Salivary duct carcinoma with heterotopic ossification in the parotid gland: A case report

YUTARO FUKUMA[1,2], MITSUAKI ISHIDA[1,2], AKINORI SASAKI[1,2], TSUYOSHI JINNIN[3], TETSUYA TERADA[3], SHIN-ICHI HAGINOMORI[3] and YOSHINOBU HIROSE[1,2]

[1]Department of Pathology, Osaka Medical and Pharmaceutical University, Takatsuki, Osaka 569-8686, Japan; [2]Division of Pathology, Osaka Medical and Pharmaceutical University Hospital, Takatsuki, Osaka 569-8686, Japan; [3]Department of Otolaryngology and Head and Neck Surgery, Osaka Medical and Pharmaceutical University Hospital, Takatsuki, Osaka 569-8686, Japan

Received February 3, 2026; Accepted June 9, 2026

DOI: 10.3892/ol.2026.15718

Abstract. Salivary duct carcinoma (SDC) is one of the most aggressive salivary gland carcinomas. Heterotopic ossification (HO) is the formation of mature bone in non-skeletal tissues. HO can occur in a number of neoplastic lesions. However, its occurrence is markedly rare in salivary gland neoplasms and to the best of our knowledge, SDC with HO has not yet been reported. Therefore, the present report describes the first reported case of SDC with HO in the parotid gland and reviews the clinicopathological features of salivary gland neoplasms with HO. A 38-year-old Japanese male presented with a mass in the left parotid region. Physical examination revealed a poorly mobile mass, measuring 2 cm, in the left parotid gland. Total left parotidectomy was performed. A number of metastases were observed in the bone and brain, despite postoperative anti-HER2 combination chemotherapy. Histopathological examination of the resected parotid gland tumour revealed invasive neoplastic growth comprising cribriform and papillary proliferations. These neoplastic cells exhibited a rich eosinophilic cytoplasm and large nuclei containing conspicuous nucleoli. In addition, the present report outlines peculiar finding in the presence of mature bone tissue within the tumour. Accordingly, a diagnosis of SDC with HO was made. Despite the detailed mechanisms underlying the occurrence of HO in salivary gland neoplasms remaining unclear, neoplastic myoepithelial cells may serve a role in the development of HO in pleomorphic adenoma and carcinoma ex pleomorphic adenoma. However, SDC exhibited no myoepithelial cell components, therefore the mechanism of HO in SDC may differ from that in PA.

Correspondence to: Dr Mitsuaki Ishida, Department of Pathology, Osaka Medical and Pharmaceutical University, 2-7 Daigakumachi, Takatsuki, Osaka 569-8686, Japan
E-mail: mitsuaki.ishida@ompu.ac.jp

Abbreviations: AR, androgen receptor; BMP, bone morphogenetic protein; CXPA, carcinoma ex pleomorphic adenoma; HO, heterotopic ossification; MEC, mucoepidermoid carcinoma; PA, pleomorphic adenoma; RUNX2, runt-related transcription factor 2; SDC, salivary duct carcinoma

Key words: salivary duct carcinoma, heterotopic ossification, salivary gland, parotid gland, case report

Introduction

Salivary duct carcinoma (SDC) is one of the most aggressive carcinomas of the salivary gland owing to frequent local recurrence and distant metastases (1). This type of carcinoma typically resembles mammary ductal carcinoma, with an apocrine phenotype (1). SDC comprises 5-10% of all salivary gland malignancies. This aggressive carcinoma commonly affects middle-aged or elderly individuals, with typical sites including the major salivary glands, particularly the parotid glands (1). Histopathologically, SDC is characterised by the solid, cribriform and/or papillary proliferation of carcinoma cells with a rich eosinophilic cytoplasm, large pleomorphic nuclei and prominent nucleoli (1). Preexisting pleomorphic adenomas (PAs) may also be present (1). Immunohistochemically, SDC frequently exhibits positive immunoreactivity for the androgen receptor (AR), which indicates an apocrine phenotype. HER2 upregulation has also been noted in an estimated one-third of cases (1).

