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Patterns and Determinants of Bilaterality, Multifocality, and Satellite Foci in Salivary Gland Tumours: Insights from a National Multicentre Cohort

Wioletta Pietruszewska
Medical University of Lodz
Hanna Klimza
haniaklimza@gmail.com

Department of Otolaryngology, Regional Specialist Hospital Wrocław, Research & Development Centre, Wrocław, Poland
Bogusław Mikaszewski
Medical University of Gdańsk
Paweł Burduk
Department of Otolaryngology, Phoniatrics and Audiology, Collegium Medicum, Nicolaus Copernicus University,
Katarzyna Radomska
Pomeranian Medical University
Daniel Majszyk
Medical University of Warsaw
Jarosław Markowski
Medical University of Silesia
Małgorzata Wierzbicka
Wrocław University of Science and Technology

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Abstract

Bilateral and multifocal salivary gland tumours pose diagnostic and surgical challenges, yet their epidemiology and determinants remain incompletely understood. This study aimed to quantify their occurrence and identify clinical and epidemiologic correlates within the Polish Salivary Gland Network Database. A retrospective analysis was conducted on 2,246 salivary gland tumour cases. The primary outcomes were bilaterality, multifocality, and the presence of satellite foci. Predictor variables included age, sex, tumour location, tumour size, facial nerve status, lifestyle and environmental exposures, imaging performed, fine-needle aspiration cytology results, surgical margins, and histologic malignancy. Associations were tested using the χ^2 test and logistic regression. Bilateral tumours occurred in 178 cases (7.9%), multifocal lesions in 257 (11.4%), and satellite foci in 121 (5.4%). Bilaterality was independently associated with male sex (OR = 2.06; 95% CI 1.27–3.33), smoking (OR = 2.22; 95% CI 1.39–3.56), parotid gland location (OR = 2.11; 95% CI 1.22–2.78), and tumour size greater than 4 cm (OR = 1.65; 95% CI 1.02–3.45). Multifocality was associated with age (OR = 1.03; 95% CI 1.01–1.05) and smoking (OR = 1.73; 95% CI 1.11–2.68), while both multifocality and satellite foci were related to prior radiation exposure. Bilaterality and multifocality represent related yet distinct salivary gland tumour phenotypes linked to patient demographics, anatomic site, and environmental exposures, with important implications for surgical planning and risk stratification.

Introduction

Salivary gland tumours (SGTs) are uncommon and heterogeneous neoplasms characterized by diverse histopathological features and variable clinical behaviour. They account for a small fraction of head and neck tumours, with an incidence of approximately 2.5–3.0 per 100,000 in Western populations. Although SGTs are typically solitary and unilateral, they can occasionally present as multiple, multifocal, or bilateral lesions.

Multiple tumours are classified by timing—synchronous (simultaneous) or metachronous (sequential)—and by distribution—ipsilateral or bilateral. Importantly, postoperative recurrence and metastasis are excluded from this definition. While population estimates suggest that multiple salivary tumours, particularly bilateral cases, are rare (0.1–3.4%), their recognition is crucial because they significantly influence diagnostic evaluation and surgical planning.

Multifocal disease may involve several nodules within a single gland or across both parotid glands, complicating the radiologic distinction from metastatic disease. Satellite foci—small, separate nodules close to the primary tumour—occur most frequently in pleomorphic adenomas and oncocytomas and can lead to overestimation of disease extent on imaging.

Within the benign spectrum, Warthin tumour (WT) warrants special attention. WT arises predominantly in the parotid gland, exhibits a strong male predominance, and has a well-documented tendency toward multifocal and bilateral occurrence. Literature reports also describe the coexistence of WTs with other

primary parotid neoplasms, both benign and malignant, emphasizing the need for careful imaging and histopathologic confirmation when multifocal disease is suspected.

Diagnostic evaluation of suspected multifocal or bilateral disease typically integrates ultrasonography, MRI or CT imaging, and fine-needle aspiration cytology (FNAC). However, these modalities can be inconclusive when synchronous lesions are present, making final histopathology critical for surgical decision-making.

Despite extensive descriptive data on SGTs overall, large-scale studies specifically addressing bilateral, multifocal, and satellite presentations remain scarce.

