Multi-modality Treatment and Survival in Sinonasal Minor Salivary Gland Tumors

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Abstract

Objectives The aim of this study was to analyze the effect of the multimodality treatment on survival in sinonasal minor salivary gland tumors.

Methods Adult clinical American Joint Committee on Cancer (AJCC) tumor (T) 1-4a staged cases of sinonasal minor salivary gland tumors were isolated from the National Cancer Database (2004–2014). Multivariate regressions were performed to analyze the effect of multimodality treatment. A subset analysis was also performed in patients with positive margins following surgical management.

Results We identified 556 cases, of which 293 (52.7%) patients were treated with surgery and radiotherapy (RT), 160 (28.8%) were treated with surgery alone, and 52 (9.4%) were treated with surgery and chemoradiotherapy (CRT). No patients were treated with chemotherapy alone. With surgery and CRT as a reference, the only treatment modality associated with decreased survival was RT alone (hazard ratio [HR]: 3.213 [95% confidence interval (CI): 1.578–6.543]; $p = 0.001$). Within a subset analysis of patients with positive margins, surgery was associated with decreased survival (HR: 2.021 [95% CI: 1.401–3.925]; $p = 0.038$), but not triple modality therapy (HR: 1.700 [95% CI: 0.798–3.662]) when compared with surgery with RT.

Conclusion The most common treatment was surgery and RT, consistent with National Comprehensive Cancer Network (NCCN) guidelines which recommends chemotherapy (CT) only in the most concerning cases. However, we found no difference in survival among most treatment modalities when compared with triple modality therapy, with the exception of RT alone. Although margins were prognostic within these cancers, we found no evidence that adjuvant CRT provides any survival benefit over surgery and RT, though surgery alone was associated with decreased survival.

Keywords
- sinonasal minor salivary gland tumors
- NCDB
- multimodality treatment
- sinonasal tumors
- outcomes

Introduction

Salivary gland cancers account for fewer than 5% of head and neck neoplasms.[1] Minor salivary gland tumors account for only 9 to 23% of all salivary gland tumors and are malignant in 80% of cases.[2] While most of the literature available on minor salivary gland tumors of the head and neck incorporate all subsites, such as the oropharynx, larynx, and sinonasal cavities, there are lack of published data on minor salivary gland tumors specific to the sinuses and nasal cavities. Minor salivary gland malignancies represent an uncommon subset of sinonasal malignancies following that of squamous cell carcinoma (40%) and diffuse large B cell lymphoma.[3,4] Unlike the oral cavity where both adenoid cystic carcinoma and mucoepidermoid carcinoma are frequent, it has been reported that over 90% of salivary gland tumors in the sinonasal tract are adenoid cystic carcinomas,[5] which is generally the more aggressive of the two.[6]

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Typically, sinonasal malignancies expand locally leading to symptoms such as epistaxis, nasal obstruction, or orbital changes. Because of their expansile growth pattern, sinonasal minor salivary gland malignancies tend to present at later stages compared with oral cavity counterparts.[6] Surgical extirpation is the preferred treatment, though many lesions may require adjuvant radiation due to difficulty obtaining negative margins.[7] This management strategy has been delineated by the National Comprehensive Cancer Network (NCCN) guidelines regarding head and neck cancers.[8]

Although attempts have been made with minor salivary tumors to treat with radiation therapy alone, similar to the squamous cell lesions of the nasopharynx, published studies have concluded that this approach is inferior to surgery alone or surgery in combination with postoperative radiation therapy.[5] Advances in skull-based surgery and endoscopic approaches have allowed complete excision for some cancers of the sinonasal cavities that were not possible in the past.

Evidence-based treatment paradigms for oral cavity minor salivary gland tumors have been well described, but due to the relative rarity of these tumors there is a paucity of data regarding treatment and survival in minor salivary gland tumors of the nasal cavity and paranasal sinuses. The objective of this study was to analyze the effect of multimodality treatment on survival in sinonasal minor salivary gland tumors with the aim of assisting clinicians with management decisions in this rare entity.