Heterotopic ossification (HO) is defined as the formation of mature bone tissue in non-skeletal tissues (2,3). Intra- or peri-tumoural HO has been reported in a number of benign and malignant neoplasms (3-8). The prevalent histological type accompanying HO is papillary thyroid carcinoma and its presence has also been described in melanocytic naevi (the skin condition Osteonevus of Nanta), a number of pancreatic neoplasms and colorectal tumours (3-8). Although markedly rare, HO has been reported to occur in benign and malignant salivary gland neoplasms [including mucoepidermoid carcinoma (MEC) (9-11), carcinoma ex pleomorphic adenoma (CXPA) (12-14) and PA (15-25)]. However, to the best of our knowledge, the occurrence of HO in SDC has not yet been reported in the English literature. Therefore the present report describes the first reported case of SDC with HO in the parotid

gland and reviews the clinicopathological features of salivary gland neoplasms with HO.

Case report

A 38-year-old Japanese male initially experienced left-sided facial pain during mastication in January 2018. The patient developed a mass in the left parotid region and, 2 months later, left-sided facial paralysis and trismus in April 2018. Based on the results of the physical examination and magnetic resonance imaging at the medical institution that he first visited, the patient was suspected of having left parotid gland carcinoma, given that a tender mass was present in the parotid gland and the patient developed facial paralysis. The patient was then referred to the Department of Otolaryngology and Head and Neck Surgery, Osaka Medical and Pharmaceutical University Hospital (Takatsuki, Japan) in August 2018. Upon physical examination, a poorly mobile and tender mass measuring ~2 cm in diameter was palpated in the left parotid region. A contrast-enhanced CT scan indicated the presence of a parotid gland carcinoma (Fig. 1A). A total left parotidectomy with left upper neck lymph node dissection was performed in August 2018. The postoperative course was uneventful.

In October 2018, post-operative radiation therapy to the left parotid gland region was performed (66 Gy in 33 fractions) and no local recurrence was observed. In August 2019, an MRI scan revealed metastatic lesions in the lumbar spine and pelvis (Fig. 1B). Needle biopsy of the iliac bone determined bone metastasis and palliative radiotherapy (30 Gy in 10 fractions) was initiated. In October 2019, anti-HER2 combination chemotherapy [trastuzumab (4 mg/kg), paclitaxel (80 mg/m^2) and carboplatin (270 mg)] was administered. After the second course, leukopenia developed; thus, combination therapy was discontinued. From November 2019 to May 2022, trastuzumab monotherapy (2 mg/kg once a week or once every 2 weeks) was administered. In May 2021, the patient developed epileptic seizures, with a PET scan suggesting brain metastasis (Fig. 1C). Therefore, the patient underwent Gamma Knife radiosurgery (42 Gy in 10 fractions). In January 2022, reduced fluorodeoxyglucose uptake was noted in the brain metastatic lesions (Fig. 1D), suggesting partial response to the Gamma Knife therapy. However, fluorodeoxyglucose uptake in the brain metastatic lesions was shown to be increased in January 2023 (Fig. 1E). Therefore, additional Gamma Knife radiosurgery was performed in June 2023 (37 Gy in 10 fractions). An MRI performed in September 2023 showed a reduction in the size of the brain metastatic lesions (Fig. 1F). In June 2024, the patient was once again admitted to the Department of Neurosurgery, Osaka Medical and Pharmaceutical University Hospital (Takatsuki, Japan) with worsening cerebral oedema and signs of brain herniation due to a number of cerebral metastases (Fig. 1G). Surgical resection of the brain tumour was performed in the right frontal lobe and whole-brain radiotherapy was performed for disease control (30 Gy in 10 fractions) in July 2024. No obvious residual tumour was noted in the surgical site; however, a new metastatic lesion was observed (Fig. 1H). The patient was transferred to the palliative care unit at another hospital in January 2025 (6 years and 5 months after the initial surgery) as his overall health condition deteriorated and he could not withstand further treatment. No information regarding the status of the patient was available due to loss of follow-up since the transfer to another hospital. The aforementioned treatments were performed according to guidelines from the National Comprehensive Cancer Network (https://jnccn.org/).