The primary objective of this study was to determine the prevalence and clinicopathologic determinants of bilateral and multifocal salivary gland tumours, as well as the occurrence of satellite foci, within the Polish Salivary Gland Network Database (n = 2,246). A secondary aim was to develop predictive models for these patterns by evaluating demographic, clinical, and environmental variables and to assess the diagnostic performance of imaging modalities and cytology in identifying these features to optimize surgical planning.

Materials and Methods

Study population

This retrospective study analyzed data from 2,246 patients diagnosed with benign or malignant salivary gland tumours registered in the Polish Salivary Gland Network Database.

Among the participants, 1,291 (57.5%) were female and 1,073 (42.5%) male.

Tumour site and characteristics

Tumour sites were classified as:

- parotid gland
- accessory parotid gland
- submandibular gland

Most tumours originated in the parotid gland (95.9%).

Histopathology confirmed 1,921 benign and 142 malignant tumours.

Lifestyle and environmental exposures

Tobacco use was reported by 727 patients (32.4%), and alcohol use by 44 (1.9%). Prior radiation exposure was recorded in 273 patients.

Imaging and cytology

Ultrasonography (USG), computed tomography (CT), and magnetic resonance imaging (MRI) were used for diagnostic evaluation.

Fine-needle aspiration cytology (FNAC) was available for 2,433 cases.

Statistical analysis

Associations between tumour patterns and clinical variables were tested using the χ^2 test or Mann–Whitney U test. Multivariable logistic regression was used to estimate odds ratios with 95% confidence intervals.

A p-value < 0.05 was considered statistically significant.

Results

Bilateral tumours occurred in 178 cases (7.9%), multifocal lesions in 257 (11.4%), and satellite foci in 121 (5.4%).

Patients with bilateral and multifocal tumours were significantly older than those with unilateral lesions.

Male sex showed strong association with bilateral and multifocal disease.

Lesions arising in the parotid gland were more often bilateral and multifocal.

Tumours larger than 4 cm were more frequently bilateral and multifocal.

Smoking was significantly associated with bilateral and multifocal tumours, but not with satellite foci.

Previous radiation exposure correlated with multifocal disease.

Imaging modalities and cytology results showed no significant association with tumour phenotype.

Multifocal and satellite tumours were more frequently associated with non-radical resections.

Discussion

In this large national cohort from the Polish Salivary Gland Network Database (n = 2,246), bilaterality and multifocality emerged as related but distinct clinical phenotypes of salivary gland tumours.

These patterns were more common among men and strongly associated with smoking and parotid gland location.

Our findings align with previous epidemiologic studies of Warthin tumour, which frequently demonstrates multifocal and bilateral behaviour.

Radiation exposure showed a moderate association with multifocal disease.

The absence of diagnostic differences between imaging modalities suggests that careful clinical evaluation and histopathologic confirmation remain essential.

Multifocality and satellite foci were associated with non-radical resections, highlighting the surgical importance of recognising these patterns preoperatively.

Limitations

This study has several limitations. The retrospective design may introduce selection bias. Exposure data —particularly regarding mobile phone use—were incomplete for a substantial proportion of patients. Registry-based analyses may also reflect referral patterns across participating centres.

Conclusions

Bilaterality and multifocality represent related but biologically distinct manifestations of salivary gland tumours.

In this national cohort, they were associated with male sex, parotid location, tumour size, facial nerve paresis, and smoking.

Multifocality and satellite foci were most strongly associated with non-radical resections.

Future studies should incorporate standardized radiologic and pathologic protocols and longitudinal follow-up to improve risk stratification and surgical planning.

Declarations

Funding:

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Competing Interests:

The authors declare that they have no competing interests.

Ethics Approval:

This study was conducted in accordance with the Declaration of Helsinki and approved by the Bioethics Committee in Wrocław (approval number: 04/BNBO/2023, approved on 11 October 2023).

Consent to Participate:

The requirement for informed consent was waived due to the retrospective nature of the study.

Consent for Publication:

Not applicable.