Materials and Methods

Data

The data were obtained from the National Cancer Database (NCDB) from 2004 to 2014. A collaboration between the American College of Surgeons (ACS) and the Commission on Cancer (CoC), the NCDB collects data from over 1,500 hospital in the United States, representing over 70% of all new diagnoses of cancer as previously described.[9] The NCDB has been used in several studies to study outcomes in head and neck cancers.[10–13] This study was determined to be exempt from institutional review by the Yale Human Investigation Committee.

Patient Population

The study population included patients of 18 years old or older who had a minor salivary gland carcinoma in the sinonasal subsites. This was obtained by utilizing the International Classification of Disease for Oncology, 3rd ed., (ICD-O-3) histology codes 8200 (adenoid cystic carcinoma), 8310 (clear cell adenocarcinoma), 8430 (mucoepidermoid carcinoma), 8525 (polymorphous low grade adenocarcinoma), 8550 (acinar cell carcinoma), 8562 (epithelial–myoepithelial carcinoma), 8941 (carcinoma in pleomorphic adenoma), and 8982 (malignant myoepithelioma). Sinonasal subsites were isolated via subsite codes C30.0–C31.9, which include the nasal cavity and accessory sinuses, excluding the middle ear. Cases were also excluded if they had an American Joint Committee on Cancer (AJCC) clinical tumor (T) classification greater than T4a or a clinical metastasis (M) classification greater than M0, as the NCCN guideline recommendations do not include surgery.[8] Cases with a T classification of T4 not otherwise specified were excluded, as we were uncertain whether they represented T4a or T4b cases. Cases were also excluded if they were missing data on vital status, T stage, nodal (N) stage, M stage, or treatment. To analyze impact of margin on survival, further exclusions were made for patients who had unknown margins or no surgery. Finally, patients with negative margins were excluded for subgroup analysis on the effect of multimodality therapy in patients with positive margins (►**Fig. 1**).

Variable Definitions

Patients were classified as having chemotherapy (CT) regardless of type or number of agents. Patients who received external-beam radiation were considered to have received radiotherapy (RT). Patients were considered to have undergone surgery if they underwent surgery at the primary site. Histologies were group into "adenoid cystic carcinoma,"

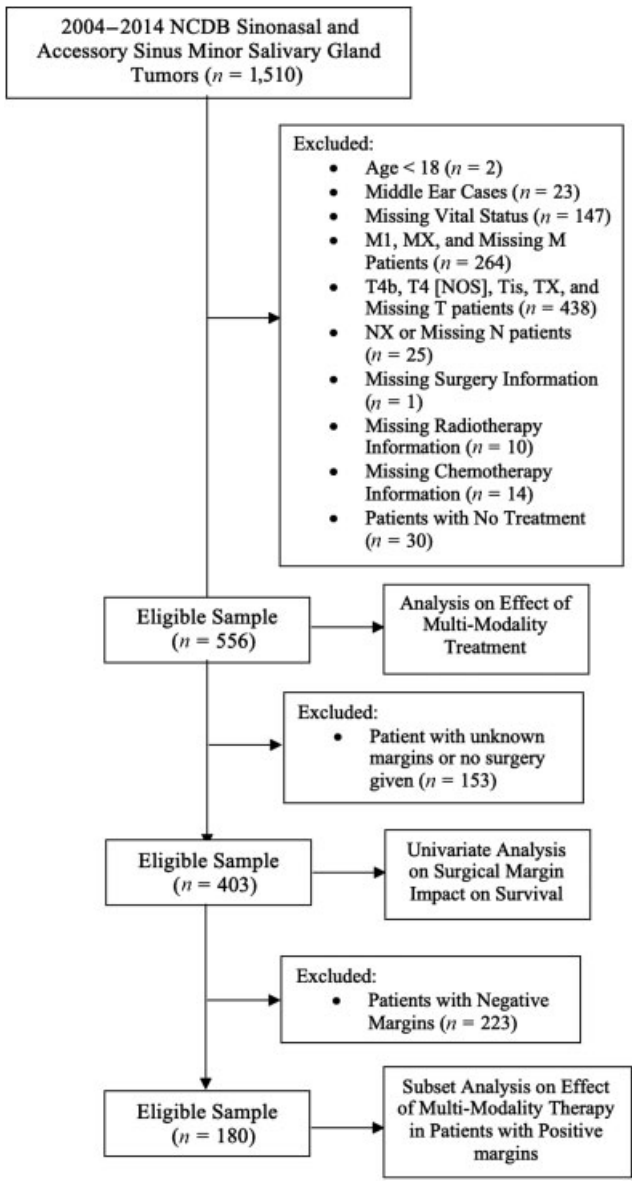

Fig. 1 CONSORT diagram of inclusion and exclusion criteria. NCDB, national cancer database. CONSORT, Consolidated Standard of Reporting Trials.