With regard to histopathological characteristics, surgically resected specimens of the left parotid gland revealed invasive neoplastic growth into the surrounding nonneoplastic parotid gland tissue. The tumour exhibited cribriform and papillary proliferation with comedo-type necrosis (Fig. 2A). These large neoplastic cells were polygonal in shape and exhibited abundant eosinophilic cytoplasm and large round to oval nuclei with conspicuous nucleoli (Fig. 2B). Lymphovascular and perineural invasion was also observed. In addition, one peculiar finding was the presence of intra- and peri-tumoural bone formation at the peripheral region of the tumour, with the bone tissues being surrounded by carcinoma nests (Fig. 2A). Osteoblasts, lacking nuclear atypia, lined the periphery of the lamella bone and the bone marrow was absent. No cartilaginous tissue was observed. Histopathological evidence of the presence of PA, such as chondromyxoid stroma and neoplastic myoepithelial cells without nuclear atypia, was not detected. In addition, no sarcomatous component was present and no lymph node metastasis was noted. Accordingly, SDC with HO (pT3N0M0) was diagnosed at the time of the diagnosis of the parotid gland tumour (in August 2018).

The needle-biopsy specimen of the iliac bone demonstrated presence of carcinoma cells having rich eosinophilic cytoplasm and large nuclei, which was consistent with metastatic SDC (Fig. 2C). The resected specimen of the brain metastasis relatively exhibited the same histopathological features as the parotid gland tumour. Cribriform or solid proliferation of neoplastic cells with rich eosinophilic cytoplasm and large nuclei in a background of abundant necrotic material was observed (Fig. 2D). Immunohistochemical analyses were performed using a Ventana BenchMark ULTRA autostainer (Roche Diagnostics). In addition, the Ventana *ultra*View Universal DAB Detection Kit (cat. no. 760-500; Roche Diagnostics), including the secondary antibody, was used. Briefly, resected specimens were fixed in 10% buffered neutral formalin at room temperature for 24 h, dehydrated in ethanol and xylene at room temperature and embedded in paraffin. The 4-μm tissue sections were used for immunostaining with a rabbit monoclonal antibody against AR (clone: SP107; cat. no. 760-4605; ready-to-use; Roche Diagnostics) and a rabbit monoclonal antibody against HER2 (clone: 4B5; cat. no. 790-2991; ready-to-use; Roche Diagnostics). Tissue sections were incubated with primary antibodies for 16 min (AR) or 10 min (HER2) at 36˚C, with the secondary antibody (pre-diluted) for 8 min at 36˚C and underwent haematoxylin counterstaining for 4 min at 36˚C. A light microscope (BX51; Olympus Corporation) was used to visualise the immunohistochemical staining. Immunohistochemical analysis of the parotid gland tumour showed that AR was expressed in the nuclei of the carcinoma cells (Fig. 2E). Diffuse membrane HER2 upregulation was also observed in these carcinoma cells (Fig. 2F). These features were typical for SDC (1).

