RESEARCH ARTICLE

Basal cell adenoma of the parotid gland; MR features and differentiation from pleomorphic adenoma

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Objectives: Among the benign tumours of the parotid gland, basal cell adenoma (BCA) is far less common than pleomorphic adenoma (PA). MR features of BCA, including diffusion-weighted imaging and dynamic contrast-enhanced study, have not been previously described. Assessment of the crucial MR features of BCA appears to offer beneficial clues for distinguishing BCA from PA.

Methods: We retrospectively reviewed 14 BCAs and 179 PAs in the parotid gland, collected between March 2000 and May 2012, from the MRI database.

Results: Nearly half of the BCAs had cystic components. The average ratio of the maximum diameter of the cysts to the BCAs (cystic ratio) was 0.80 ± 0.11 [standard deviation (SD)]. The BCA cystic ratio was significantly higher ($p = 0.00232$) than that of PAs. The cystic ratio threshold was 0.65 between cystic BCA and cystic PA. Sensitivity and specificity were 76.5% and 100%, respectively. The average of the apparent diffusion coefficient (ADC) values of the 12 BCAs [1.24 ± 0.18 (SD) $\times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$] was significantly lower than that of the 151 PAs [1.86 ± 0.40 (SD) $\times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$] ($p < 0.001$) and also lower than that of the cystic PAs [1.83 ± 0.57 (SD) $\times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$] ($p < 0.00495$). The ADC threshold was $1.31 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ between BCA and cystic PA, with sensitivity and specificity of 81.2% and 91.7%, respectively, and also the same threshold $1.31 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ between BCA and PA, with sensitivity and specificity of 92.7% and 91.7%, respectively. Time-signal intensity curves (TICs) showed various patterns.

Conclusions: A small cystic mass with well-circumscribed borders and slightly lower ADC value may suggest BCA, although TICs showed various patterns.

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Introduction

By the previous WHO classification (1991), basal cell adenoma (BCA) was recognized as an independent entity among salivary gland tumours. Although the incidence of BCA is 1–7.5%, it is the third most common type of benign parotid tumour.^{1,2} BCA predominantly affects persons over 50 years of age and is seen more often in females. Most BCAs are unilateral and round or oval in shape with well-circumscribed borders, and

they are usually <3.0 cm in diameter in the superficial lobe of the parotid gland at the time of excision. A painless, slowly enlarging mass is the most common clinical symptom. Some surgeons have mistaken these tumours for lymph nodes clinically. The accuracy of the cytological diagnosis of BCA is not so good.³ The majority of BCAs arise in the major glands, with the parotid gland being the most frequent site. BCAs are composed of basaloid cells with eosinophilic cytoplasm, have indistinct cell borders and round-to-oval nuclei and are distributed in solid, trabecular, tubular and

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membranous patterns.⁴ However, the tumours may present with more than one of these patterns, although one will usually predominate. Membranous BCA has biologic behaviour different from that of the other variants of BCA in that it has multifocal microadenomas, incomplete or no capsules, frequent post-operative recurrences and malignant transformations.⁴

Pleomorphic adenoma (PA) is the most common benign neoplasm of parotid gland origin, being the most common neoplasm of the salivary gland even in children and adolescents.⁵ Females are more likely to be affected than males. PA is usually solitary, round and well circumscribed, with a smooth but sometimes lobulated surface. Tumours >1-cm diameter often have numerous protuberances, giving them a lobulated appearance. PAs are commonly encapsulated in parotid glands. PAs are renowned for their cytomorphological and architectural variability. Despite their protean histopathology, all tumours share the essential diagnostic features of being composed of both epithelial and myxoid tissues.⁵ The proportions of these components vary widely, although one or the other is often predominant. The variety of MR findings of PAs reflects their cytomorphological and architectural variability.⁶ The diagnostic clue of PA is to find the myxoid component, which shows high intensity on short-inversion-time inversion recovery (STIR) and T_2 weighted images, progressive enhancement on dynamic MR images and high apparent diffusion coefficient (ADC) values on diffusion-weighted (DW) images.⁶