"mucoepidermoid," and "other," which included all other histologies.

Statistical Analysis

Chi-square tests were performed to analyze differences in age, sex, race, Charlson–Deyo comorbidity condition (CDCC) score, AJCC T and N stages, tumor grade, histologies, and interventions between all primary sites. In instances where a category had $\leq$10 cases, Fisher's exact test was employed. Univariate survival analyses were performed via Kaplan–Meier two-tailed log rank tests. Multivariate survival analyses controlling for the above variables were performed via a Cox's proportional hazards model. Data analyses was performed using SPSS 25.0 (IBM Corp., Armonk, NY, U.S.A.) and significance was defined at the $p < 0.05$ level.

Results

Characteristics of T1–T4a, M0 Sinonasal Minor Salivary Gland Tumor Patients Stratified by Primary Site

After exclusion, we identified 556 patients of which 239 (43.0%) were located in the nasal cavity, 282 (50.7%) in the maxillary sinuses, and 35 (6.3%) in the ethmoid sinuses. Patients were predominantly white (45.1%), under 54 (38.7%), with similar numbers of the sexes (50.9%) female and 49.1% male). 82.7% of patients had a CDCC score of 0. Most patients also presented with no nodal metastases (95.7%) and the majority of the sinonasal minor salivary gland tumors were identified histologically as adenoid cystic carcinoma (72.5%). Dual-modality therapy including surgery and RT was most often utilized (52.7%) with 28.8% obtaining surgery alone. Only 9.4% received triple-modality therapy (►**Table 1**).

When stratified by primary site, we found no differences in sex, race, CDCC, N stage, tumor grade, histology, or treatment choice. A greater proportion of patients with nasal cavity minor salivary gland tumors were $\geq$75 (22.6%), compared with the maxillary sinuses (10.6–14.2%) and ethmoid sinuses (< 28.6%; $p = 0.025$). However, nasal cavity tumors tended to present with a T1 stage (nasal cavity: 41.8%; maxillary sinuses: 7.1–10.6%; ethmoid sinuses: < 28.6%), while maxillary and ethmoid sinus tumors tended to present with a T4a stage (nasal cavity: 15.5%; maxillary sinuses: 39.7%; ethmoid sinuses: 28.6%; $p < 0.001$; ►**Table 1**).

Table 1 Univariate Chi-square analysis of demographics of sinonasal minor salivary gland patients stratified by site

	All cases $n = 556$	Nasal cavity $n = 239$ (%)	Maxillary sinus $n = 282$ (%)	Ethmoid sinus $n = 35$ (%)	*p*-Value
Age (y)					0.025[a]
18–54	214 (38.4)	90 (37.7)	111 (39.4)	13 (37.1)	
55–64	129 (23.2)	50 (20.9)	70–80[b] (24.8–28.4)	< 10[b] (< 28.6)	
65–74	119 (21.4)	45 (18.8)	61 (21.6)	13 (37.1)	
≥ 75	94 (16.9)	54 (22.6)	30–40[b] (10.6–14.2)	< 10[b] (< 28.6)	
Sex					0.617
Male	273 (49.1)	116 (48.5)	137 (48.6)	20 (57.1)	
Female	283 (50.9)	123 (51.5)	145 (51.4)	15 (42.9)	
Race					0.430[a]
White	451 (81.1)	201 (84.1)	222 (78.7)	28 (80.0)	
Black	66 (11.9)	20–30[b] (8.4–12.6)	38 (13.5)	< 10[b] (< 28.6)	
Asian/Pacific Islander	27 (4.9)	< 10[b] (< 4.2)	10–20[b] (3.5–7.1)	< 10[b] (< 28.6)	
Other/unknown	12 (2.2)	< 10[b] (< 4.2)	< 10[b] (<3.5)	< 10[b] (< 28.6)	
Charlson's/Deyo's Score					0.731[a]
0	460 (82.7)	203 (84.9)	228 (80.9)	29 (82.9)	
1	85 (15.3)	30–40[b] (12.6–16.7)	40–50[b] (14.2–17.7)	< 10[b] (< 28.6)	
≥ 2	11 (2.0)	< 10[b] (< 4.2)	< 10[b] (< 3.5)	< 10[b] (< 28.6)	
Clinical T classification					< 0.001[c]
1	130 (23.4)	100 (41.8)	20–30[b] (7.1–10.6)	< 10[b] (< 28.6)	
2	91 (16.4)	40 (16.7)	40–50[b] (14.2–17.7)	< 10[b] (< 28.6)	
3	176 (31.7)	62 (25.9)	101 (35.8)	13 (37.1)	
4a	159 (28.6)	37 (15.5)	112 (39.7)	10 (28.6)	