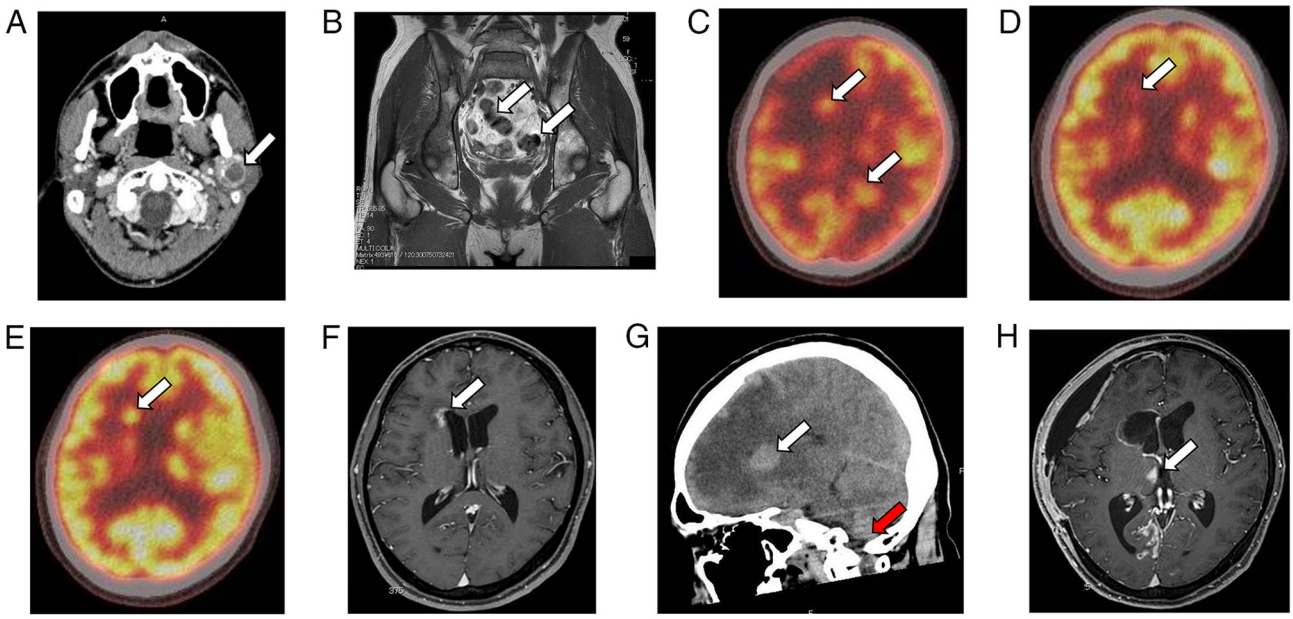

Figure 1. Imaging findings. (A) Contrast-enhanced CT revealing the presence of an ill-defined and irregularly shaped mass predominantly involving the deep lobe of the left parotid gland (arrow). (B) MRI scan showing metastatic lesions in the iliac bone (arrows). (C) PET scan demonstrating metastatic lesions in the brain (arrows). (D) PET scan showing reduced fluorodeoxyglucose uptake in the metastatic lesion in the brain (arrow). (E) PET scan demonstrating increased fluorodeoxyglucose uptake in the metastatic lesion in the brain (arrow). (F) MRI scan showing the reduction in size of the metastatic lesion in the brain (arrow). (G) CT scan showing brain oedema around the metastatic tumour (white arrow) and brain herniation (red arrow). (H) MRI scan demonstrating no obvious tumorous lesion in the surgical site, but a new metastatic lesion present in the brain (arrow).

Discussion

To the best of our knowledge, the present report is the first case in the literature to describe SDC with HO in the parotid gland. A total of only 18 patients with salivary gland neoplasms and HO [3 patients with MEC and CXPA, 11 patients with PA, and 1 patient with SDC (the present patient)] have been reported in the English-language literature (Table I) (9-25). Table I summarises the clinicopathological features of salivary gland neoplasms with HO. The predominant histological type of salivary gland neoplasm with HO was PA, followed by CXPA and MEC (Table I). CXPA is defined as the occurrence of carcinoma, frequently SDC and myoepithelial carcinoma, arising from a pre-existing PA. Furthermore, ~80% of salivary gland neoplasms with HO are PA or associated neoplasms (Table I). Despite 1 case having reported that three of 19 intraoral PAs harbour osseous components, detailed clinicopathological information was unavailable (26). Therefore, these 3 PA cases were excluded from the present review. In addition, minor salivary glands, including those present in the lip, may show a high frequency of HO in PA, given that 5 of 11 PA with HO cases were from the lip or buccal mucosa (Table I), consistent with the results of the aforementioned report (26). Despite SDC being one of the common carcinoma components of CXPA, neither PA nor sarcomatous component was detected in the present parotid gland tumour. Therefore, the diagnosis of SDC with HO was made.

Although the detailed mechanism of HO development in salivary gland neoplasms has not been clarified, a number of hypotheses have been proposed (19). Firstly, neoplastic myoepithelial cells, one of the main neoplastic components of PA, as well as ductal cells, serve an important role in the development of HO in PA (19). Neoplastic myoepithelial cells may serve as a source of bone-forming cells given that they express osteoblastic marker, such as runt-related transcription factor 2 (RUNX2) (19). An additional hypothesis is endochondral ossification given that 70% (7 of 10) PAs exhibited cartilaginous tissue surrounding the HO (Table I). The pre-existing PA component may be associated with the presence of HO in CXPA given that 2 of 3 CXPAs exhibited cartilaginous tissue surrounding the HO (13,14). In addition, one CXPA had collagenous stroma surrounding the HO without cartilaginous tissue; rich stroma may be associated with the presence of HO given that rich fibrous stroma is frequently observed in HO in colorectal adenocarcinoma and mesenchymal cells within rich fibrous stroma could provide a bone-forming niche (26). MEC is a common salivary gland carcinoma characterised by the presence of mucus and intermediate and squamoid carcinoma cells that form cystic and solid growth patterns (27). As well as SDC, MEC exhibits no neoplastic myoepithelial cells or cartilaginous components. Therefore, HO in MEC and SDC is not associated with neoplastic myoepithelial cells or cartilaginous tissues, as speculated for PA. Therefore, the mechanisms underlying the development of HO in patients with PA (including CXPA), MEC and SDC may differ.

