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Dynamic contrast enhanced (DCE) and Diffusion weighted (DWI) magnetic resonance imaging – A promising tool to differentiate between benign and malignant salivary gland tumors

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Abstract:
Background*: Salivary gland tumors form nearly 3% of head and neck tumors. Due to their large histological variety and vicinity to facial nerves, pre-operative diagnosis and differentiation of benign and malignant parotid tumors are a major challenge for radiologists.*
Objective & Methods: *Functional MRI techniques, namely dynamic contrast enhanced (DCE-) MRI and diffusion-weighted MRI (DWI) can indicate the characteristics of tumor tissue. DCE-MRI analysis is based on the parameters of time intensity curve (TIC) before and after contrast agent injection. This method has the potential to identify the angiogenesis of tumors. DWI analysis is performed according to diffusion of water molecules in a tissue for determination of the cellularity of tumors.*
Conclusion:*Analysis of TIC curves and ADC values offers added value in the accurate characterization of SGTs in combination with the conventional MR sequences , thereby avoiding unnecessary surgery for benign tumors or delayed treatment for malignant tumors.*
Keywords: *DCE-MRI, DWI, Salivary Gland Tumors, MRI*

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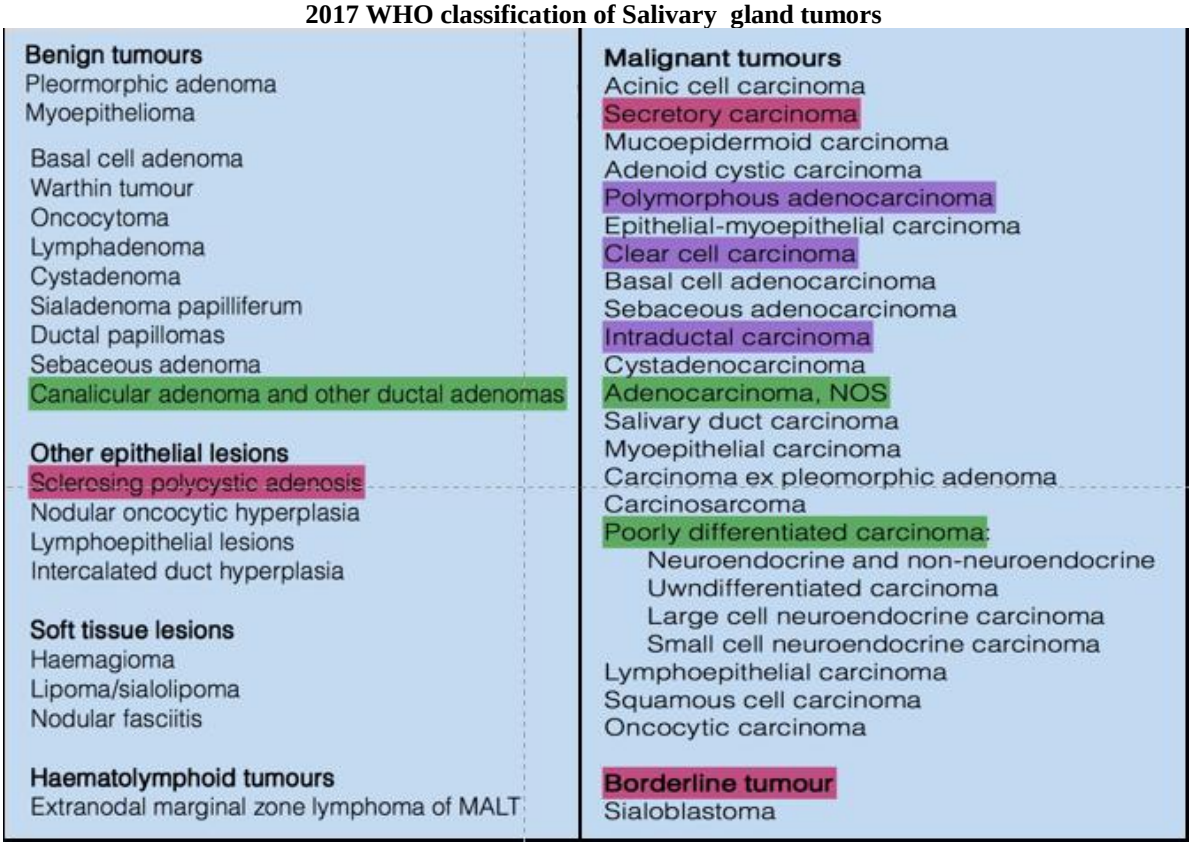
I. Introduction:

- Salivary gland tumors form approximately 2-5% of head and neck tumors[1, 2]. They are commonly located in Parotid gland (~70%) > Submandibular gland (10%), minor glands(20%) and the sublingual gland (< 1%). According to world health organization (WHO), 54-79% of salivary gland tumors are benign and 21-64% of them are malignant [3]. Nearly 80% of salivary gland tumors occur in parotid glands. It should be noted that the majority of parotid tumors are benign (mostly pleomorphic adenoma) and a large number of minor salivary gland tumors are malignant [4]. Salivary gland tumors are very diverse in terms of histopathology and therefore, classification of these tumors has become a challenge for diagnosis, treatment and prognosis for surgeons and clinicians.

2017 WHO classification of Salivary gland tumors



*Newly added entities(pink),

*New Names /simplification of terminologies(Purple)

*Regrouping of rare entities(Green)

Imaging evaluation of salivary gland tumors

Ultrasound

- Initial imaging modality, apart from the **tissue characterization**, color flow doppler can evaluate the **vascularity** of the lesion. USG cannot assess the deeper compartments,retropharyngeal lymphadenopathy and perineural spread (limited role in staging). Benign v/s malignant lesions shows similar sonographic appearance [(3)]

Computed tomography

- CT shows similar mean attenuation values for pleomorphic adenoma v/s malignant entity.Additional exposure to ionising radiation and hazards of contrast media. Other disadvantages include limited studies and non-availability of satisfactory criteria[(4)].

MRI:

- MRI provides better soft tissue characterisation and anatomical localisation.

- It Provides better details about the location(intraglandular or extra-glandular, superficial or deep to the facial nerve),nature of tumor, locoregional spread and invasion, nodal status or distant metastasis and perineural spread.

- DWI/ADC : evaluates the cellularity density

- DCE Sequence : different types of time intensity curves- based on combined evaluation of T peak and washout ratio (WR) where T peak values represents the micro vascularity of the tumor and washout ratio (WR) assesses the cellular/stromal component of the tumor.

- Added advantage of nonionizing radiation[5,6].

AIMS & OBJECTIVES:

- To differentiate between benign and malignant salivary glandtumors based on the time intensity curves (TIC) and mean ADC values derived from Dynamic contrast enhancement and DWI sequences.

Materials & methods:

- This prospective cross sectional study was performed on 20 patients who presented to the Otorhinolaryngology department with palpable swelling in parotid region.
- All MRI examinations were performed with a 1.5 T MRI scanner.
- Following MRI sequences will be taken –
  - T1W axial
  - T2W axial and sagittal
  - STIR axial and coronal
  - FFE (fast field echo) axial
  - DWI sequence - Sensitizing diffusion gradients were applied sequentially in the x, y, and z directions with b values of 0 and 1000 s/mm^2 and mean ADC values were calculated.
  - DCE sequence after injecting gadolinium-based contrast (at 2 mL/s , total dose - 0.1 mmol per kg of body weight, by using a power injector): Semi-quantitative analysis of TIC curves was done.

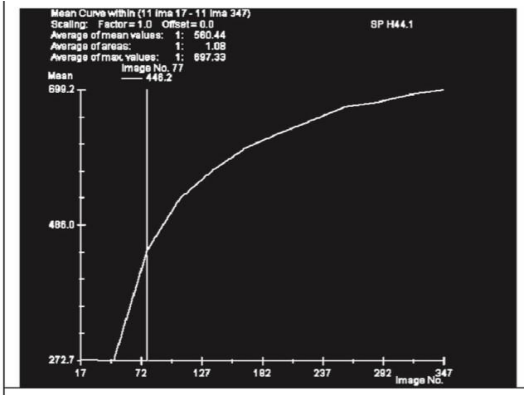
DWI and DCE sequence analysis

- For analysis of time intensity curve (TIC), a region of interests (ROIs) was selected covering maximum of the tumor that showed largest tumor diameter and greatest degree of early enhancement as seen on the dynamic images and were drawn in circular shape (area >10mm ^{2} & diameter 3-4 mm).
- Regions with cystic areas, necrosis, vessels, calcifications and hemorrhages were avoided. Time signal intensity curve (TIC) were plotted based on time of peak enhancement (T-peak) andwashout ratio (WR)based on the TIC classification by Yabuuchi et al. [5]
- For calculating mean ADC value of the tumor, a copy of region of interest was placed on the ADC map. Average of two ADC values were recorded.