Warthin's tumour (WT) is the second most common type of benign parotid tumour. Its incidence is markedly higher in elderly males, and most tumours develop in the inferior pole of the parotid gland.⁷ The features of WT are different from those of PA.⁸ Typical WT shows early enhancement and high washout ratio on dynamic enhanced study and low ADC value on DW images.⁸

Of course, clinicians want to know first whether a parotid gland tumour is malignant or benign. If it is the former, they want to know whether it is low- or high-grade malignancy. However, if it is benign, they want to know whether it is PA tending to recur or others. Surgical treatment for PA is a complete, wide surgical excision with a good safety margin, and inadequate resection or rupture of the capsule or tumour spillage during excision can lead to local recurrence. WT undergoes local excision, as there is no worry about the margin. As for BCA, the prognosis is good, except for the membranous type. The recurrence rate is so low as to be almost non-existent, especially when conservatively but adequately excised. If it is possible to show the BCA on MRI to the clinician, it will provide useful information.

There are few reports regarding MRI findings of BCAs, and especially any including dynamic enhanced study and ADC values.^{9–13} The present study aimed to describe the MR features of BCAs and to clarify the differences between BCAs and PAs.

Methods and materials

Patients

We retrospectively reviewed 14 BCAs (5 males and 9 females; median 52 years, range 39–75 years) and 179 PAs (51 males and 128 females; median 48 years, range 16–84 years) in the parotid gland, collected between March 2000 and April 2012, from the MRI database of our hospital.

MRI techniques

All MRI examinations were performed using 1.5-T MRI units (GE Medical Systems, Milwaukee, WI) with a neurovascular array coil. T_1 weighted images [400–560/8–14 (repetition time ms/echo time ms)] of the transverse plane, STIR images [3000–4000/30–40, 12 (echo train length), 150 (inversion time ms)] of the same transverse plane as the T_1 weighted images, DW images (spin-echo single-shot echoplanar sequence with b factors of 0 and 1000 s mm⁻²) of the same transverse plane and T_2 weighted SE images [4000/104, 16 (echo train length)] of the coronal plane were obtained at a section thickness of 6 mm, intersection gap of 1 mm, acquisition matrix of 256 × 256 and a field of view (FOV) of 22 × 22 cm.

Dynamic contrast-enhanced MR images were obtained by three-dimensional fat-suppression T_1 weighted multiphase spoiled gradient-recalled echo (SPGR) [6.3/1.5 (repetition time ms/echo time ms)] for 4 min, with each phase lasting 27 s followed by a 3-s interval, effective section thickness of 4 mm, FOV of 22 × 22 cm and acquisition matrix of 256 × 256. After the first set was obtained, contrast material injection was started immediately. Gadodiamide hydrate was administered (0.2 ml kg⁻¹ body weight) at a rate of 2.0 ml s⁻¹, followed by a 20-ml saline flush into the antecubital vein. Seven sets of dynamic contrast-enhanced images were obtained serially at 3, 33, 63, 93, 123, 153 and 183 s. Soon after the dynamic contrast-enhanced MRI, fat-suppression T_1 weighted images [340–400/20 (repetition time ms/echo time ms)] of the same transverse plane as the pre-contrast-enhanced T_1 weighted images were obtained. ADC maps were automatically constructed from DW images.