Furthermore, it is necessary to determine whether presence of HO in malignant salivary gland tumours affects the prognosis, although its presence has not been associated with prognosis in patients with papillary carcinoma of the thyroid (8). However, only one SDC and three MEC have been

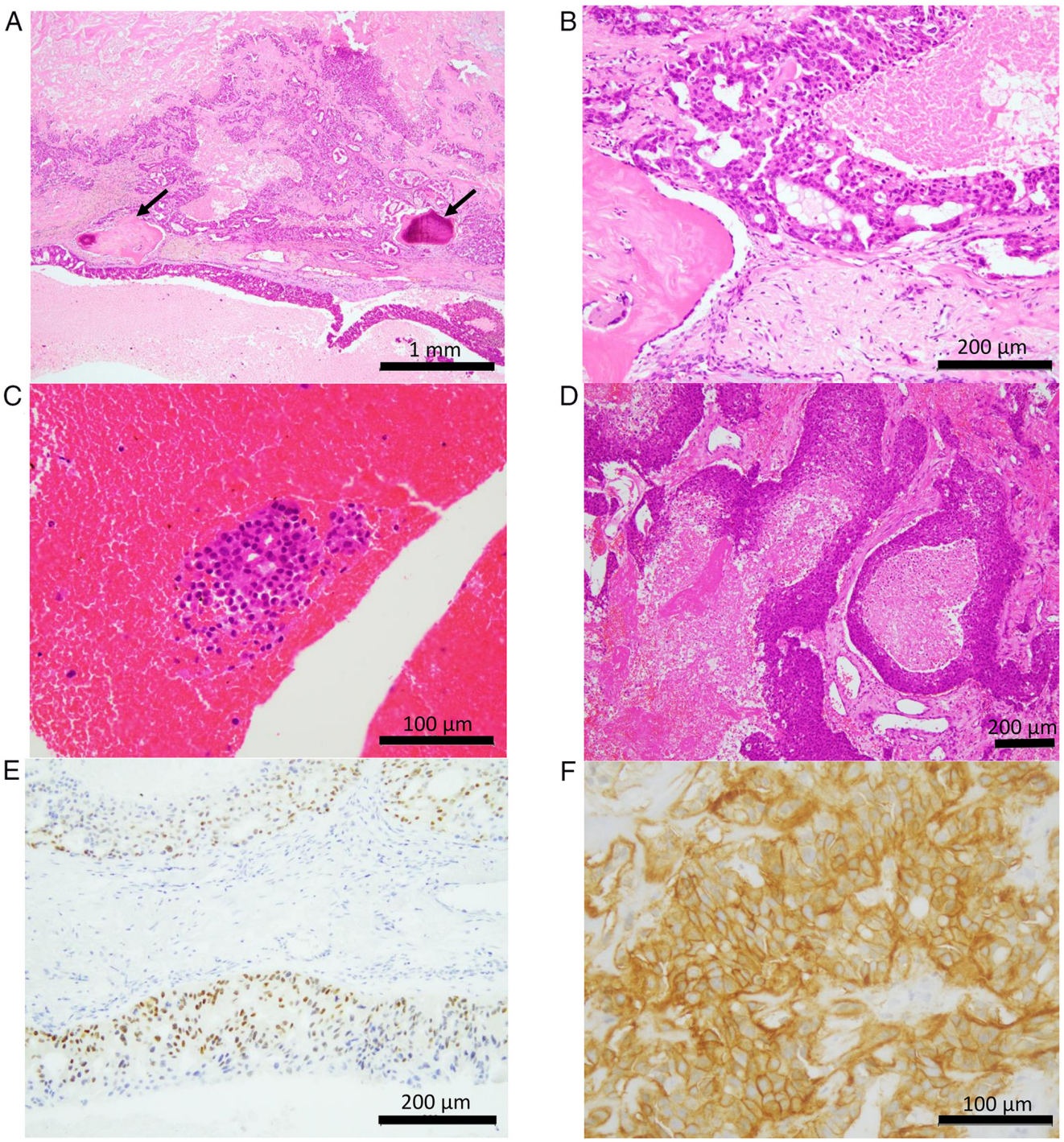

Figure 2. Histopathological and immunohistochemical features of parotid gland and metastatic iliac bone and brain tumours. (A) Parotid gland tumour. Cribriform proliferation of carcinoma with central necrosis is noted. Heterotopic ossification within the tumour is observed (arrows) (H&E staining; magnification, x40). (B) Carcinoma cells exhibit rich eosinophilic cytoplasm and large round to oval nuclei with conspicuous nucleoli. Heterotopic ossification with osteoblasts in the outer face is observed around the carcinoma nests (H&E staining; magnification, x200). (C) Metastatic iliac bone lesion. Presence of a cluster of carcinoma cells exhibiting a rich eosinophilic cytoplasm, with a large nuclei shown (H&E staining; magnification, x400). (D) Metastatic brain tumour. Proliferation of carcinoma cells with rich eosinophilic cytoplasm and large nuclei is noted in a rich necrotic background (H&E staining; magnification, x100). (E) Positive immunoreactivity for androgen receptor is noted in the nuclei of carcinoma cells (magnification, x200). (F) Diffuse membranous HER2 observed in carcinoma cells (magnification, x400).

reported in the English-language literature (9-11), therefore, the prognostic importance of HO presence cannot be determined. Accumulation of the clinicopathological data of malignant salivary gland tumours with HO is thus required for resolving this issue. In addition, the patient was young for SDC, however the association between the age and clinical aggressiveness of the patient or presence of HO remains unclear due to the rarity of HO in SDC.

Bone morphogenic proteins (BMPs), members of the TGF-β superfamily, have been recognised as inductive factors for osteogenesis and BMP2 is a major inducer of HO (28). Higher immunohistochemical expression of BMP2 has been noted in

Table I. Clinicopathological features of salivary gland neoplasms with heterotopic ossification.

