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HEAD AND NECK

Mesenchymal neoplasms of the major salivary glands: clinicopathological features of 18 cases

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Abstract Non-lymphoid mesenchymal neoplasms of salivary gland origin are rare, accounting for 1.9–5% of major salivary gland tumors. We describe the clinico-pathologic features of 18 cases of mesenchymal neoplasms of the major salivary glands experienced at Asan Medical Center, Seoul, Korea, from 1998 to 2004. Mesenchymal neoplasms accounted for 3.4% of the total of 524 major salivary gland tumors. The parotid gland was the preponderant site (15 cases). Thirteen tumors were benign, constituting 3.5% of the total of 371 benign neoplasms. Schwannomas were the most common benign tumors (six cases), followed by lipomas (three cases), plexiform neurofibroma, hemangioma, desmoid tumor, and solitary fibrous tumor (one each). The malignant tumors consisted of one dermatofibrosarcoma protuberans, synovial sarcoma, leiomyosarcoma, pleomorphic liposarcoma and desmoplastic small round cell tumor each. Immunohistochemical analysis for the expresssion of vimentin, actin, desmin, neuron-specific enolase, keratin, CD34, CD99 and bcl-2 contributed to the differential diagnoses. Genetic analysis for fusion transcripts was conclusive in the diagnosis of desmoplastic small round cell tumor, which is extremely rare at this location. Pre-operative imaging study and fine needle aspiration cytology had limitations in prediction of the mesenchymal nature of the tumors, due to either low index of suspicion, similarities to mixed tumors, or specimen inadequacy. Awareness of the development of various mesenchymal tumors in the major salivary glands could increase the accuracy of preoperative and postoperative diagnosis, and therapeutic efficacy.

Keywords Salivary gland · Mesenchymal · Neoplasm · Sarcoma

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Introduction

Although mesenchymal neoplasms of salivary gland origin are very rare, accounting for only 1.9–5% of major salivary gland tumors [1–5], their diversity appears to be comparable with the soft tissue counterparts. Hemangiomas, lipomas, and neurogenic tumors are common forms of benign tumors [2–4], while reports of solitary fibrous tumor have increased recently [6, 7]. The incidence of sarcomas of the major salivary gland appears to be about one tenths of benign mesenchymal tumors [3], and small series or individual cases of various sarcomas have been described.

We reviewed 524 surgically treated tumors of the major salivary glands over a 7-year period, and found 18 mesenchymal tumors including some rare forms of sarcomas. Their clinicopathologic features are described, along with molecular analysis of a desmoplastic small round cell tumor.

Materials and methods

Data search

We searched the Surgical Pathology file of Asan Medical Center from 1998 to 2004 to retrieve cases of non-epithelial, non-lymphoid neoplasms of major salivary glands. Pathologic materials of cases diagnosed as non-epithelial salivary gland lesions were re-examined. After excluding fibrotic lesions related to inflammatory processes, sarcomatous lesions related to malignant mixed tumors, hematologic malignancies, and periglandular tumors without direct relation to the salivary gland, 18 cases of intraparenchymal mesenchymal tumors of the salivary glands were identified. Medical information on these cases, including radiologic findings and follow-up data, was obtained.

Immunohistochemistry

For most benign neurogenic tumors, lipomas, hemangioma, and liposarcoma, diagnoses could be made by histologic examination without immunohistochemical study. Three schwannomas had been confirmed as of neurogenic nature by S-100 protein immunostaining. Immunohistochemical analysis of various markers had been performed to diagnose desmoid tumor, solitary fibrous tumor, dermatofibrosarcoma protuberans, synovial sarcoma, leiomyosarcoma, liposarcoma and desmoplastic small round cell tumor (Table 1).

Molecular analysis

RT-PCR for EWS–WT1 fusion transcript was performed to confirm the diagnosis of desmoplastic small round cell tumor. Six 10 μm sections of formalin-fixed and paraffin-embedded tumor tissue were deparaffinized by xylene and alcohol washes, digested overnight in buffer containing 20 μg/l proteinase K (Invitrogen, Carlsbad, CA, USA). Total RNA was extracted using a modified guanidine isothiocyanate method (Trizol, Life Technologies, Inc., Grand Island, NY, USA). First-strand cDNA was synthesized from 5 μg total RNA using a first-strand synthesis kit (Stratagene, La Jolla, CA, USA). The EWS–WT1 chimeric transcripts were amplified by semi-nested PCR with the forward primers 5′-TCCTACAGCCAAGCTCCAAG-3′ (first primer, EWS exon 7), 5′-TATAGCCAACAGAGC AGCAGC-3′ (second primer, EWS exon 7), 5′-TGATCGT GGAGGCATGAGC-3′ (EWS exon 8), 5′-CAGCGCTGG AGAGCGAGG-3′ (EWS exon 9) and the reverse primer 5′-ACCTTCGTTCACAGTCCTTG-3′ (WT1 exon 8). Each reaction consisted of 25 μl volume containing 2 μl of RT reaction product and 1.0 U Taq polymerase (TaKaRa Biomedicals, Japan). The amplification protocol consisted of an initial denaturation at 94°C for 10 min, 35 cycles of denaturation at 94°C for 40 s, annealing at 55°C for 40 s and extension at 72°C for 1 min. Two microliter of each first PCR product was added to a second PCR mix and subjected to the same PCR amplification. The final products were resolved on 2% agarose gels. As a loading control, the samples were amplified with β-actin primers.