Image and pathological analysis

All MR images were retrospectively evaluated with respect to size, location, marginal morphology (definition and lobulation) and enhancement behaviour by two experienced radiologists (HM and KM). The signal intensities of the lesions on each dynamic image were measured with an electronic cursor to define the region of interest (ROI) in each patient. Where markedly heterogeneous enhancement was seen, multiple ROIs were obtained. When measuring the signal intensities, obvious cystic portions were avoided. Time-signal intensity curves (TICs) of the solid components of the lesions on dynamic MRIs were plotted, and washout ratios were also calculated. TICs were divided into three types:

Table 1 Comparison of imaging features between basal cell adenomas (BCAs) and pleomorphic adenomas (PAs)

MR findings	BCAs	PAs	p-value
Diameter of the tumours (cm)	2.7 ± 0.77 (1.5–4.4)	2.8 ± 1.3 (0.7–11)	0.88993
Tumour site ^a	86%	91%	
Cystic components	43% (6/14)	9% (17/179)	
Diameter of the cysts (cm)	2.3 ± 0.96	1.7 ± 0.8	
Cystic ratio	0.80 ± 0.11	0.48 ± 0.21	
TICs	Type A 14% Type B 14% Type C 36% Type B + C 36%	Type B 18% Type C 70% Type B + C 12%	
ADC values (×10 ⁻³ mm ² s ⁻¹)	1.24 ± 0.18 (0.74–1.50)	1.86 ± 0.40 (1.09–2.86) 1.83 ± 0.57 (1.09–2.86): cystic PAs	<0.001 0.00495

ADC, apparent diffusion coefficient; TICs, time–signal intensity curves.

^aRatios for the superficial lobe tumour.

Type A, curve peaks earlier than 120 s (<120 s) after administration of contrast material with a high washout ratio (>30%); Type B, curve peaks earlier than 120 s (<120 s) with a low washout ratio (<30%); and Type C, curve peaks later than 120 s (>120 s).¹⁴

The ADC values of the lesions were measured on each DW image with an electronic cursor to define the ROI. When measuring the signal intensities, obvious cystic portions were avoided.

Statistical analysis

Mann–Whitney *U* test was used to compare the size and ADC values of BCAs and PAs. The optimal cut-off values for the cystic ratio and ADC value were calculated by means of receiver-operating characteristic (ROC) analysis for distinguishing between BCAs and PAs. All statistical analyses were performed with EZR (Saitama Medical Center, Jichi Medical University, Shimotsuke, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, v. 2.13.0, Vienna, Austria).¹⁵

Results

MRI findings

Size, location and marginal morphology: The average maximal cross-sectional diameter of 14 BCAs was

2.7 ± 0.77 cm (SD) (1.5–4.4 cm). 12 (86%) BCAs were located in the superficial lobe of the parotid gland and the other 2 (14%) BCAs in the deep lobe. All BCAs showed well-defined margins, and 4 (29%) tumours had lobulated margins. 6 (43%) of the 14 BCAs had cystic components. The average maximal diameter of the cysts was 2.3 ± 0.96 cm (SD) and the average ratio of the maximum diameter of the cysts to the tumours (cystic ratio) was 0.80 ± 0.11 (SD) (0.65–0.90).

The average maximal cross-sectional diameter of 179 PAs was 2.8 ± 1.3 cm (SD) (0.7–11 cm). 162 (91%) PAs were located in the superficial lobe of the parotid gland and the other 17 (9%) PAs in the deep lobe. 17 (9%) of the 179 PAs had cystic components. The average maximal diameter of the cysts was 1.7 ± 0.80 cm (SD) and the cystic ratio was 0.48 ± 0.21 (SD) (0.20–0.88).

There was no significant difference between BCAs and PAs in the maximal cross-sectional diameter. The cystic ratio of the BCAs was significantly higher than that of the PAs (*p* = 0.00232). The cystic ratio threshold derived from the ROC curve-based positive test was 0.65 between cystic BCA and cystic PA. Sensitivity and specificity were 76.5% and 100%, respectively.