First author, year	Case no.	Age	Sex	Location	Histological type	Cartilaginous tissue	(Refs.)
Present case	1	38	Male	Parotid	Salivary duct carcinoma	Absent	Present case
Yamao *et al*, 2025	2	78	Female	Sublingual	Mucoepidermoid carcinoma	NA	(9)
Wolf *et al*, 2021	3	48	Female	Sublingual	Mucoepidermoid carcinoma	NA	(10)
Maruse *et al*, 2015	4	75	Female	Sublingual	Mucoepidermoid carcinoma	NA	(11)
Rauso *et al*, 2019	5	50	Male	Parotid	CXPA (histology NA)	NA	(12)
Mohan *et al*, 2015	6	76	Male	Parotid	CXPA (non-invasive)	Present	(13)
Spencer *et al*, 1991	7	83	Female	Parotid	CXPA (poorly differentiated)	Present	(14)
Gubod *et al*, 2022	8	32	Female	Parotid	Pleomorphic adenoma	Present	(15)
Pérez-De-Oliveira *et al*, 2020	9	73	Female	Lip	Pleomorphic adenoma	Absent	(16)
Mandal *et al*, 2008	10	27	Male	Buccal mucosa	Pleomorphic adenoma	Present	(17)
Kato *et al*, 2007	11	38	Female	Parotid	Pleomorphic adenoma	Present	(18)
Nakano *et al*, 2007	12	34	Male	Lip	Pleomorphic adenoma	NA	(19)
Xu *et al*, 2003	13	36	Female	Submandibular	Pleomorphic adenoma	Present	(20)
Shigeishi *et al*, 2001	14	58	Male	Parotid	Pleomorphic adenoma	Present	(21)
Hamakawa *et al*, 1997	15	53	Female	Lip	Pleomorphic adenoma	Present	(22)
Takeda and Yamamoto, 1996	16	44	Female	Lip	Pleomorphic adenoma	Absent	(23)
Lee *et al*, 1992	17	21	Male	Maxillary sinus	Pleomorphic adenoma	Absent	(24)
Yates and Paget, 1952	18	21	Male	Submandibular	Pleomorphic adenoma	Present	(25)

CXPA, carcinoma ex pleomorphic adenoma; NA, not available.

tumours and/or stromal cells surrounding HO in colorectal tumours (5). The BMP2 signalling pathway induces the expression of RUNX2, a master regulator of osteoblastic differentiation from mesenchymal stem cells, leading to the differentiation of osteoprogenitor cells into osteoblasts (5,28,29). Neoplastic myoepithelial cells surrounding HO in PA exhibit positive immunoreactivity for RUNX2, indicating their important role in the development of HO (19). Expression analysis of these osteogenic molecules in the present specific SDC case with HO was not performed. Therefore, molecular analyses are required to further elucidate the molecular mechanisms underlying HO in salivary gland neoplasms.