Data Availability:

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Author Contribution

Conceptualization: M.W.Data curation: B.M., P.B., K.R., D.M., J.M.Funding acquisition: J.M.Investigation: B.M., P.B., K.R., D.M., J.M., H.K.Methodology: B.M., P.B., K.R., D.M., J.M., H.K.Project administration: B.M., P.B., K.R., D.M., J.M.Resources: W.P., M.W.Supervision: M.W., J.M.Validation: W.P., M.W.Visualization: J.M., W.P.Writing – original draft: W.P., M.W.Writing – review and editing: All authors.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Tables

Table 1. The histological findings in the study cohort.

HP	Bilateral tumors	Multifocal tumors	Satellite tumors
Acinic cell carcinoma	0	0	1
Adenoid cystic carcinoma	0	1	2
Basal cell adenocarcinoma	0	1	1
Basal cell adenoma	3	5	3
Carcinoma ex pleomorphic adenoma	0	1	3
Diffuse large B-cell lymphoma	2	5	0
Epithelial-myoepithelial carcinoma	0	0	1
Melanoma malignum	0	1	0
Mucoepidermoid carcinoma	0	1	0
Myoepithelioma	1	2	4
Oncocytoma	2	2	2
Pleomorphic adenoma	16	60	82
Squamous cell carcinoma	0	1	0
Warthin tumour	154	177	22
Total	178	257	121

Table 2. Histopathological diagnoses categorized according to the scheme

HP Category	Bilateral tumors	Multifocal tumors	Satellite tumors
I	16	60	82
II	154	177	22
III	6	9	9
IV	2	11	8
Total	178	257	121

Table 3. The occurrence of bilateral multifocal salivary gland tumours, and the presence of satellite foci, in relation to demographic and clinical variables

Sex	Bilateral tumours		Multifocal tumours		Satellite tumours	
	Yes	No	Yes	No	Yes	No
Female	**74**	1217	**121**	1178	72	1216
	(103.2)	(1187.8)	(150)	(1149)	(73)	(1215)
Male	**115**	958	**154**	929	62	1014
	(85.8)	(987.2)	(125)	(958)	(61)	(1015)
Test χ^2	χ^2	p	χ^2	p	χ^2	p
	19.129	**<0.001**	13.438	**<0.001**	0.008	0.928
Tumour location	Bilateral tumours		Multifocal tumours		Satellite tumours	
	Yes	No	Yes	No	Yes	No
PG	184	1970	265	1906	123	2030
	(172.4)	(1981.6)	(251)	(1920)	(122.2)	(2030.8)
APG	4	77	9	73	6	76
	(6.5)	(74.5)	(9.5)	(72.5)	(4.7)	(77.3)
SG	**1**	125	**1**	125	5	121
	(10.1)	(115.9)	(14.6)	(111.4)	(7.2)	(118.8)
Test χ^2	χ^2	p	χ^2	p	χ^2	p
	10.776	**0.005**	15.201	**0.001**	1.104	0.576
Primary tumour size	Bilateral tumours		Multifocal tumours		Satellite tumours	
	Yes	No	Yes	No	Yes	No
<2 cm	44	635	59	624	30	647
	(54.9)	(624.1)	(76.5)	(606.5)	(38.7)	(638.3)
2-4 cm	104	1187	144	1158	76	1214
	(104.4)	(1186.6)	(145.8)	(1156.2)	(73.7)	(1216.3)
>4 cm	**39**	303	**58**	287	26	319
	(27.7)	(314.3)	(38.6)	(306.4)	(19.7)	(325.3)
Test χ^2	χ^2	p	χ^2	p	χ^2	p
	7.42	**0.024**	15.453	**<0.001**	4.272	0.118

Sex	Bilateral tumours		Multifocal tumours		Satellite tumours	
	Yes	No	Yes	No	Yes	No
Facial nerve paresis	Bilateral tumours		Multifocal tumours		Satellite tumours	
	Yes	No	Yes	No	Yes	No
Yes	**1**	323	**9**	315	**7**	317
	(25.8)	(298.2)	(35)	(289)	(17.4)	(306.6)
No	**183**	1804	241	1749	117	1865
	(158.2)	(1828.8)	(215)	(1775)	(106.6)	(1875.4)
Test χ^2	χ^2	p	χ^2	p	χ^2	p
	28.918	**<0.001**	24.225	**<0.001**	6.948	**0.008**

Table 4. The occurrence of bilateral multifocal salivary gland tumours, and the presence of satellite foci, in relation to environmental variables.