Apparent diffusion coefficient values of tumours

DW images were obtained from 12 of the 14 BCAs and 151 of the 179 PAs, and the ADC values of the tumours

Table 2 Clinical and imaging features of basal cell adenoma

Case	Age	Sex	Tumour size (cm)	Cyst size (cm)	Cystic ratio	ADC value (×10 ⁻³ mm ² s ⁻¹)	TIC type	Tumour site
#1	53	F	2.9	2.6	0.90	–	B, C	S
#2	60	F	2.1	1.7	0.81	–	C	S
#3	67	M	2.8	2.5	0.89	1.25	B	S
#4	40	F	2.1	–	–	1.22	C	S
#5	42	M	3.0	–	–	1.29	B, C	S
#6	61	F	1.7	1.2	0.65	1.23	A	S
#7	51	F	3.7	–	–	1.30	B, C	S
#8	41	M	2.8	–	–	1.23	B, C	S
#9	39	M	4.4	3.9	0.89	1.25	C	D
#10	56	F	2.6	1.8	0.68	1.28	B	S
#11	49	F	2.3	–	–	1.31	C	D
#12	75	F	4.4	–	–	1.50	B, C	S
#13	43	F	2.6	–	–	0.74	C	S
#14	68	M	2.3	–	–	1.29	A	S

ADC, apparent diffusion coefficient; D, deep lobe tumour; F, female; M, male; S, superficial lobe tumour; TICs, time–signal intensity curves.

were calculated. The average of the ADC values of the 12 BCAs [1.24 ± 0.18 (SD), $0.74\text{--}1.50 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$] was significantly lower than that of the 151 PAs [1.86 ± 0.40 (SD), $1.09\text{--}2.86 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$] ($p < 0.001$) and also lower than that of the cystic PAs [1.83 ± 0.57 (SD), $1.09\text{--}2.86 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$] ($p = 0.00495$). The ADC thresholds was derived from the ROC curve- based positive test were $1.31 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ between BCA and PA, with sensitivity and specificity of 92.7% and 91.7%, respectively.

Time vs contrast enhancement ratio and washout ratio of tumours

2 (14%) of the 14 BCAs had Type A curve, 2 (14%) BCAs had Type B curves, 5 (36%) BCAs had Type B and C curves and 5 (36%) BCAs had Type C curves. 3 (18%) of the 17 cystic PAs had Type B curves, 2 (12%) PAs had Type B and C curves and 12 (70%) PAs had Type C curves. Comparison of the imaging features between BCAs and PAs are summarized in Table 1.

Correlations between radiological and pathological findings

All BCAs had fibrous capsules at the maximal diameter section. 10 of the BCAs were classified as the trabecular dominant type, one as tubular dominant type and three as solid-dominant type. 12 BCAs existed in the superficial lobe and 2 BCAs in the deep lobe. Cystic changes were seen in six tumours, five of which were in the superficial lobe and one in the deep lobe. Large fibrous scars were seen in two BCAs and small fibrous scars in four BCAs. Cystic degeneration was seen in six BCAs. All BCAs had many vascular channels. Subtypes, ADC values, TICs and washout ratio of the tumours are summarized in Table 2.

In Case 10 (Figure 1), the tumour in the superficial lobe of the left parotid gland had a solid component showing Type B enhancement and a large cyst. The cystic ratio was 0.68. The pathological specimen revealed the trabecular type of BCA, with anastomosing cords of basaloid cells and intervening stroma.

Figure 1 Basal cell adenoma in the left parotid gland of a 56-year-old female. (a) Short-inversion-time inversion recovery image [3000/40 (repetition time/echo time), axial plane] shows a superficial lobe tumour with moderately high intensity in the peripheral region and markedly high intensity in the central area (*). The markedly high-intensity area is a cystic lesion. (b) T_1 weighted image (560/8, axial plane) shows a hypointensity tumour (arrows). (c) T_2 weighted image (4000/104, coronal plane) shows a low-intensity capsule around the tumour (arrows). The ratio of the maximum diameter of the cyst to this tumour (cystic ratio) is 0.68. (d) On axial dynamic enhanced study, the time-signal intensity curve of the solid component of this tumour (solid line) shows Type B early enhancement with poor washout ratio (4%). The cystic region (dashed line) shows no enhancement. The apparent diffusion coefficient value of the solid component is $1.28 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$. (e) Loupe image on the axial section of the specimen with haematoxylin-eosin (HE) staining shows solid and large cystic components (**). The large cyst had lost its contents. (f) Solid component has anastomosing cords of basaloid cells and a small amount of intervening stroma ($\times 100$ HE staining).