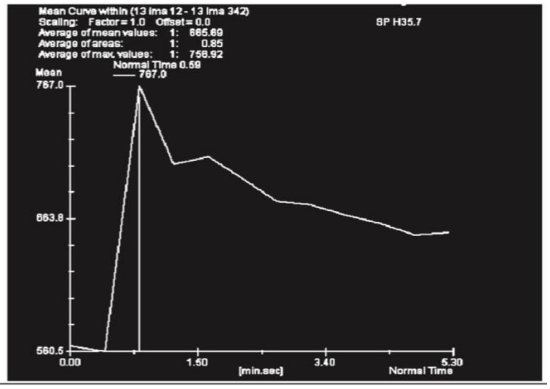
ADC-mean (×10^{-3} mm^2/sec)	Tumor Type
1.92±0.36	Pleomorphic adenoma
0.83±0.16	warthin tumors
1.12±0.41	carcinoma
0.88±0.77	malignant lymphomas

Four different time intensity curves(TIC) based on classification proposed by Yabuuchi et al [5] -:

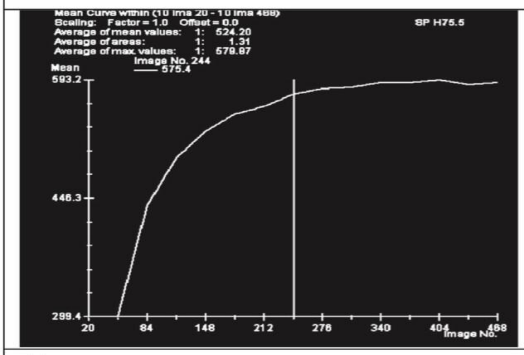
- **Type A** : t- peak of >120s without WR(gradual enhancement) for benign disease
- **Type B :** t peak < 120 s with WR >30%, (early enhancement and high washout type) - for Warthin'stumor
- **Type C :** t peak <120s and WR <30% , (early enhancement and low washout) - for malignant and benign tumors and
- **Type D :** flat line for cysts



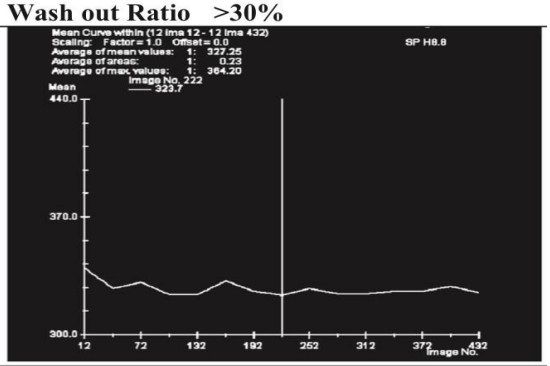
(a) Type A curve: Peak time >120 seconds