Table 1 (*Continued*)

	All cases $n = 556$	Nasal cavity $n = 239$ (%)	Maxillary sinus $n = 282$ (%)	Ethmoid sinus $n = 35$ (%)	*p*-Value
Clinical N classification					0.943[a]
0	532 (95.7)	229 (95.8)	260–270[b] (92.2–95.7)	25–35 (71.4–100.0)[b]	
1+	24 (4.3)	10 (4.2)	10–20[b] (3.5–7.1)	< 10[b] (< 28.6)	
Grade					0.231[a]
Well differentiated	63 (11.3)	28 (11.7)	30–40[b] (10.6–14.2)	< 10[b] (< 28.6)	
Moderately differentiated	97 (17.4)	38 (15.9)	50–60[b] (17.5–21.3)	< 10[b] (< 28.6)	
Poorly or undifferentiated	113 (20.3)	45 (18.8)	50–60[b] (17.5–21.3)	< 10[b] (< 28.6)	
Unknown	283 (50.9)	128 (53.6)	133 (47.2)	22 (62.9)	
Histology					0.402[a]
Adenoid cystic carcinoma	403 (72.5)	166 (69.5)	212 (75.2)	25 (71.4%)	
Mucoepidermoid	89 (16.0)	45 (18.8)	30–40[b] (10.6–14.2)	< 10[b] (< 28.6)	
Other	64 (11.5)	28 (11.7	30–40[b] (10.6–14.2)	< 10[b] (< 28.6)	
Treatment					0.107[c]
Surgery + CRT	52 (9.4)	16 (6.7)	30–40[b] (10.6–14.2)	< 10[b] (< 28.6)	
Surgery + CT	< 10[b] (< 1.8)	< 10[b] (< 4.2)	< 10[b] (< 3.5)	< 10[b] (< 28.6)	
Surgery + RT	293 (52.7)	118 (49.4)	156 (55.3)	19 (54.3)	
Surgery	160 (28.8)	84 (35.1)	66 (23.4)	10 (28.6)	
CRT	22 (4.0)	< 10[b] (< 4.2)	15 (5.3)	< 10[b] (< 28.6)	
RT	20–30[b] (3.6–5.4)	13 (5.4)	11 (3.9)	< 10[b] (< 28.6)	

Abbreviations: CT, chemotherapy; CRT, chemoradiotherapy; N, nodal stage; RT, radiotherapy; T, tumor stage.
[a]Fisher's exact test.
[b]Cells suppressed to prevent identification of patients within cells with < 10 cases as per NCDB data use agreement.
[c]Chi-squared test due to lack of computing power for Fisher's exact test.

Survival Outcomes Associated with Primary Site and Treatment

Upon univariate analysis, minor salivary gland tumors in the nasal cavity were associated with increased 5-year survival (76.1% [standard error {SE}: 3.4%]) when compared with those in the maxillary (61.6% [SE: 3.3%]) and ethmoid (64.4% [SE: 8.3%]) sinuses ($p = 0.008$; ►**Fig. 2A**). Five-year survival was also increased in the patients who received treatment that included surgery (surgery and chemoradiotherapy [CRT]: 68.6% [SE: 6.8%]; surgery and RT: 73.0% [SE: 3.0%]; surgery alone: 69.9% [SE: 4.6%]) when compared with those who received no surgery (CRT: 33.0% [SE: 10.9%]; RT alone: 30.5% [SE: 9.2%]; $p < 0.001$; ►**Fig. 2B**).