Results

Clinicopatholgical data of 18 mesenchymal tumors of the major salivary glands are summarized in Table 2. Six *schwannomas* occurred in female patients of ages from 23 to 66, who presented with a parotid or submandibular mass of variable duration, ranging from 6 months to 20 years. Pre-operative radiologic and cytologic diagnoses had been correct in only one case (Fig. 1a). At surgery, all parotid gland tumors were arising from temporal and zygomatic

Table 1 Immunohistochemical results with antibody list

Antibody	CK	Vimentin	S-100 p	SMA	Desmin	CD34	CD99	bcl-2	CD56	NSE
Tested cases										
Schwannoma 1,2,4			(+)							
Desmoid tumor	(−)		(−)	(−)		(−)				
SFT	(−)		(−)	(−)		(+)	(+)	(+)	(−)	
DFSP	(−)		(−)	(−)		(+)	(+)	(+)	(−)	
Synovial sarcoma	(+/−)	(+)	(−)	(−)		(−)	(−)	(+)	(+/−)	
Leiomyosarcoma				(+)	(+/−)					
DSRCT	(+)	(+)	(−)	(−)	(+)				(−)	(+)
Source	Zymed	Zymed	Zymed	Dinona	Dako	Immunotech	Dako	Dako	Novocastra	Dako
Dilution	×250	×200	×500	×100	×200	×50	×25	×20	×400	×100

SFT solitary fibrous tumor, *DFSP* dermatofibrosarcoma protuberans, *DSRCT* desmoplastic small round cell tumor, *CK* cytokeratin, *S-100 p* S-100 protein, *SMA* smooth muscle actin, *NSE* neuron specific enolase

Table 2 Summary of clinical findings of mesenchymal tumors of major salivary glands

Tumor type	Sex/age	Location	Size (cm)	Radiologic diagnosis	Cytologic diagnosis (sono-guide)	Follow-up (months)
Benign						
Schwannoma 1	F/47	Parotid	1.5 × 1 × 0.8	s/o PA	Non-diagnostic	Rec (66), Reop (87), NED(98)
Schwannoma 2	F/57	Parotid	3 × 2 × 1.1	Benign fibroblastic lesion	s/o PA	Lost
Schwannoma 3	F/23	Parotid	2 × 2 × 1.5	Benign parotid tumor		NED (60)
Schwannoma 4	F/56	SMG	0.6	s/o neoplastic condition	Non-diagnostic (+)	Rec (6), Reop (39), NED (49)
Schwannoma 5	F/66	Parotid	3 and 1.2	LN or schwannoma	favor schwannoma	NED (46)
Schwannoma 6	F/61	Parotid	3	Parotid tumor	Cystic fluid	NED (35)
Plexiform NF	F/4	Parotid	5 × 1.1 × 1	Plexiform NF		Lost
Lipoma 1	M/62	Parotid	6 × 4.5 × 3	Lipoma	Non-diagnostic	NED (76)
Lipoma 2	M/66	Parotid	3.5 × 3 × 2	Lipoma	c/w lipoma	Lost
Lipoma 3	F/47	Parotid	7 × 4 × 2.5	Lipoma		NED (49)
Hemangioma	M/4 months	Parotid	6.3 × 5× 3.1	Hemangioma	s/o spindle cell proliferative lesion	Lost
Desmoid tumor	M/49	SMG	3.5 × 2.5 × 2.5	SMG tumor	s/o adenocarcinoma	NED (94)
SFT	M/58	Parotid	6.5 × 5 × 3.5	Parotid gland tumor	Mixed tumor, s/o malignancy (+)	NED (67)
Malignant						
DFSP	F/30	Parotid	4.3 × 3.5 × 3.5	PA	Salivary tumor, unknown malignant potential	NED (55)
Synovial sarcoma	F/35	Parotid	3 × 3 × 2.8	r/o malignant tumor	Spindle cell sarcoma (+)	DOD (18)
Leiomyosarcoma	M/67	Parotid	9 × 8 × 6	Known leiomyosarcoma	c/w leiomyosarcoma	DOD (31)
Liposarcoma	M/14	Parotid	5 × 4.5 × 4.2	Sarcoma	Sarcoma (+)	NED (32)
DSRCT	M/26	SMG	4 × 3.7 × 3	Malignant tumor	Round cell malignancy, type undetermined (+)	DOD (25)

NF neurofibroma, *SFT* solitary fibrous tumor, *DFSP* dermatofibrosarcoma protuberans, *DSRCT* desmoplastic small round cell tumor, *SMG* submandibular gland, *PA* pleomorphic adenoma, *s/o* suggestive of, *c/w* consistent with, *r/o* rule out, *Rec* recurrence, *Reop* reoperation, *AWD* alive with disease, *NED* no evidence of disease, *DOD* died of disease

branches of the facial nerve. Superficial or total parotidectomies were performed in three and two patients, respectively, with facial nerve repairs using sural nerve grafts. One submandibular gland (SMG) schwannoma, which was considered of marginal branch origin, was excised without a nerve repair. The excised tumors measured 0.6–3 cm in greatest dimensions. All cases were histologically conventional, consisting of Antoni A and B areas in various proportions. Cystic changes were prominent in two cases. Two patients developed recurrent tumors and re-excisions have recently been performed, 39 and 87 months after the first operation of each case. The latter case remained with a facial palsy.

Plexiform neurofibroma involving both the parotid and submandibular gland (SMG) occurred in a 4-year-old girl with type 1 neurofibromatosis. Computed tomography (CT) of the neck revealed a linear vermiform mass of more than 10 cm dimension. The tumor histologically displayed characteristic plexiform pattern of spindle cells within the salivary gland parenchyma (Fig. 1b). The patient was lost to post-operative follow-up.