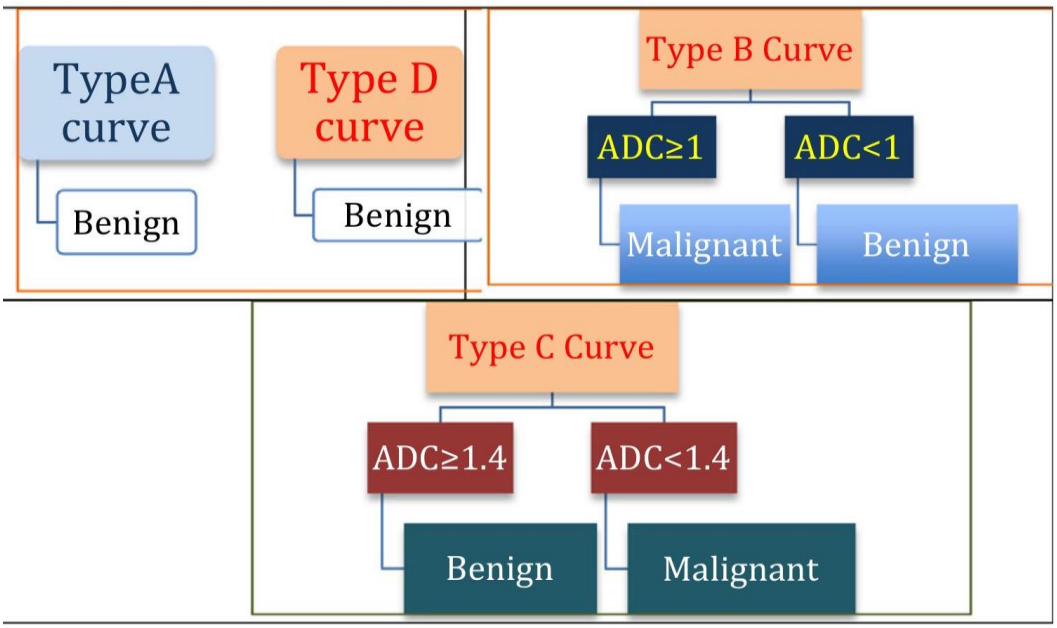
(b) Type B curve:
Peak time <120 seconds
Wash out Ratio >30%



(c) Type C curve:
Peak time >120 seconds
Wash out Ratio < 30%



(d) Type D Curve: Flat Curve



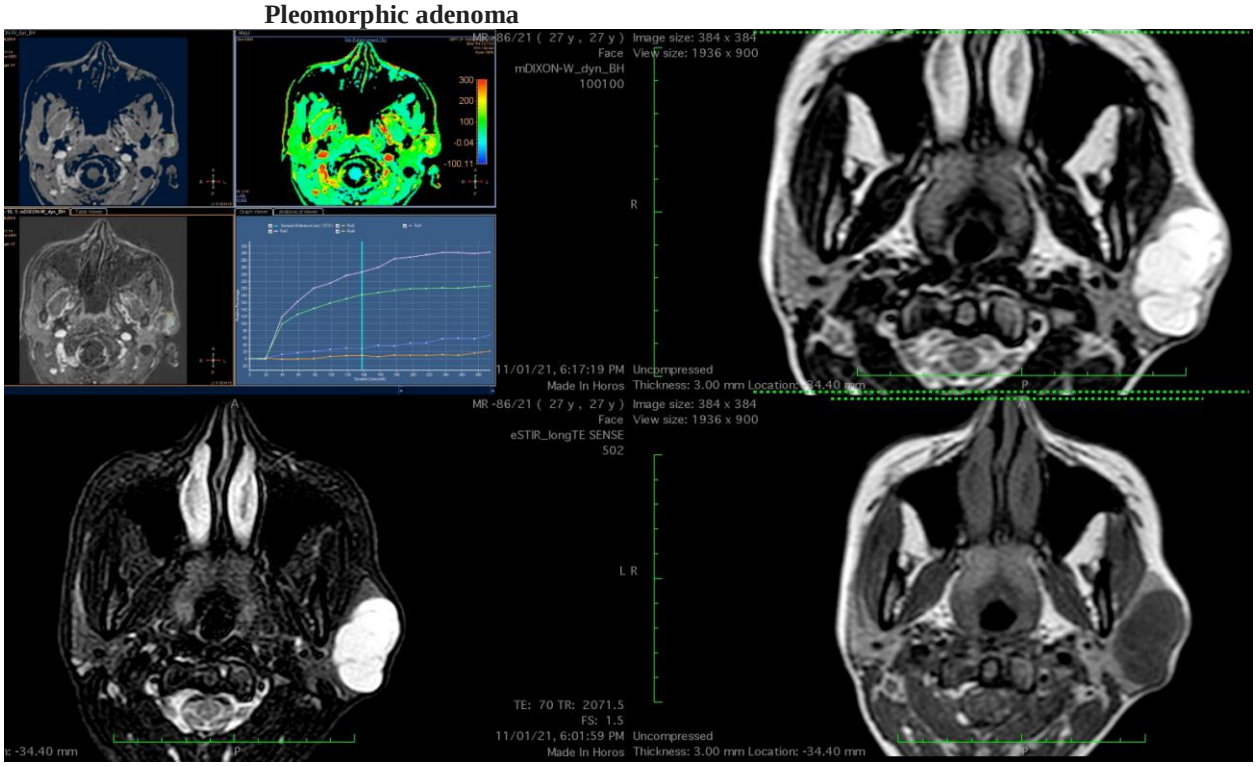
II. Results

The 14 benign and 6 malignant tumors consisted of -:

Histological type of tumor	No.	Mean ADC values	Type of TIC Curve
PleomorphicAdenomas	9	2.4 $x10^{-3}$ mm^2/s^{-1}	A- 5/9 C- 4/9
Warthin tumors	5	$1.1x10^{-3}$ mm^2/s^{-1}	B
MucoepidermoidCarcinomas	2	$1x10^{-3}$ mm^2/s^{-1}	C
High gradeCarcinoma	4	$0.7x10^{-3}$ mm^2/s^{-1}	C

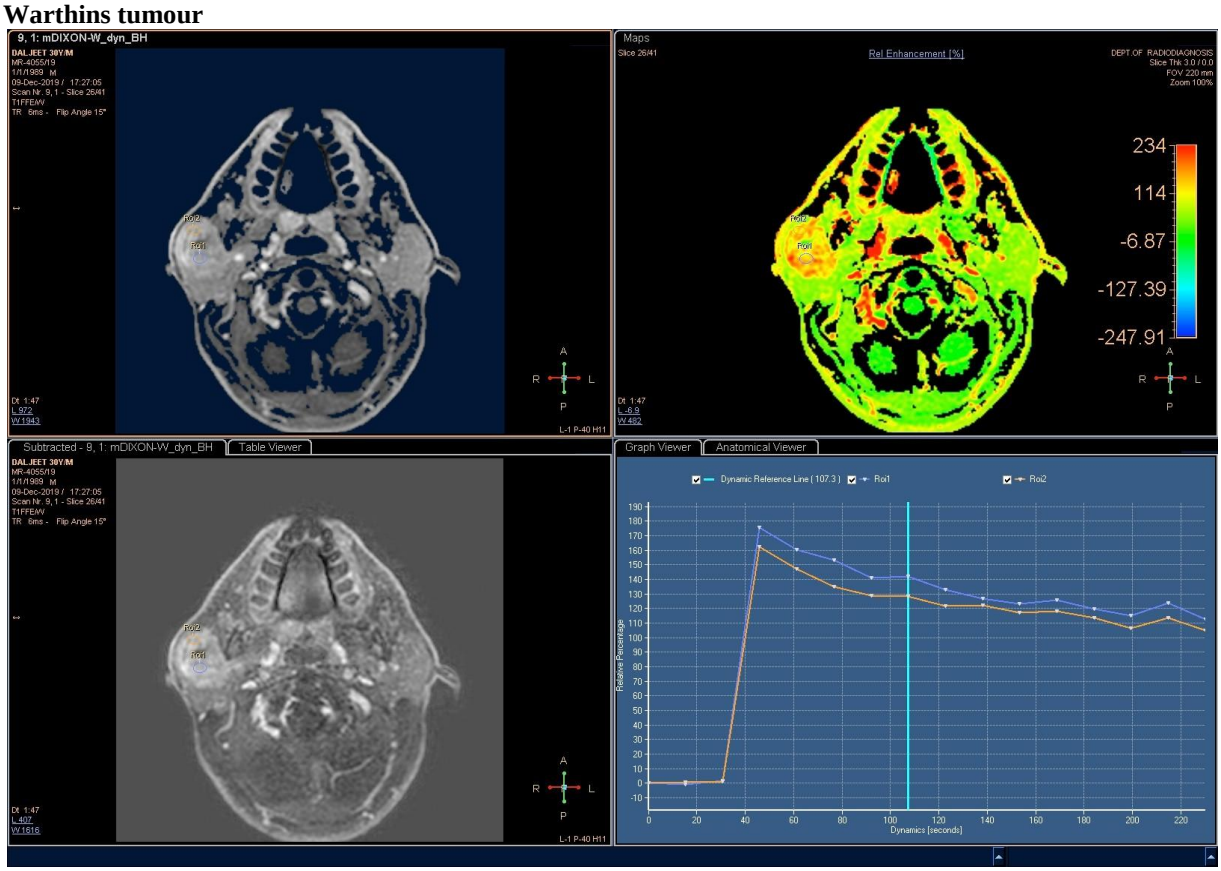
- Combination of type A curve + high ADC (>1.2) values were seen in 25%(5/20) of the cases.Type B curve was seen in 15% (3/20) cases.Combination of type C curve with high ADC values (>1.2) in 35% (7/20) cases. All 75% (15/20) of which turned out to be **benign** on histopathology
- Combination of type C curve with intermediate ADC values(0.8-1.2) seen in 22% cases (5/18).Four of which revealed **malignant** histology.