Tobacco use	Bilateral tumors		Multifocal tumors		Satellite tumors	
	Yes	No	Yes	No	Yes	No
Yes	**100**	627	**118**	608	34	690
	(65.6)	(661.4)	(84.9)	(641.1)	(37.6)	(686.4)
No	**43**	814	**67**	789	48	808
	(77.4)	(779.6)	(100.1)	(755.9)	(44.4)	(811.6)
Test χ^2	χ^2	p	χ^2	p	χ^2	p
	35.508	**<0.001**	26.2	**<0.001**	0.49	0.484
Alcohol use	Bilateral tumors		Multifocal tumors		Satellite tumors	
	Yes	No	Yes	No	Yes	No
Yes	4	40	5	39	3	41
	(3.9)	(40.1)	(5)	(39)	(2.3)	(41.7)
No	133	1385	173	1343	79	1435
	(133.1)	(1384.9)	(173)	(1343)	(79.7)	(1434.3)
Test χ^2	χ^2	p	χ^2	p	χ^2	p
	0.038	0.846	0.053	0.818	0.016	0.900
Use of mobile phone (years)	Bilateral tumors		Multifocal tumors		Satellite tumors	
	Yes	No	Yes	No	Yes	No
>5	82	815	90	805	56	837
	(81.8)	(815.2)	(90.7)	(804.3)	(59.1)	(833.9)
1-5	1	12	2	11	**4**	9
	(1.2)	(11.8)	(1.3)	(11.7)	(0.9)	(12.1)
Test χ^2	χ^2	p	χ^2	p	χ^2	p
	0.093	0.760	0.029	0.866	8.790	**0.003**
Exposure to chemical substances	Bilateral tumors		Multifocal tumors		Satellite tumors	
	Yes	No	Yes	No	Yes	No
Yes	6	81	7	80	8	79
	(7.9)	(79.1)	(9)	(78)	(5.8)	(81.2)

No	89	868	101	854	61	892
	(87.1)	(869.9)	(99)	(856)	(63.2)	(889.8)
Test χ^2	χ^2	p	χ^2	p	χ^2	p
	0.304	0.581	0.311	0.577	0.605	0.437
Exposure to radiation	Bilateral tumors		Multifocal tumors		Satellite tumors	
	Yes	No	Yes	No	Yes	No
Yes	29	244	38	235	25	248
	(24.8)	(248.2)	(28.3)	(244.7)	(18.1)	(254.9)
No	66	706	70	700	44	724
	(70.2)	(701.8)	(79.7)	(690.3)	(50.9)	(717.1)
Test χ^2	χ^2	p	χ^2	p	χ^2	p
	0.813	0.367	4.555	**0.033**	3.291	0.070

Table 5. Summary of significant associations with bilateral, multifocal, and satellite salivary gland tumours