In Case 11 (Figure 2), the tumour in the deep lobe of the right parotid gland showed Type C enhancement and had an ADC value of $1.31 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$. The pathological specimen revealed the trabecular type of BCA, with rich intervening stroma.

In comparative images of cystic PA (Figure 3), the tumour in the deep lobe of the right parotid gland showed Type C enhancement and had an ADC value of $1.52 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$. The cystic ratio was 0.22. Cystic PA had smaller cystic ratio and higher ADC value than BCA. The TIC of cystic PA was Type C as shown in some BCA.

Discussion

In this study, the median age of BCA patients was 52 years. All BCAs were unilateral and had well-circumscribed borders. A painless, slowly enlarging mass was the usual clinical symptom. The average maximal cross-sectional diameter of the 14 BCAs was

$2.7 \pm 0.77 \text{ cm}$ (SD). Our data agreed well with those of the previous articles. 4 (29%) of the 14 BCAs had lobulated margins in this study. Generally, a lobulated appearance is a particular feature of PA, when it is $>1 \text{ cm}$.

According to Shi *et al*,¹⁰ BCA in the superficial region tends to be solid and small in size. Cystic BCAs occur mostly in the deeper region. This trend was not observed in our study, but 6 (43%) of the 14 BCAs had cystic components. On the other hand, only 17 (9%) of the 179 PAs showed cystic degeneration in our study. The cystic ratio of the BCAs was significantly higher than that of the PAs ($p = 0.00232$), and the cystic ratio threshold was 0.65 between cystic BCA and cystic PA.

Some MRI findings of BCAs of the parotid gland have been reported,^{11–13} but those reports have not included DW images, ADC values and TICs with wash-out ratio. MRI findings of basal cell adenomas are relatively low signal intensities on T_1 weighted images and hypointense to slightly hyperintense on T_2 weighted images, showing rapid and prolonged enhancement on

Figure 2 Basal cell adenoma in the right parotid gland of a 49-year-old female. (a) On short-inversion-time inversion recovery image [3000/40 (repetition time/echo time), axial plane], the deep lobe tumour shows heterogeneous high intensities (arrows). (b) On T_1 weighted image (560/8, axial plane), the tumour shows isointensity for muscle (arrows). The apparent diffusion coefficient value of the tumour component is $1.31 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$. (c and d) Fat-suppression contrast-enhanced T_1 weighted image (540/8.2, axial plane) and time-intensity curve (TIC) on enhanced dynamic study, with the tumour showing heterogeneous enhancement (arrows) with TIC peaks later than 120 s (Type C). (e and f) Loupe and light microscopy (original magnification, $\times 100$) images show the solid component with anastomosing cords of basaloid cells and rich intervening stroma (***).

Figure 3 Cystic pleomorphic adenoma in the right parotid gland of a 37-year-old male. (a) On short-inversion-time inversion recovery image [3000/40 (repetition time/echo time), axial plane], the deep lobe tumour shows heterogeneous moderately high intensities with cystic component in the peripheral region (arrows). (b) T_2 weighted image (4000/104, coronal plane) shows a low-intensity capsule (arrowhead). The cystic component is located in the peripheral region (arrow). The cystic ratio is 0.22. (c) Fat-suppression contrast-enhanced T_1 weighted image (540/8.2, axial plane) and time-intensity curve (TIC) on enhanced dynamic study, with the tumour showing heterogeneous enhancement and Type C TIC. The cystic component has no enhancement (arrows). The apparent diffusion coefficient value of the solid component is $1.52 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$.