Lipomas of the parotid gland presented as infraauricular swelling or masses for 4–10 years, and could be diagnosed by CT scans showing fatty density masses without enhancement. The tumors measured 3.2–6 cm in greatest dimensions and were histologically composed of mature adipocytes. Two patients are well without disease for 49 and 76 months after parotidectomies; the third patient has been lost to follow-up.

A 4-month-old boy presented with an intraparotid *hemangioma*, appearing as a strongly enhanced lobulated mass replacing the total right parotid gland on CT scan. Hemangioma was radiologically suspected, but aspiration cytology resulted in a diagnosis of spindle cell proliferative lesion. The removed tumor measured 5 × 4 × 4 cm and showed pinkish tan hemorrhagic cut surface. It was microscopically of infantile type, displaying a distinctive histologic appearance of cellular proliferation of capillary-sized vessels

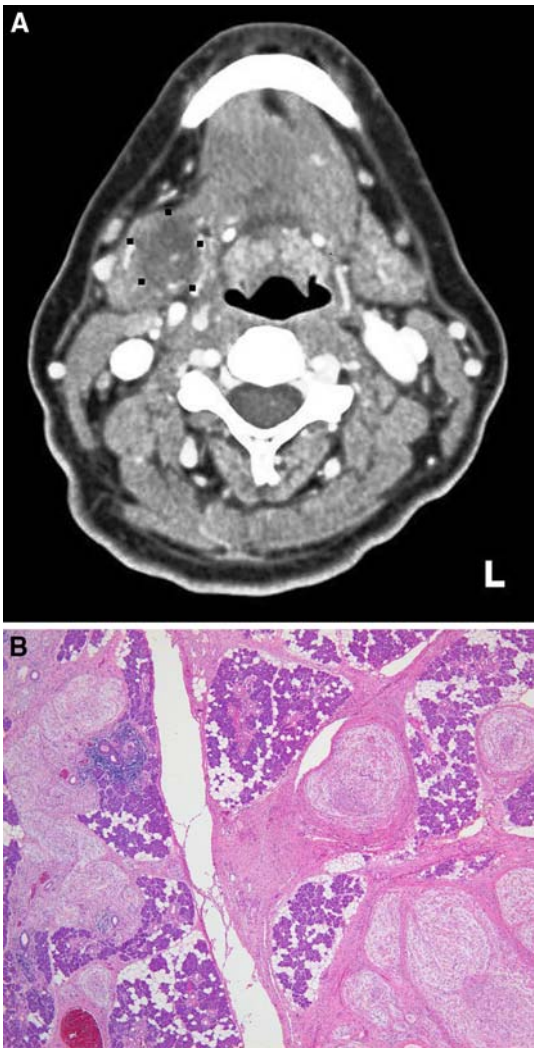

Fig. 1 **a** A schwannoma in the right submandibular gland appears as a 2.5 cm-sized heterogeneous enhancing mass on post-contrast neck CT (*rectangles*), rendering a non-specific radiologic diagnosis. **b** Photomicrograph of plexiform neurofibroma, showing multiple intraglandular proliferative bundles of spindle cells

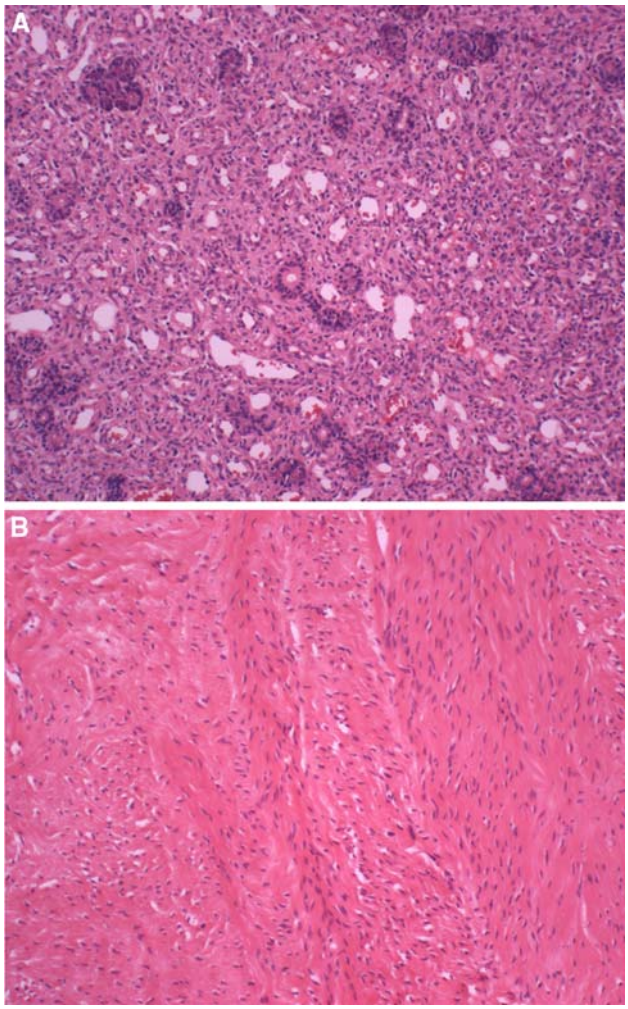

Fig. 2 **a** Most of salivary lobule is occupied by hypercellular proliferation of rudimentary capillaries in juvenile hemangioma. Several residual ducts are evident. **b** Desmoid tumor is composed of hypocellular fibrogenic spindle cells and dense collagenous matrix

around retained salivary ducts (Fig. 2a). The patient was lost to follow-up 8 months after the surgery.