In conclusion, to the best of our knowledge, the present report described the first reported case of SDC with HO in the salivary gland and reviewed the clinicopathological features of benign and malignant salivary gland neoplasms with HO. It is important to recognize that HO can occur in SDC and not to misunderstand that its presence is almost exclusively found in PA in diagnostic practice of the salivary gland tumour. The detailed mechanism of HO in salivary gland neoplasms remains unclear and its mechanism in SDC may differ from that in PA, although the present single case does provide sufficient evidence. Further molecular analyses are thus required to clarify the mechanism of development of HO in salivary gland neoplasms.

Acknowledgements

Not applicable.

Funding

No funding was received.

Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

MI conceived and designed the present study. YF, MI and AS analysed the histological and immunohistochemical features. YF and MI confirm the authenticity of all the raw data. YF, MI, AS, TJ, TT, SIH and YH contributed to data collection and analysis. YF and MI wrote the manuscript and prepared figures and tables. All authors read and approved the final version of the manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Written consent for the publication of patient data and associated images was obtained from the patient.

Competing interests

The authors declare that they have no competing interests.

References

1. Chiosea S, Agaimy A, Hellquist H, Nagao T, Simpson RHW and van Herpen CML: Salivary duct carcinoma. In: WHO Classification of Tumours, Skin Tumours. 5th edition. IARC, Lyon, pp225-227, 2024.
2. Meyers C, Lisiecki J, Miller S, Levin A, Fayad L, Ding C, Sono T, McCarthy E, Levi B and James AW: Heterotopic ossification: A comprehensive review. JBMR Plus 3: e10172, 2019.
3. Liu K, Tripp S and Layfield LJ: Heterotopic ossification: Review of histologic findings and tissue distribution in a 10-year experience. Pathol Res Pract 203: 633-640, 2007.
4. Fukuma Y, Ishida M, Yasuda E, Nakanishi K, Kushiyama S, Tomioka A, Asakuma M and Hirose Y: Ossification in pancreatic neoplasms: A report of three cases of neuroendocrine tumor, mucinous cystic neoplasm, and intraductal papillary mucinous neoplasm with review of the literature. Biomed Rep 24: 10, 2025.
5. Vos AM, Pijnenborg L, van Vliet S, Kodach LL, Ciompi F, van der Post RS, Simmer F and Nagtegaal ID: Biological background of colorectal polyps and carcinomas with heterotopic ossification: A national study and literature review. Hum Pathol 145: 34-41, 2024.
6. Bezić J, Karaman I, Zekić Tomaš S, Živković PM and Božić J: Osteonevus of Nanta revisited: Clinicopathological features of 33 cases. Am J Dermatopathol 38: 859-861, 2016.
7. Ishida M, Iwai M, Kagotani A, Iwamoto N and Okabe H: Epidermal cyst of the skin with ossification: Report of two cases. Int J Clin Exp Pathol 7: 1823-1825, 2014.
8. Bai Y, Zhou G, Nakamura M, Ozaki T, Mori I, Taniguchi E, Miyauchi A, Ito Y and Kakudo K: Survival impact of psammoma body, stromal calcification, and bone formation in papillary thyroid carcinoma. Mod Pathol 22: 887-894, 2009.
9. Yamao N, Shimamoto H, Munshi MZ, Nishimura DA, Takagawa N, Assapattarapun V, Hirose K, Oya K, Uchihashi T, Kreiborg S, *et al*: Imaging diagnosis of mucoepidermoid carcinoma with intratumoral bone formation: A case report. Oral Radiol 42: 460-466, 2025.
10. Wolf B, Roth S, Fantasia J and Nannini V: 'Ossifying' mucoepidermoid carcinoma: A deceptive clinical presentation. Oral Surg Oral Med Oral Pathol Oral Radiol 131: 217-220, 2021.
11. Maruse Y, Kawano S, Kiyoshima T, Goto Y, Matsubara R, Chikui T, Yoshiga D and Nakamura S: Case of mucoepidermoid carcinoma of the sublingual gland accompanied with extensive dystrophic calcification and intratumoral bone formation. Head Neck 37: E161-E164, 2015.
12. Rauso R, Colella G, Franco R, Ronchi A and Chirico F: Ossified carcinoma ex pleomorphic adenoma in accessory lobe of parotid gland: Complexity in clinical, imaging and histologic diagnosis and minimally invasive surgery. Oral Oncol 92: 95-98, 2019.
13. Mohan S, Puram SV, Yarlagadda B, Nosé V and Deschler DG: Ossifying parotid carcinoma ex pleomorphic adenoma. Case Rep Otolaryngol 2015: 395358, 2015.
14. Spencer J, Mason A and Denton K: Ossifying parotid carcinoma ex pleomorphic adenoma: CT findings. J Comput Assist Tomogr 15: 516-518, 1991.
15. Gubod ER, Ramanathan A, Chong Mei Yee S and Tilakaratne WM: Bone formation in pleomorphic adenoma: A case report. Cureus 14: e22868, 2022.
16. Pérez-De-Oliveira ME, Leite AA, de Lima Morais TM, Lopes MA, de Almeida OP and Vargas PA: Intraoral pleomorphic adenoma with extensive bone formation. Int J Surg Pathol 28: 410-411, 2020.
17. Mandal S, Dhingra K, Roy S and Khurana N: Extensive bone with marrow formation in pleomorphic adenoma. Report of a case. ANZ J Surg 78: 323-324, 2008.
18. Kato H, Kanematsu M, Ando K, Mizuta K, Ito Y, Hirose Y and Hoshi H: Ossifying pleomorphic adenoma of the parotid gland: A case report and review. Australas Radiol 51 (Suppl 1): B173-B175, 2007.
19. Nakano K, Watanabe T, Shimizu T and Kawakami T: Immunohistochemical characteristics of bone forming cells in pleomorphic adenoma. Int J Med Sci 4: 264-266, 2007.
20. Xu H, Shimizu Y, Niki T, Nagasaka H, Kawamura H and Ooya K: Pleomorphic adenoma of the submandibular salivary glands with marked ossification. J Oral Pathol Med 32: 499-501, 2003.
21. Shigeishi H, Hayashi K, Takata T, Kuniyasu H, Ishikawa T and Yasui W: Pleomorphic adenoma of the parotid gland with extensive bone formation. Pathol Int 51: 883-886, 2001.
22. Hamakawa H, Takarada M, Ito C and Tanioka H: Bone-forming pleomorphic adenoma of the upper lip: Report of a case. J Oral Maxillofac Surg 55: 1471-1475, 1997.