Adjusting for demographic and oncologic factors via a multivariate survival regression (►**Table 2**), we found tumors in the sinuses to be associated with decreased survival when compared with tumors in the nasal cavity (maxillary sinus hazard ratio [HR] 1.610 [95% confidence interval (CI): 1.103–2.305]; $p = 0.014$; Ethmoid Sinus HR 2.104 [95% CI: 1.139–3.890]; $p = 0.018$). No difference in survival was associated with treatment given when compared with triple modality treatment, which the exception of RT alone, which has a decreased survival (HR 3.213 [95% CI: 1.578–6.543]; $p = 0.001$). Of note, increased age, CDCC scores, T stage, N stage, and tumor grade were also associated with decreased survival, while sex, race, and histology were not.

Outcomes Differences Based on Margin Status

After excluding patients who did not undergo surgery or had unknown margins ($n = 153$), we identified 403 cases, of which 223 (55.3%) had negative margins and 180 (44.7%) had positive margins. Upon univariate analysis, patients with positive margins (5-year survival: 64.6% [SE: 4.1%]) had significantly diminished survival compared with patients with negative margins (5-year survival: 74.6% [SE: 3.6%]; $p < 0.001$; ►**Fig. 3**).

Outcomes Differences Based on Treatment Modality in Patients with Positive Margins

After excluding patients with negative margin ($n = 223$), we identified 180 patients. We found no differences in 3-year survival based on treatment type upon univariate log rank test (surgery and CRT: 61.0% [SE: 9.8%]; surgery and RT: 77.4% [SE: 4.0%]; surgery alone: 75.7% [SE: 7.5%]; $p = 0.735$; ►**Fig. 4**). Adjusting for demographics and oncologic factors in a subgroup Cox's regression (►**Table 3**), we

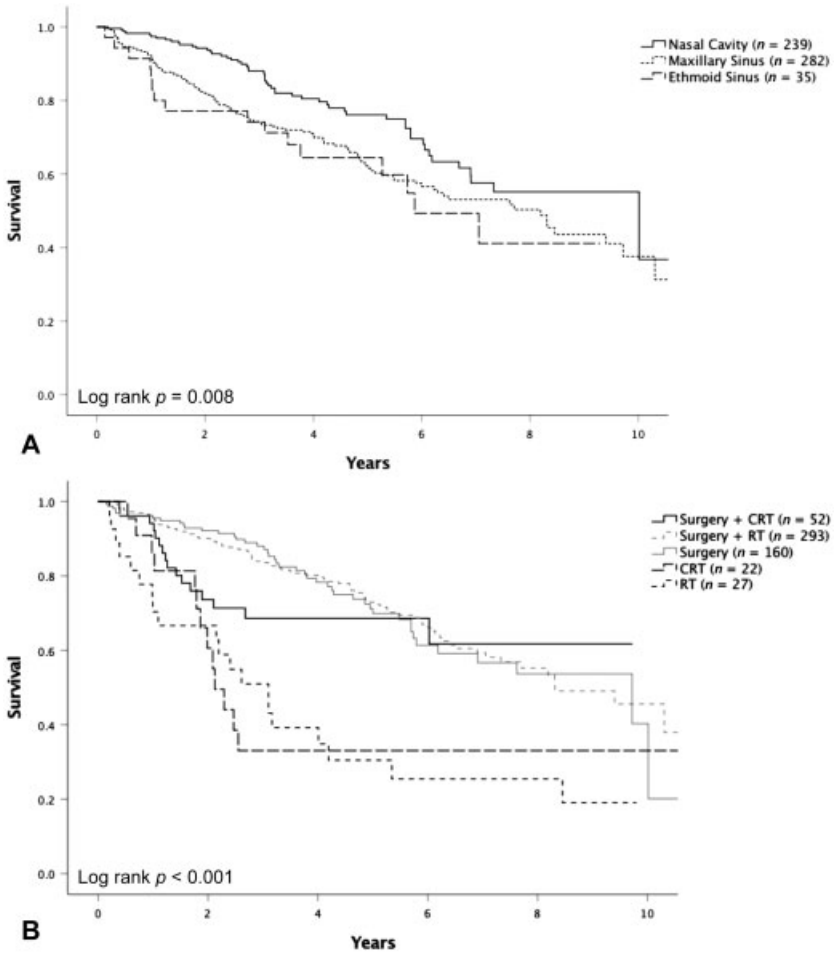

Fig. 2 Kaplan–Meier curve for survival stratified by **(A)** site and **(B)** treatment. CRT, chemoradiotherapy; RT, radiotherapy.