The patient with a *desmoid tumor*, a 49-year-old male, presented with a neck mass for 3 months. The excised submandibular gland mass measured 3.5 × 2.5 × 2.5 cm and showed whitish firm fasciculated cut surface. The tumor was histologically of hypocellular type, exhibiting a relatively demarcated mass of dense collagenous tissue with some fibroblasts (Fig. 2b). He has been healthy except for calcifications in his liver and lungs, for 94 months postoperatively.

A 58-year-old man diagnosed with *solitary fibrous tumor* complained of a slowly growing left parotid mass over 3 years. The magnetic resonance imaging (MRI) diagnosis was a parotid gland tumor, and the diagnosis by sonoguided aspiration cytology was a mixed tumor. A total parotidectomy was performed, and the excised tumor, which measured 6.5 × 5×3.5 cm, showed a lobulated firm whitish tan cut surface (Fig. 3a). Microscopic examination revealed compact patternless proliferation of spindle cells with occasional whirling or hemangiopericytomatous characteristics (Fig. 3b). Immunohistochemical positivity for CD34, CD99 and bcl-2 protein, and negativity for neurogenic (S-100 protein), myogenic (smooth muscle actin) and epithelial (cytokeratin) markers supported the diagnosis. The patient is well without recurrence 67 months after surgery.

The patient with a *dermatofibrosarcoma protuberans* (*DFSP*), a 30-year-old woman, presented with a 2-year history of a slowly enlarging mass at the left parotid area. A CT scan revealed a 4 cm-sized well-circumscribed mass involving both the superficial and deep lobes of the parotid gland without extraparotid extension (Fig. 4a). Radiologic

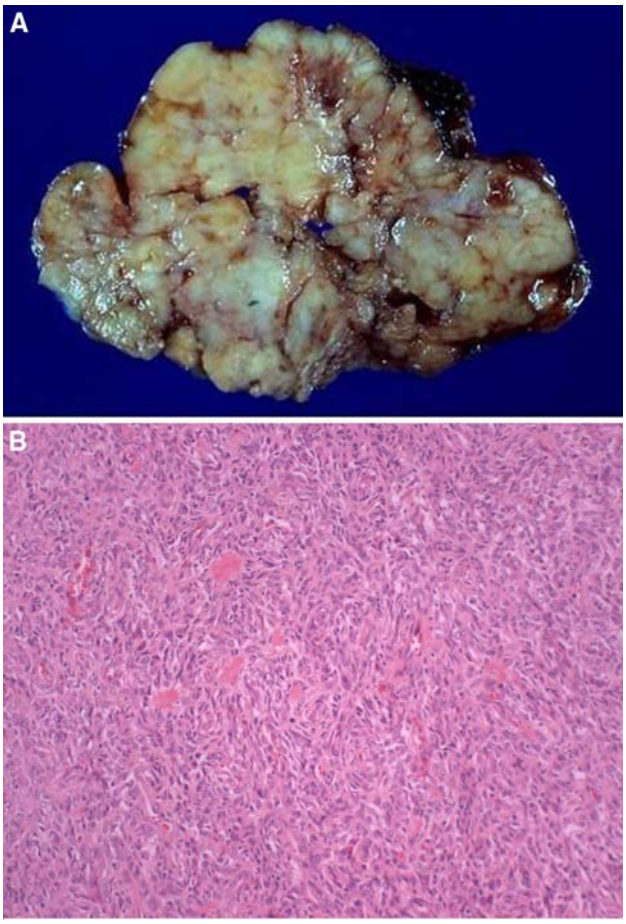

Fig. 3 **a** Gross photograph of solitary fibrous tumor, showing finely lobulated solid tan cut surface. **b** Solitary fibrous tumor microscopically shows hypercellular patternless proliferation of spindle cells with little cytoplasm

diagnosis was a pleomorphic adenoma. Cytologic diagnosis was a salivary tumor of unknown malignant potential. A total parotidectomy was performed, and the specimen revealed a well demarcated grayish tan solid mass surrounded by salivary gland parenchyma (Fig. 4b), which was histologically composed of uniformly proliferating short spindle cells in storiform patterns (Fig. 4c). The vasculature and matrix were sparse and thick collagen bundles were irregularly scattered. Individual cells showed mild nuclear atypia and low mitotic activity. Immunophenotype of the tumor was typical for a DFSP (Fig. 4d). Adjuvant therapy was not given, and the patient is alive without disease 55 months after the surgery.

A 34-year-old woman with a *synovial sarcoma* (SS) initially presented similar to the previous patient, with a 4 cm-sized highly enhancing mass in the deep and superficial lobes of the left parotid gland. But the preoperative cytologic features suggested a spindle cell sarcoma. The resected tumor after a total parotidectomy with neck dissection showed features of monophasic SS, consisting of cellular fascicles and sheets of uniform, relatively small ovoid cells. The vasculatures were prominent with occasional hemangiopericytomatous patterns. The tumor showed a multinodular permeant growth pattern, entrapping the normal salivary gland elements (Fig. 5a). Immunopositivity of tumor cells for cytokeratin, bcl-2 and CD56 supported the diagnosis of SS (Fig. 5b). She subsequently received four cycles of adjuvant chemotherapy and 70 Gy of radiotherapy, but a fast local recurrence occurred and a brain mass suspected of being a single metastasis developed 13 months after the operation, and the patient died 18 months post-operatively.

