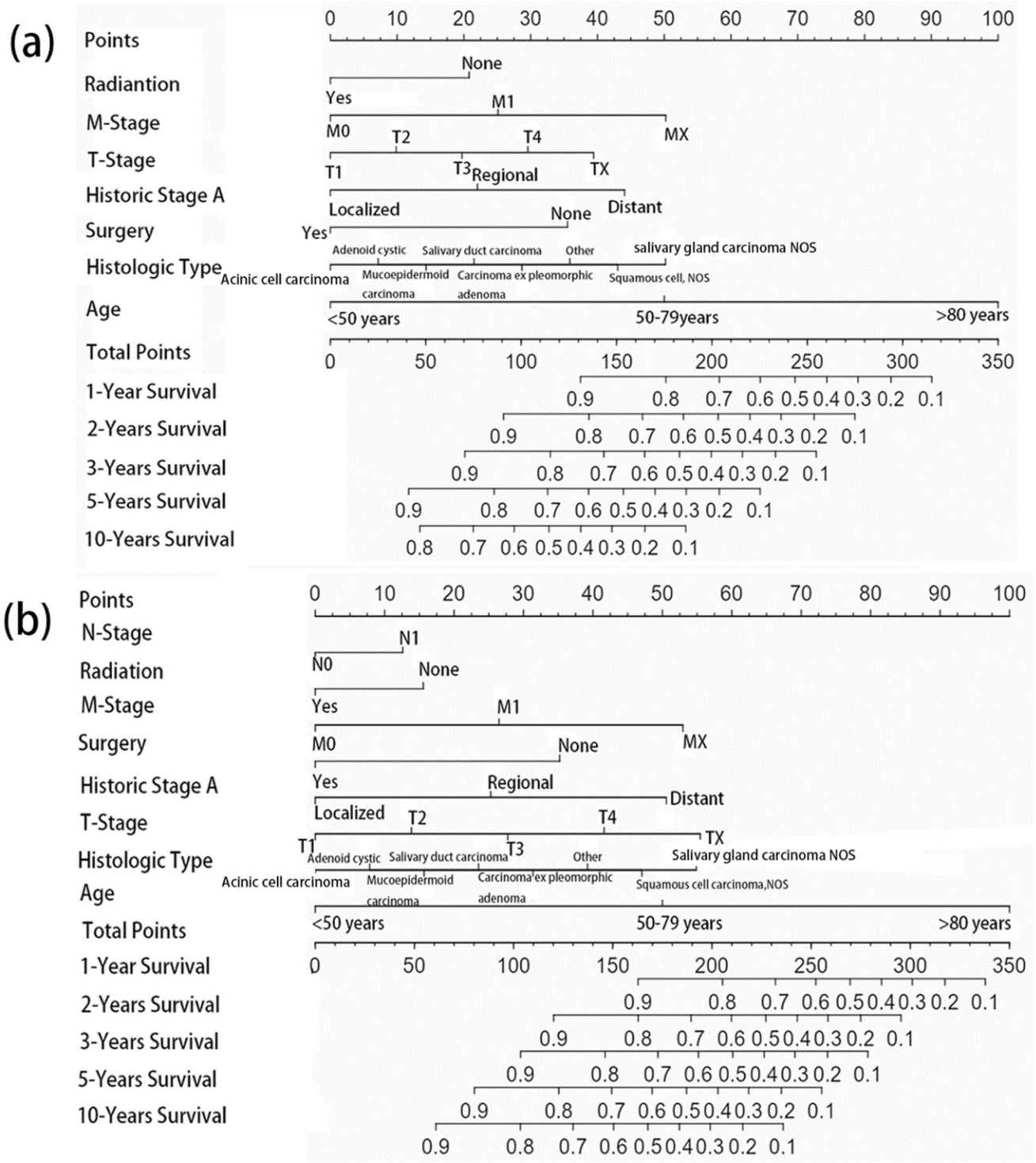


**Fig. 2** Nomograms for Predicting 1-Year, 2-Year, 3-Year, 5-Year, and 10-Year Cancer-Specific Survival and Overall Survival; a: Cancer-Specific Survival; b: Overall Survival

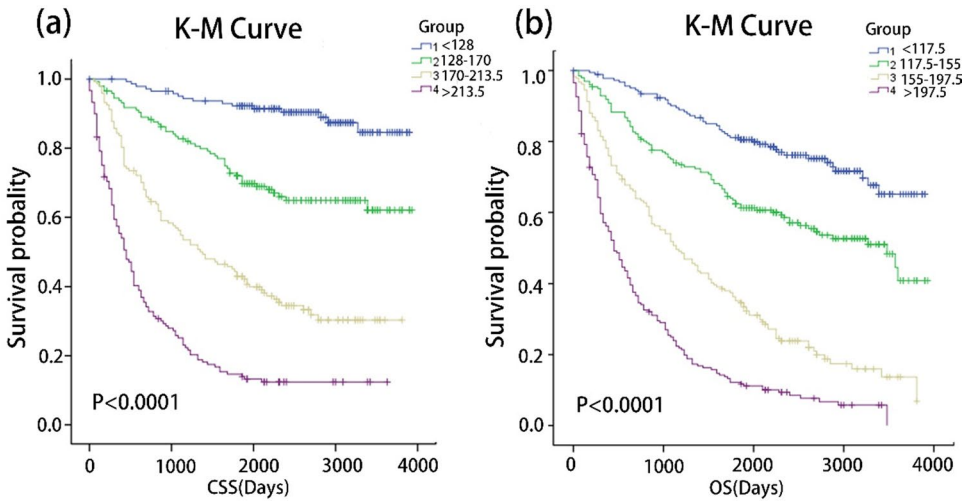


**Fig. 3** The K-M curve is used to evaluate the differences in survival rates among patients in different scoring groups, *P < 0.05* Considered statistically significant; a: Cancer-Specific Survival; b: Overall Survival;