found no difference in survival in patients given triple modality therapy when compared with the NCCN-recommended dual modality therapy (surgery and RT) (HR: 1.700 [95% CI: 0.798–3.662]; $p = 0.168$). However, surgery alone was associated with diminished survival when compared with dual-modality therapy (HR: 2.021 [95% CI: 1.401–3.925]; $p = 0.038$). In addition, only increased age and tumor grade were associated with diminished survival in patients with positive margins, while sex, race, CDCC score, primary site, T stage, N stage, and histology were not.

Discussion

Minor salivary gland malignancies of the sinonasal tract represent a rare and challenging group of tumors. Complex anatomical location, proximity to important structures, advanced stage at presentation, and difficulty in achieving negative surgical margins have all been theorized to contribute to poorer outcomes. In addition, there has been a paucity of data regarding the best treatment regimen for these aggressive cancers. We used a nationwide cancer database to retrospectively evaluate the effect of multimodal therapy on oncologic outcomes. In our analysis, we found that patients with maxillary and ethmoid sinus tumors were more likely to present with advanced T stage compared with patients with nasal cavity tumors. Five-year survival was also decreased in patients with sinus tumors compared with those in the nasal cavity. The simplest and most logical explanation for this finding is that nasal cavity tumors are often discovered at an earlier stage by both patients and their providers due to their location compared with their "hidden" paranasal sinus counterparts,[14] leading to improved survival. In addition, resection of nasal cavity lesions may be technically easier in terms of access and ability to achieve negative surgical margins.

Historically, sinonasal minor salivary gland malignancies have been treated with a combination of surgery, either alone or followed by adjuvant radiation therapy (RT). In our study, the most common treatment was dual-modality therapy with surgery and RT (52.7%), followed by surgery alone (28.8%), though 90.9 to 92.7% received surgery as part of their treatment regimens. Patients whose treatment included surgery had improved survival compared with those who did not upon univariate survival analysis, emphasizing that surgery should still be the mainstay of therapy. Studies by Pantvaidya et al, Michel et al, and Rhee et al found similar outcomes.[6,15,16] In fact, we found no difference in survival between triple-modality therapy and surgery alone. This is in contrast to sinonasal undifferentiated carcinomas in which an NCDB study found inferior outcomes in the surgery-only cohort.[13]

Table 2 Multivariate Cox's regression analyzing the effect of therapy on survival

	Hazard ratio (95% CI)	*p*-Value
Age (y)		
18–54	1.000	Reference
55–64	2.124 (1.368–3.297)	0.001
65–74	1.985 (1.266–3.113)	0.003
≥ 75	4.156 (2.268–6.573)	< 0.001
Sex		
Male	1.000	Reference
Female	0.778 (0.572–1.059)	0.111
Race		
White	1.000	Reference
Black	0.788 (0.463–1.344)	0.382
Asian/Pacific Islander	0.681 (0.314–1.479)	0.332
Other/Unknown	0.799 (0.282–2.266)	0.673
Charlson's/Deyo's Score		
0	1.000	Reference
1	1.528 (1.031–2.264)	0.035
≥ 2	1.408 (0.419–4.728)	0.580
Primary site		
Nasal cavity	1.000	Reference
Maxillary sinus	1.610 (1.103–2.350)	0.014
Ethmoid sinus	2.104 (1.139–3.890)	0.018
Clinical T classification		
1	1.000	Reference
2	1.147 (0.604–2.180)	0.675
3	2.194 (1.306–3.684)	0.003
4a	2.243 (1.293–3.890)	0.004
Clinical N classification		
0	1.000	Reference
1+	2.274 (1.116–4.635)	0.024
Grade		
Well differentiated	1.000	Reference
Moderately differentiated	1.906 (0.926–3.920)	0.080
Poorly differentiated	4.365 (2.216–8.598)	< 0.001
Unknown	1.946 (1.007–3.763)	0.048
Histology		
Adenoid cystic carcinoma	1.000	Reference
Mucoepidermoid	0.957 (0.613–1.494)	0.846
Other	0.851 (0.498–1.455)	0.556
Treatment		
Surgery + CRT	1.000	Reference
Surgery + CT	0.923 (0.111–7.693)	0.941
Surgery + RT	0.763 (0.438–1.331)	0.341
Surgery	1.227 (0.660–2.283)	0.518
CRT	1.870 (0.806–4.340)	0.145
RT	3.213 (1.578–6.543)	0.001