A *leiomyosarcoma* was diagnosed in a 67-year-old man who presented with a left parotid mass of 6 months duration. He had a history of previous outside biopsy of the parotid gland and had been diagnosed with leiomyosarcoma. MRI showed a $9 \times 8 \times 6$ cm-sized lobulated mass involving the parotid gland, extending to the masseter muscle and SMG. A wide excision with neck dissection was performed. The tumor was very large at the time of surgery, involving not only the parotid gland, but the surrounding connective tissue including many blood vessels (Fig. 6a). However, it appeared to be centered at the parotid gland which was invaded and distorted by the tumor. The tumor showed features of high-grade spindle cell sarcoma with cellular pleomorphism and high mitotic activity. The diagnosis of leiomyosarcoma was confirmed by positivity for smooth muscle antigen and desmin (Fig. 6b). Extensive vascular invasions were present in the surgical specimen, and an enlarged right axillary lymph node was found soon afterward. The patient rejected further work-up or treatment and died 31 months post-operatively.

The patient with pleomorphic *liposarcoma* was a 14-year-old boy who presented with a left parotid swelling and facial palsy for several months. CT and MR images revealed a lobulated mass involving the parotid gland, extending to the parapharyngeal space and approaching the posterior skull base. Because of the tumor's lipogenic nature, it was suspected to be a sarcoma on the CT scan and MRI. Fine needle aspiration cytology resulted in the presence of isolated bizarre cells, leading to a diagnosis of pleomorphic sarcomatoid lesion. Marginal total removal of the $5 \times 4.5 \times 4.2$ cm-sized mass was performed, and the mass showed a multinodular cut surface composed of bright yellow, reddish yellow or pinkish white soft tissue with areas of hemorrhage (Fig. 7a). The tumor histologically showed very unusual type of liposarcoma for the young age of the patient. It was composed predominantly of diffuse sheets of large bizarre cells including unequivocal lipoblasts with cytoplasmic vacuoles (Fig. 7b), along with a small myxoid area with less cellularity, resembling myxoid liposarcoma. The patient received adjuvant radiotherapy and is alive 32 months later without further disease.

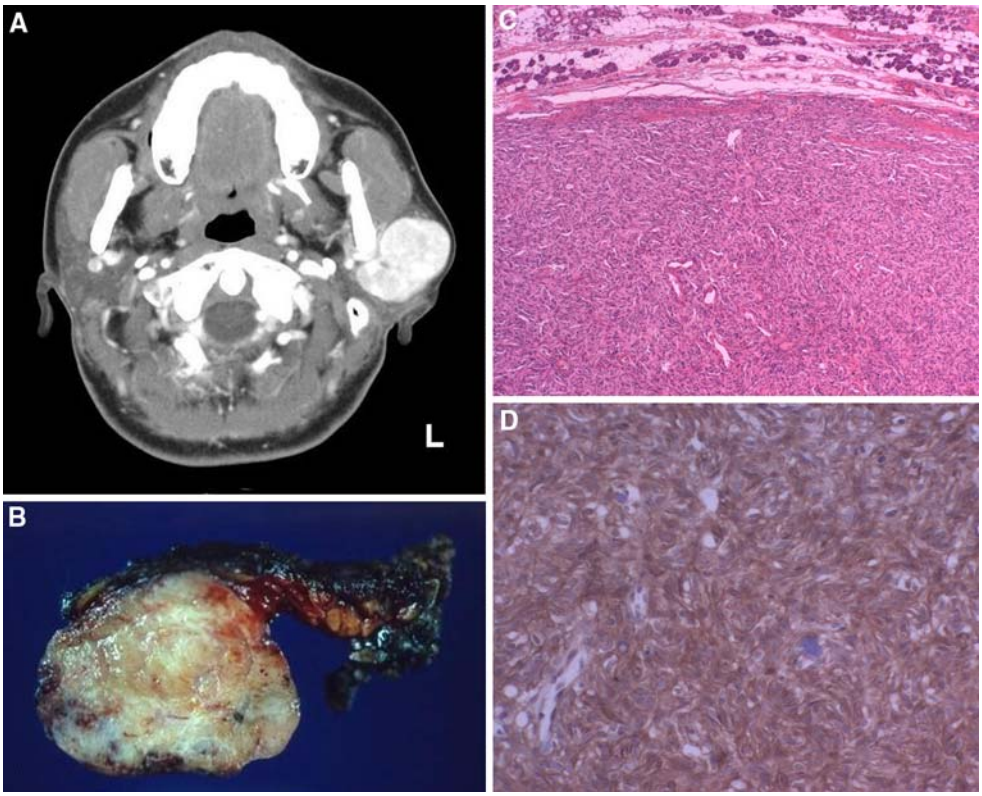

Fig. 4 **a** A post-contrast image of dermatofibrosarcoma protuberans (*DFSP*) shows a strongly enhanced lobulating mass of 4 cm greatest dimension. **b** DFSP grossly appears as a well demarcated solid oval mass with whitish dense appearance. **c** Photomicrograph of DFSP, showing compact proliferation of short spindle cells in storiform pattern, well demarcated from the salivary gland parenchyma. **d** Diffuse expression of CD34 in DFSP by immunohistochemical staining

A *desmoplastic small round cell tumor* of the SMG in a 26-year-old man with a left submandibular mass noticed 10 months previously had been initially diagnosed as an undifferentiated carcinoma after submandibular gland excision with neck dissection. The tumor was 4 × 3.7 × 3 cm in size with regional metastases to two lymph nodes. It showed histologic features identical to those of tumors of intraabdominal origin, consisting of small round, triangular or polygonal islands of small undifferentiated cells in abundant collagenous stroma (Fig. 8a). The diagnosis was aided by immunohistochemical study, which showed a multiphenotypic tumor with expressions for cytokeratin, desmin and neuron specific enolase (Fig. 8b). RT-PCR confirmed the diagnosis with positive result in one (EWS exon 9–WT1 exon 8; 83 bp) of four tested EWS–WT1 fusion transcripts (Fig. 8c). Despite 60 Gy of adjuvant radiotherapy, local (submental) and remote (hilar) recurrences developed 6 months later. This unusually aggressive course led to a case review and a revised diagnosis of desmoplastic small round cell tumor (DSRCT) was made 8 months after surgery. His disease progressed to systemic metastases in spite of chemotherapy of a changed regimen and the patient expired 25 months after the initial operation.