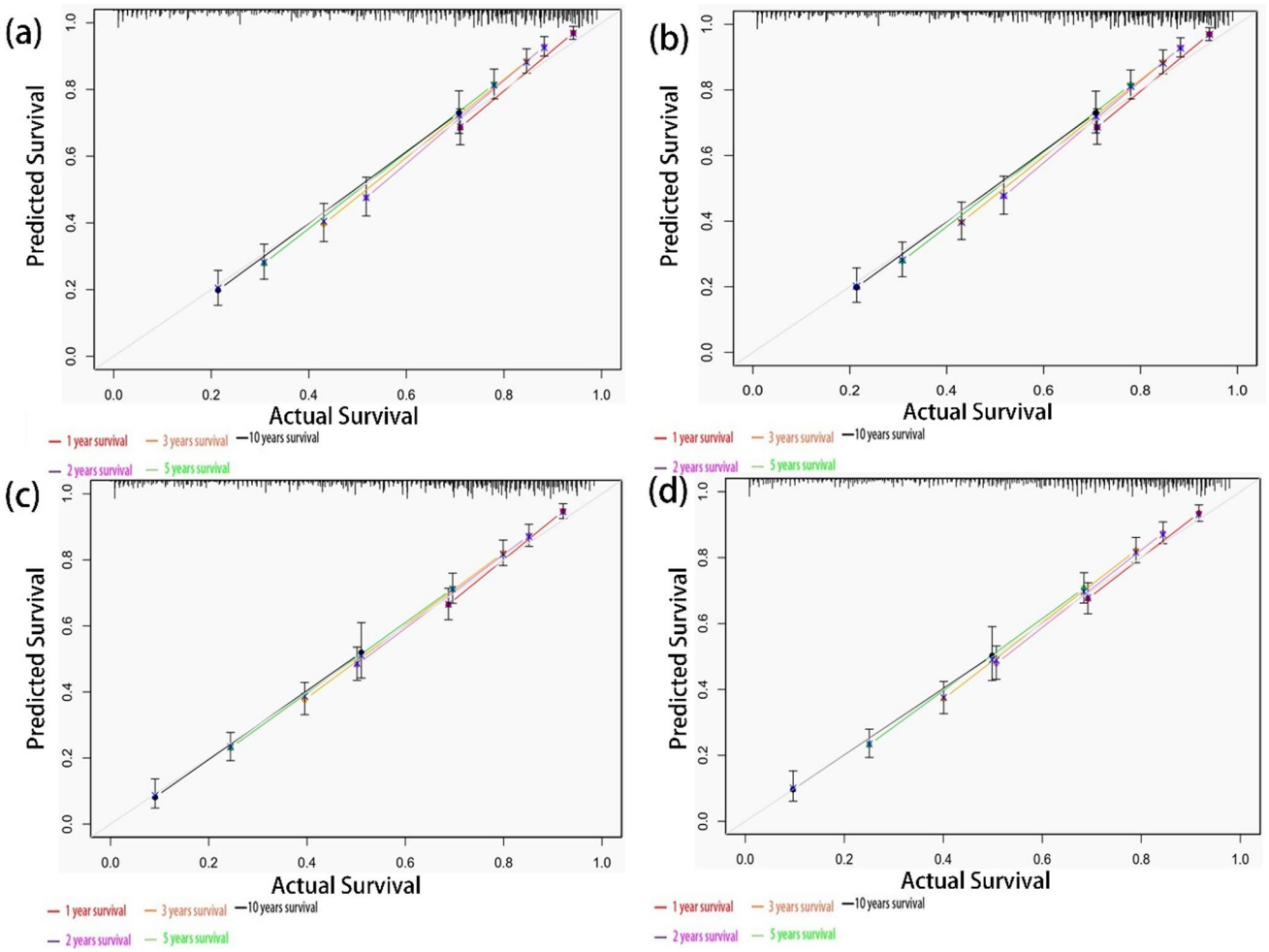


**Figure4** The red, purple, orange, green, and black lines represent the fitting between predicted and actual survival rates for 1 year, 2 years, 3 years, 5 years, and 10 years, respectively. **a** CSS training set, C-Index: 0.783; **b** CSS test set, c-Index: 0.739; **c** OS training set, C-Index: 0.748; **d** OS test set, C-Index: 0.711

## 5 Conclusion

Nomograms constructed based on patient clinical data can be used to predict 1-year, 2-year, 3-year, 5-year, and 10-year cancer-specific survival and overall survival of late-stage salivary gland malignancy patients. This predictive model provides a potential reference tool for personalized clinical care and adjunct treatment decision-making for advanced salivary gland malignancy patients.

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**Data availability** The datasets generated during the current study are available from the corresponding author on reasonable request.

### Declarations

**Ethics approval and consent to participate** This study uses anonymized and de-identified data previously collected from the SEER database. Therefore, no additional ethical approval or consent is required.

**Consent for publication** Not applicable.

**Competing interests** The authors declare no competing interests.



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