Abbreviations : CI, confidence interval; CRT, chemoradiotherapy; RT, radiotherapy.

The combination of surgery and RT has been shown to improve survival in numerous studies.[6,14,16] Although surgery is the cornerstone of treatment for these tumors, achieving negative margins can be quite difficult as indicated by the high number of patients (45%) in our study who had positive surgical margins. This is fairly consistent with other studies in the literature who report a positive margin rate of between 45 to 67%.[6,14,15,17,18] Several factors may contribute to this problem. Sinonasal tumors are often asymptomatic, growing in the sinuses until they cause nonspecific symptoms of nasal obstruction, hyposmia, or facial pain. Patients are often misdiagnosed with sinusitis or other benign inflammatory conditions leading to a delay in diagnosis. Many patients are diagnosed unsuspectingly during routine sinus surgery for benign inflammatory diseases. Achieving negative surgical margins in previously operated sites then becomes even more difficult. Close proximity to vital structures, such as the optic nerves, skull base, and carotid artery make complete resection of these tumors extremely challenging.

In our cohort, patients with negative surgical margins had increased survival compared with patients who had positive margin, which coincides with other published reports.[17,19–21] This highlights the importance of complete surgical resection with clear margins and may also underscore the benefit of postoperative RT in sinonasal malignancies. In those patients who had positive margins, we did find that patients treated with surgery alone had an increased risk of mortality compared with those who received surgery and adjuvant RT. Furthermore, we did not find any survival benefit to adding chemotherapy to the treatment regimen. In fact, the majority of these tumors are not responsive to chemotherapy and the risk of toxicity often outweighs any benefit.[15,22]

Though the NCDB allows analysis of large sample sizes for investigation of rare malignancies, such as sinonasal minor salivary gland tumors, which can be an invaluable tool for helping to guide treatment recommendations, there are limitations to using a large secondary data source. We were limited by the information captured, and certain key variables, such as smoking status or type, dose, or duration of chemotherapy, were not collected. Uncaptured variables may be informative in characterizing these diseases and understanding treatment choices and there is an inherent risk of bias with retrospective analysis due to the possibility of unmeasured confounders. We were also unable to measure cause-specific mortality, as the only survival outcome available was overall survival.[13]

Conclusion

Due to the rarity of these cancers, recommendations are mostly based on single institution retrospective studies and expert opinion. To our knowledge, this is the largest analysis of patients with sinonasal minor salivary gland malignancies described in the literature to date. Despite the limitations inherent to a retrospective database analysis, our results suggest that of the many combinations of surgery, CT, and RT, there may be no survival difference between most therapy combinations that include some form of surgery. However, in

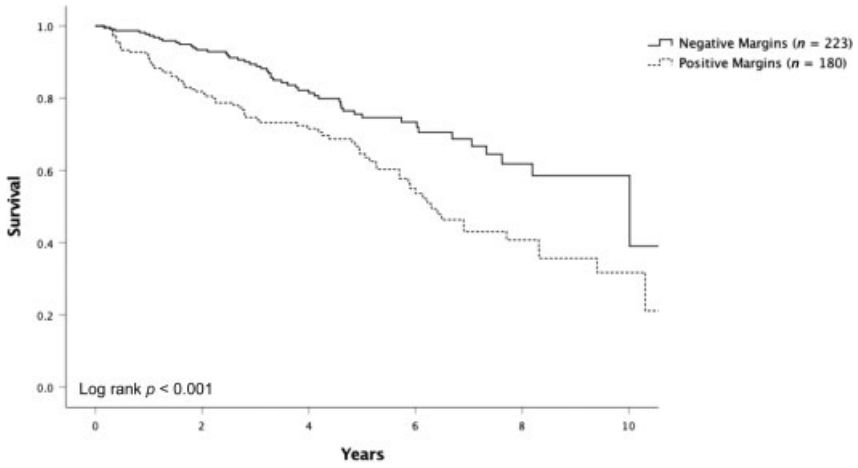

Fig. 3 Kaplan–Meier curve for survival stratified by margins.