Discussion

Tumors of mesenchymal origin can occur in any parts of the body, but are much rarer in solid organs such as the salivary glands than in the soft tissue. The incidence of salivary gland mesenchymal tumors has been reported to range from 1.9 to 5% [1–5]. We observed a 3.4% incidence of mesenchymal tumors of the major salivary glands, with 13 benign tumors comprising 3.5% of all benign salivary neoplasms and 5 sarcomas comprising 3.3% of all malignant tumors.

Unlike other statistics [1–4], we found that neurogenic tumors were the most common benign neoplasms. Five of six schwannomas occurred in the parotid gland. Although the intraparotid location, mostly of temporal and zygomatic branch origin, is not rare for facial nerve schwannomas, accounting for about one fourth of these tumors [8], preoperative diagnosis of intraparotid schwannomas is not always easy radiologically or pathologically. Radiological findings can be non-specific, and the presence of bland spindle cells in cytologic specimens does not exclude pleomorphic adenomas. Although the specific diagnostic rate of fine needle aspiration for spindle cell and mesenchymal

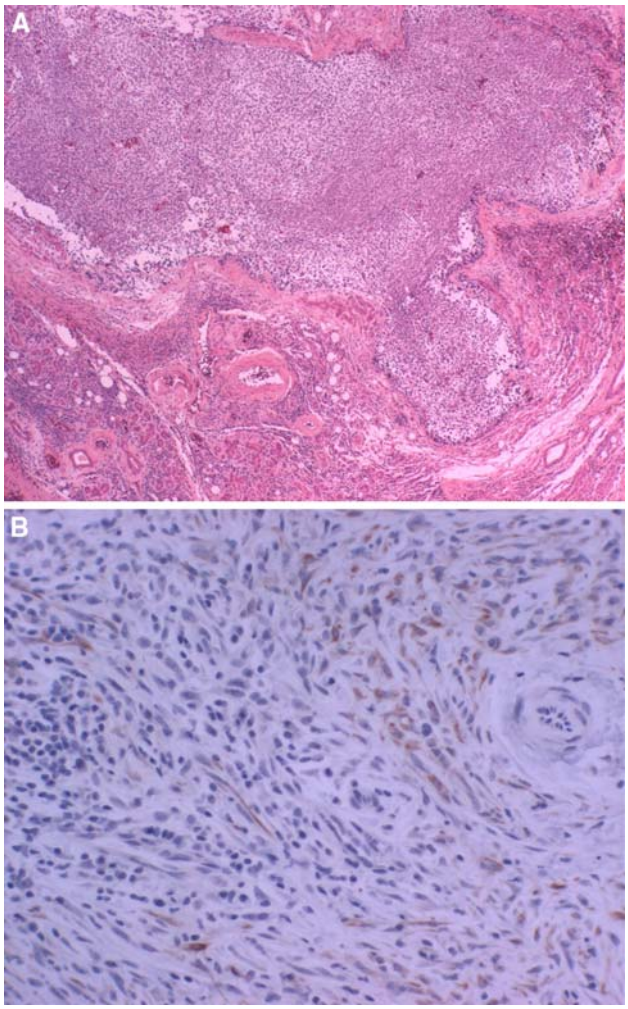

Fig. 5 **a** Tumor cells of synovial sarcoma are small oval to spindle and hypercellular, showing permeant growth within the salivary gland parenchyma. **b** Cytokeratin immunoreactivity in synovial sarcoma

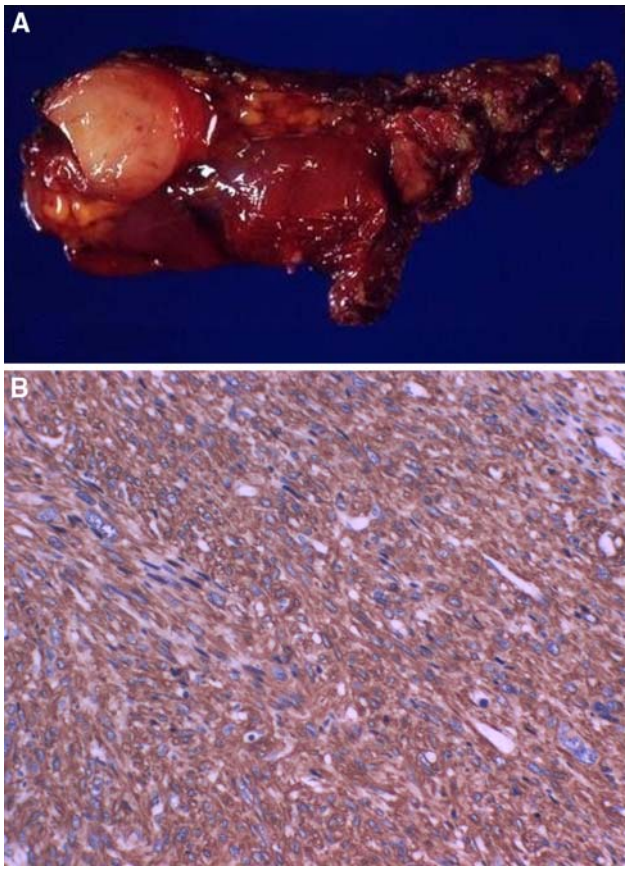

Fig. 6 **a** Leiomyosarcoma showing multinodular growth with *yellowish* or hemorrhagic myxoid appearance. **b** Leiomyosarcoma shows diffuse immunopositivity for smooth muscle actin

lesions of the salivary glands has been reported to be as high as 84% in a previous report [9], the unrivalled incidence of pleomorphic adenomas, which commonly harbor spindle cell components, tends to lower the cytopathologists' index of suspicion for mesenchymal tumors. Greater awareness of the intraparotid development of schwannomas may increase the diagnostic accuracy, avoiding an unnecessary facial nerve sacrifice. It was interesting to note the preponderance of these tumors in women.