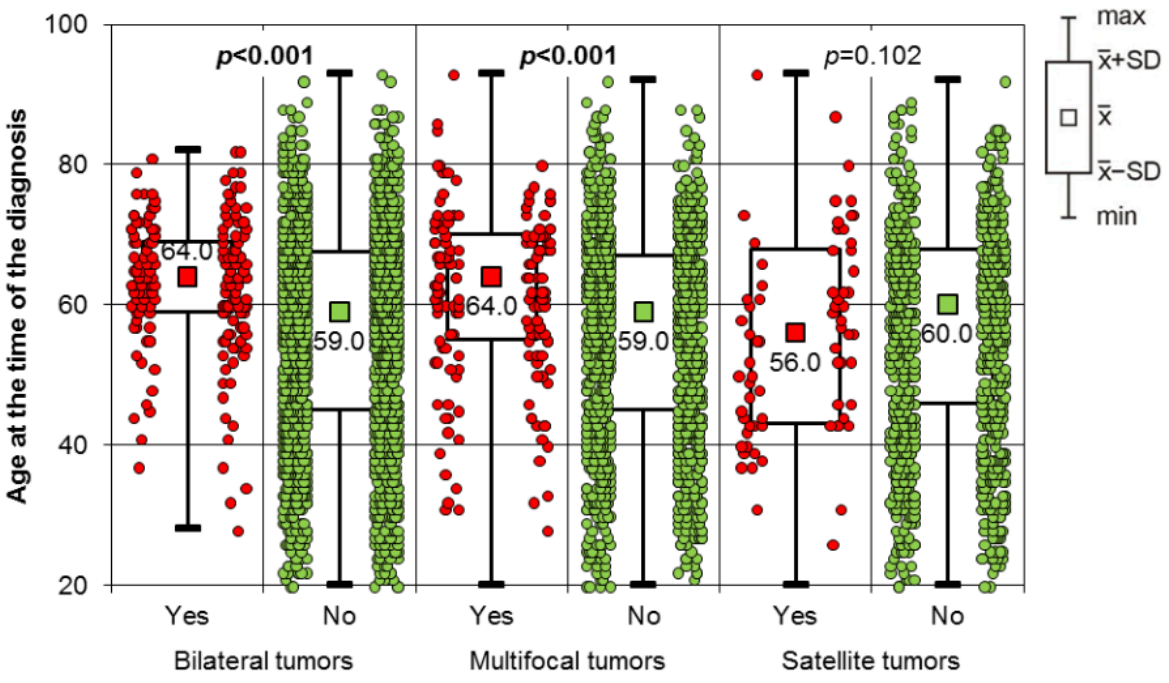
Variable	Bilateral	Multifocal	Satellite foci
Sex (male)	↑ p<0.001	↑ p<0.001	–
Tumour site (PG)	↑ p=0.005	↑ p=0.001	–
Tumour size >4 cm	↑ p=0.024	↑ p<0.001	–
Paresis	↑ p<0.001	↑ p<0.001	↑ p=0.008
Imaging (USG/CT/MRI)	–	–	–
BAC cytology	–	–	–
Smoking	↑ p<0.001	↑ p<0.001	–
Alcohol use	–	–	–
Mobile phone	–	↑ p=0.001	↑ p=0.003
Chemical exposure	–	–	–
Radiation exposure	–	↑ p=0.033	–
Margins (non-R0)	–	↑ p<0.001	↑ p<0.001
Residence (non-urban)	↑ p=0.036	↑ p=0.010	–
Histology (malignant)	↓ p=0.003	–	–

↑ significant positive association; ↓ lower frequency; – no association.

Table 6. Results of the chi-square test of independence assessing the statistical significance of the association between the use of ultrasonography, computed tomography, and magnetic resonance imaging and the selected characteristics of salivary gland tumors

USG	Bilateral tumors		Multifocal tumors		Satellite tumors	
	Yes	No	Yes	No	Yes	No
Yes	180	2007	261	1942	125	2060
	(173.5)	(2013.5)	(253.8)	(1949.2)	(124)	(2061)
No	6	152	11	147	8	150
	(12.5)	(145.5)	(18.2)	(139.8)	(9)	(149)
Test χ^2	χ^2	p	χ^2	p	χ^2	p
	3.381	0.066	2.989	0.084	0.028	0.867
CT	Bilateral tumors		Multifocal tumors		Satellite tumors	
	Yes	No	Yes	No	Yes	No
Yes	29	364	47	346	19	374
	(31.2)	(361.8)	(45.3)	(347.7)	(22.3)	(370.7)
No	157	1795	225	1743	114	1836
	(154.8)	(1797.2)	(226.7)	(1741.3)	(110.7)	(1839.3)
Test χ^2	χ^2	p	χ^2	p	χ^2	p
	0.117	0.732	0.045	0.832	0.45	0.502
MRI	Bilateral tumors		Multifocal tumors		Satellite tumors	
	Yes	No	Yes	No	Yes	No
Yes	66	796	100	762	49	810
	(68.4)	(793.6)	(99.3)	(762.7)	(48.8)	(810.2)
No	120	1363	172	1327	84	1400
	(117.6)	(1365.4)	(172.7)	(1326.3)	(84.2)	(1399.8)
Test χ^2	χ^2	p	χ^2	p	χ^2	p
	0.088	0.767	0.001	0.979	0.002	0.961

Figures



Mean	63.1	56.3	61.9	56.2	55.5	56.9
SD	9.4	14.8	11.7	14.7	14.7	14.5
p_{SW}	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.098	**<0.001**

Figure 1. Relationship between the occurrence of bilateral tumors, multifocal lesions, and satellite foci with patient age.

Figure 1

See image above for figure legend.