23. Takeda Y and Yamamoto H: Stromal bone formation in pleomorphic adenoma of minor salivary gland origin. J Nihon Univ Sch Dent 38: 102-104, 1996.
24. Lee KC, Chan JK and Chong YW: Ossifying pleomorphic adenoma of the maxillary antrum. J Laryngol Otol 106: 50-52, 1992.
25. Yates PO and Paget GE: A mixed tumour of salivary gland showing bone formation with a histochemical study of the tumour mucoids. J Pathol Bacteriol 64: 881-888, 1952.
26. Pérez-de-Oliveira ME, Leonel ACLDS, de Castro JFL, Carvalho EJA, Vargas PA and Perez DEDC: Histopathological findings of intraoral pleomorphic adenomas: A retrospective study of a case series. Int J Surg Pathol 27: 729-735, 2019.
27. Leivo I, Bishop JA, Cipriani NA, Costes-Martineau V, Inagaki H and Vielh P: Mucoepidermoid carcinoma. In: WHO Classification of Tumours, Skin Tumours. 5th edition. IARC, Lyon, pp200-203, 2024.
28. Akiyama T, Raftery LA and Wharton KA: Bone morphogenetic protein signaling: The pathway and its regulation. Genetics 226: iyad200, 2024.
29. Njie R, Xu S, Wu T, Pi J, Lin S, Zhang P, Wang J, Dai Q, Shen H, Zhang N and Chen G: Hedgehog signalling in osteogenesis and bone metabolism: Molecular mechanisms, regulatory networks and implications for skeletal disease. J Cell Mol Med 29: e70813, 2025.