Juvenile hemangioma is the most common form of salivary gland hemangioma, and is principally a disease of infants [10]. Microscopically, these tumors show compact proliferation of endothelial cells within the salivary lobules; as the lesions mature, small capillary vessels and larger thin-walled vessels become evident [1, 2]. Diagnosis should be aided by imaging, since the specimen by aspiration cytology at an early stage may show spindle cells with little evidence of vascular tumor leading to an unnecessary surgery, as in our case. Once a diagnosis of juvenile hemangioma is made, the current recommendation is to delay surgical treatment, since most lesions will have involuted by the age of 7 years [1, 2]. It is assumed that more patients with juvenile hemangiomas must have visited our institute, but did not undergo biopsy or surgery.

Solitary fibrous tumor (SFT) is now a well-recognized entity, most commonly occurring in the pleura, but also in various extrapleural locations. Reports of salivary gland SFT appear to be increasing [6, 7]. It may be difficult to diagnose SFT based on cytologic features alone, but histologic diagnosis can be aided by positive immunoreactivity for CD34 and CD99. It is an essentially benign tumor, and no further treatment is necessary after its complete excision.

Primary sarcomas of the major salivary glands are very rare, accounting for 0.3–0.5% of all salivary gland neoplasms [1–3] and 1.5–2.3% of malignant salivary tumors [1, 5]. The criteria for establishing a primary salivary gland origin are (1) the patient must not have, or have had, a sarcoma in another site; (2) patient evaluation has excluded the likelihood of metastatic disease; (3) the gross and

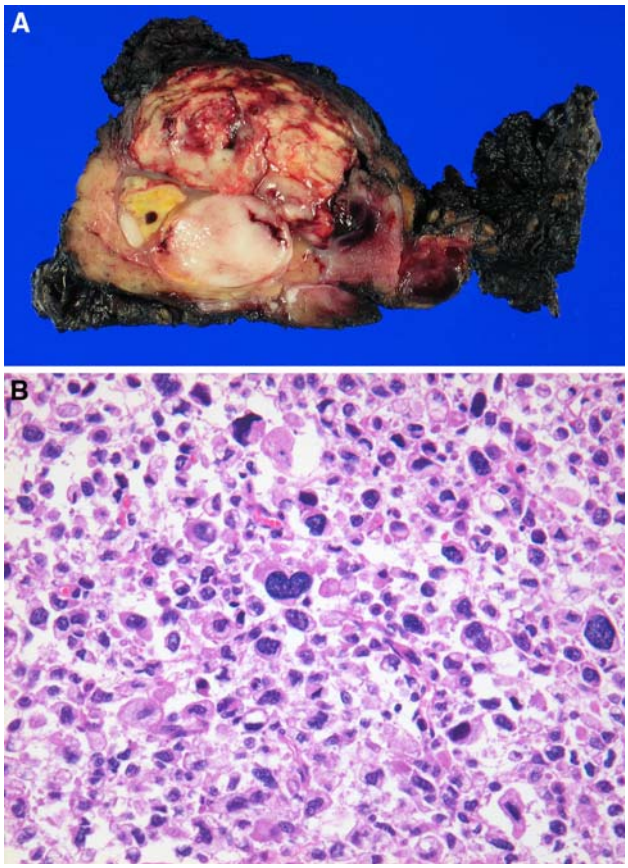

Fig. 7 **a** Gross appearance of pleomorphic liposarcoma showing lobulated soft cut surface variegated with *yellow*, *tan*, *pinkish* or hemorrhagic areas. **b** Pleomorphic liposarcoma is histologically composed of large anaplastic lipoblasts

microscopic appearances support primary origin rather than invasion from adjacent soft tissue; and (4) carcinosarcoma has been excluded [1].

Most of our cases satisfied the criteria, except that the case of leiomyosarcoma which presented as a huge mass with extensive extraparenchymal involvement. We included this case as a primary sarcoma after a careful review of pathologic materials and patient history. Sarcomas in our series were of unusual histological types, in contrast to that malignant schwannoma, malignant fibrous histiocytoma and fibrosarcoma are reported to be the most common forms of salivary gland sarcomas [1–3].

Dermatofibrosarcoma protuberans (DFSP) of the salivary gland has been reported in English literature only once before [11]. The present case was a well-demarcated mass, leading to a radiologic diagnosis of pleomorphic adenoma. An accurate imaging diagnosis of the head and neck sarcoma can be more often made when the tumor is bulky in the soft tissue spaces such as the masticator space without lymph node metastasis. Spindle cell sarcomas of the salivary gland may be one of the most difficult entities to diagnose. Pathological diagnosis of DFSP can also difficult at unusual locations. DFSP shares the immunophenotype of SFT, but is histologically distinguished from the latter by uniformly hypercellular features, storiform growth pattern, increased mitotic activity and infiltrative growth. Biologic behavior of soft tissue DFSP is generally indolent with a metastatic rate of less than 5%. Our patient remains alive without tumor recurrence 55 months after surgery without adjuvant therapy.