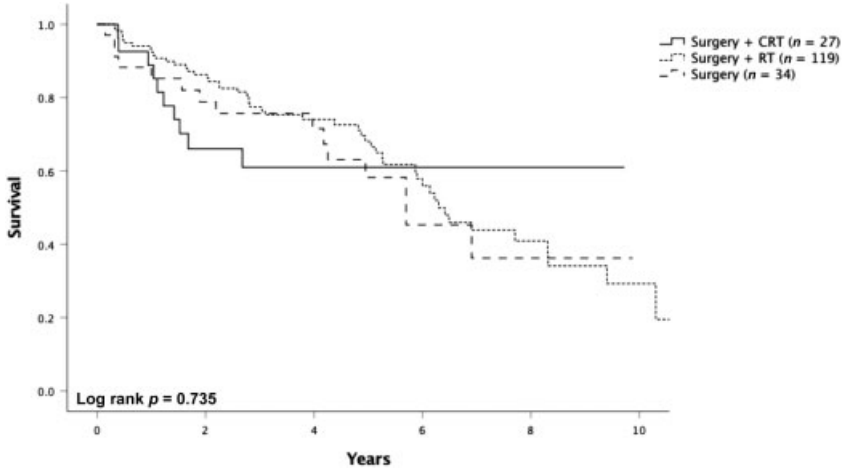

Fig. 4 Kaplan–Meier curve for survival stratified by treatment in patients with positive margins. CRT, chemoradiotherapy; RT, radiotherapy.

Table 3 Subgroup Cox's regression analyzing treatment modality in patients with positive margins

	Hazard ratio (95% CI)	*p*-Value
Age (y)		
18–54	1.000	Reference
55–64	2.317 (1.162–4.619)	0.017
65–74	2.538 (1.195–5.390)	0.015
≥ 75	2.863 (1.138–7.199)	0.025
Sex		
Male	1.000	Reference
Female	0.926 (0.564–1.522)	0.763
Race		
White	1.000	Reference
Black	0.608 (0.239–1.549)	0.297
Asian/Pacific Islander	0.366 (0.082–1.637)	0.188
Other/unknown	0.623 (0.133–2.908)	0.547
Charlson's/Deyo's score		
0	1.000	Reference
1	1.692 (0.919–3.116)	0.091
≥ 2	1.063 (0.131–8.604)	0.954
Primary site		
Nasal cavity	1.000	Reference
Maxillary sinus	1.687 (0.811–3.509)	0.162
Ethmoid sinus	2.337 (0.672–8.127)	0.182
Clinical T classification		
1	1.000	Reference
2	0.782 (0.216–2.837)	0.709
3	1.342 (0.413–4.357)	0.625
4a	1.515 (0.455–5.049)	0.498

Table 3 (*Continued*)

	Hazard ratio (95% CI)	*p*-Value
Clinical N classification		
0	1.000	Reference
1+	1.676 (0.434–6.470)	0.453
Grade		
Well differentiated	1.000	Reference
Moderately differentiated	4.684 (1.240–17.688)	0.023
Poorly differentiated	8.645 (2.333–32.042)	0.001
Unknown	4.993 (1.240–17.688)	0.015
Histology		
Adenoid cystic carcinoma	1.000	Reference
Mucoepidermoid	0.641 (0.256–1.606)	0.343
Other	2.539 (0.643–10.023)	0.184
Treatment		
Surgery + RT	1.000	Reference
Surgery + CRT	1.700 (0.798–3.662)	0.168
Surgery	2.021 (1.401–3.925)	0.038

Abbreviations: CI, confidence interval; CRT, chemoradiotherapy; N, nodal stage; RT, radiotherapy; T, tumor stage.

cases where positive margins are found, patients may have improved survival when also administered RT or CRT.

Conference
Accepted for podium presentation at 29th Annual North American Skull Base Society Meeting.

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Conflict of Interest
None.

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