dynamic study. BCA sometimes has cystic or haemorrhagic components. In fact, it is difficult to make a differential diagnosis between BCA and PA from only the slight difference in the signal intensities on T_1 weighted and T_2 weighted images. In our study, in 9 (64%) of the 14 BCAs, 2 BCAs had Type A and 7 BCAs had Type B curves on dynamic enhanced study, with rapidly enhanced components. 10 (71%) of the 14 BCAs had gradual upward enhanced components. According to past articles of parotid tumours, the types of TICs at gadolinium-enhanced dynamic MRI correlate well with histopathological findings. Rapid enhancement and high washout ratio (Type A) for WTs, low WR (Type B) for malignant tumours and gradual upward enhancement (Type C) for PAs were observed in most instances. In our study, 7 (50%) of the 14 BCAs had malignant type of TIC (Type B) at gadolinium-enhanced dynamic MRI. Tumour cells, vascular channels, ductal lumen, stroma and fibrosis were mixed at

various proportions in the BCAs. These various proportions resulted in a variety of TICs on dynamic MR images: Type A, cellular component-dominant area showing early enhancement and high washout ratio; Type B, cellular components with moderate stroma and fibrosis showing early enhancement with poor washout; and Type C, abundant stroma or fibrotic tissue with few cellular components showing gradual upward enhancement. Our study also reports the ADC values on DW images in patients with BCA. The average of the ADC values of the BCAs [1.24 ± 0.18 (SD) $\times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$] was significantly lower than that of the PAs [1.86 ± 0.40 (SD) $\times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$]. The ADC thresholds was $1.31 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ between BA and PA. There is no report of a specific ADC value of BCA, although Yerli showed that the ADC value of adenomas including 6 PA and 2 BCA was $1.75 \pm 0.40 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$.¹⁶ Our result of the ADC value on PA and BCA seems to be compatible with the previous report.

A previous article reported an ADC threshold of 1.22 or $1.40 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ between malignancy and PA. The ADC value of BCA in our study was between 0.74 and $1.50 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$. According to the threshold level of $1.40 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$,¹⁷ all BCAs except for Case 12 in our study might be classified as malignant tumours. All BCAs had well-defined margins suggesting benign tumours morphologically, which indicates a discrepancy with the results of the TIC and ADC analysis. Because BCA is a relatively rare benign epithelial tumour, a past MR study of salivary gland tumours did not include BCAs.¹⁷ The BCAs in our study had fibrous capsules, with many of them having fibrous scars and cystic degeneration. All BCAs also had many vascular channels. Clear margins as benign and TICs as malignant or PA may reflect these pathological features. Although the ADC values and TICs may classify BCA as malignant according to a past study,¹⁷ the morphological features of a clear margin and relatively small size, <3.0 cm in diameter, suggest BCA as being benign. Large cystic ratio and slightly lower ADC value are clues for differentiating BCA and PA.

Our study has some limitations. First, this study had a relatively small number of BCAs. We had no

membranous-type BCA, and most of our cases consisted of trabecular type. Thus, our study population might not make a satisfactory assessment of the correlation between pathological types and MR results. Further studies in more patients are needed. Second, manual ROI setting to measure TIC and ADC value is a subjective method. However, the ROI method is the most common method in previous articles.^{6,8,14,17} We set ROIs as carefully as possible to maintain consistency among the TIC, ADC value and pathological features.

In conclusion, BCA predominantly affected older persons (>50 years) and occurred more often in females. A painless, slowly enlarging mass was the main clinical symptom. All BCAs (except membranous type) were unilateral small masses, usually <3.0 cm in diameter, with well-circumscribed borders. BCA often had a cystic component, and the ratio of the maximum diameter of the cysts to the tumours in BCA was significantly higher than that in PA. The cystic ratio threshold was 0.65 between cystic BCA and cystic PA. The ADC values of BCA [1.24 ± 0.17 (SD), 0.74 to $1.50 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$] were significantly lower than those of PA. A cystic small mass with well-circumscribed borders and slightly lower ADC value may suggest BCA, regardless of the TIC pattern.

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