Synovial sarcoma, leiomyosarcoma and liposarcoma are all very rare in the major salivary glands, and only a small number of cases have been described [12–17]. Our case of liposarcoma was very unusual in that the patient was a 14-year-old boy, and the histologic subtype was pleomorphic. This patient is the fourth case of pleomorphic variant and the youngest among reported cases of salivary gland liposarcomas; the others ranged in age from 25 to 80 years [17]. Our patient is in his short follow-up period (32 months) after surgery and radiotherapy, and his prognosis seems unpredictable considering the variable clinical courses of previously reported cases [17].

The treatment policy for head and neck sarcomas has not been standardized, attributing to the difficulty to deliver aggressive treatments because of the critical anatomy, rareness of these diseases and the lack of a full multidisciplinary team. The local control rates for head and neck sarcomas after combined therapy have been reported to be lower than those of extremity sarcomas so far [18].

Desmoplastic small round cell tumor (DSRCT) is a rare aggressive neoplasm of older children and young adults, usually based on the mesothelial tissue. Unusual occurrences at atypical extraabdominal sites, such as paranasal sinus and scalp have been reported [19]. We found only two previous cases of salivary gland DSRCT [20, 21], both involving the parotid gland. To our knowledge, our case is the first reported primary DRSCT of the submandibular gland. DRSCT is a multiphenotypic malignancy with epithelial, myogenic and neural marker expression, and histologic characteristics comprising nests of small undifferentiated cells in desmoplastic stroma. Our patient manifested a rapidly progressing clinical course over 2 years after initial diagnosis of undifferentiated carcinoma. This initial misdiagnosis might have affected the patient's survival time, though the general prognosis of DSRCT remains very poor despite multimodal therapy [22]. In addition to the acquisition of immunohistochemical evidences, we performed a molecular study to confirm the diagnosis of DSRCT in this unusual location. DSRCT has a specific cytogenetic abnormality, t(11;22)(p13;q12), resulting in the fusion gene EWS–WT1, which encodes a novel transcription factor. The breakpoints in two genes are located between EWS introns 7–10 and WT1 exons 7–8. The fusion transcript in our patient was a rather uncommon form (EWS exon 9–WT1 exon 8) which has been observed

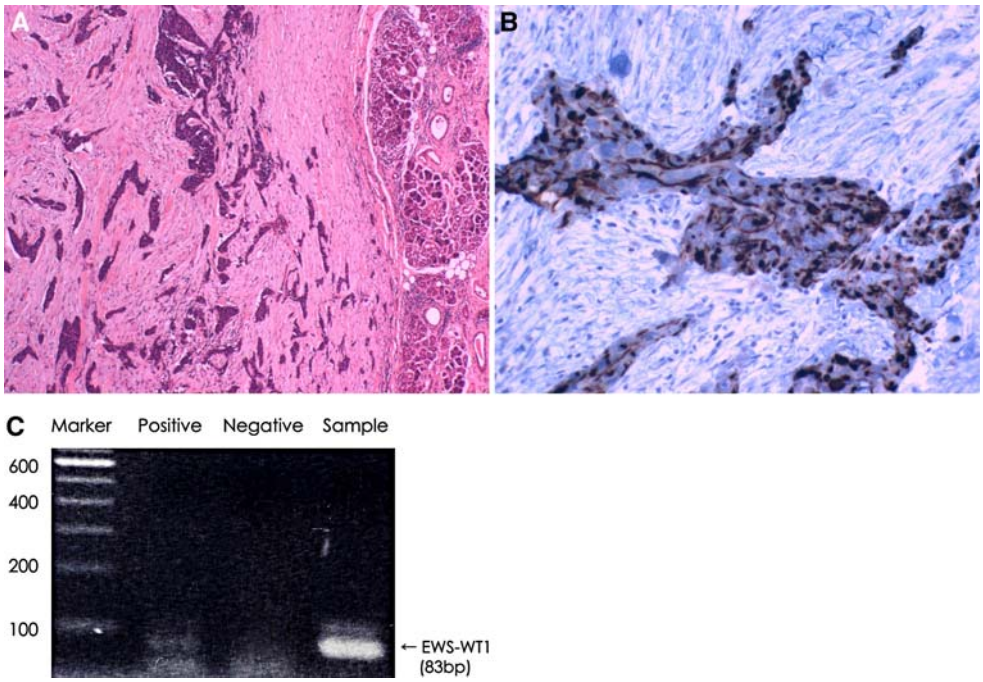

Fig. 8 **a** Irregular nests of small undifferentiated cells in abundant desmoplastic stroma are characteristic in desmoplastic small round cell tumor (*DSRCT*). **b** Characteristic dot-like intracytoplasmic localization of desmin in DSRCT on immunostaining. **c** Detection of EWS–WT1 fusion transcript in DSRCT by reverse transcriptase-polymerase chain reaction. A 83 bp sized product is visualized for the case

in fewer than 5% of these tumors [23]. Although the same variant has been reported in another adult case of extraabdominal DSRCT [23], associations between the fusion type and the tumor location or the patients' age have not been documented.

In summary we observed a 3.4% incidence of mesenchymal neoplasms in the major salivary glands during a 7-year period, and described clinico-pathologic features of 18 cases including 5 rare forms of sarcomas. Awareness of the development of various mesenchymal tumors in the major salivary glands could increase the accuracy of preoperative and postoperative diagnosis, and therapeutic efficacy.

Conflict of interest statement The authors declare that they have no conflict of interest.

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