Pleomorphic adenoma



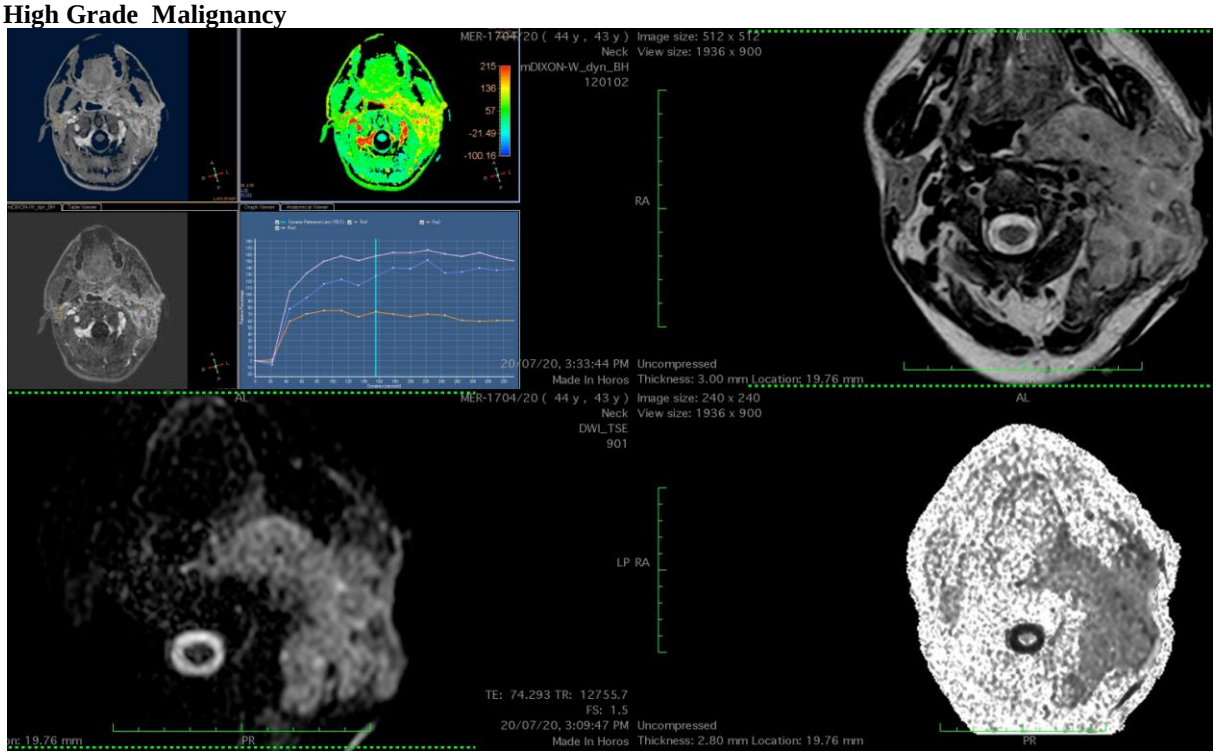
Lesion showswell defined margins and appearsHyperintense* on T2W image with type A TIC curve and High ADC value - $1.4x10^{-3}$ mm^2/s^{-1} .

Warthins tumour



Lesion shows well defined margins with heterogeneousenhancement on contrast administration. Type B curve on TIC curve with ADC value – 1.1 x 10^{-3} mm^2/s^{-1} .

High Grade Malignancy



Lesion shows ill-defined Margins with heterogenous enhancement and Type C Curve Diffusion restrictionnoted(mean ADC value- 0.4x10^{-3} mm^2/s^{-1}).

Limitations :

- Small sample size
- Overlap between Warthin's tumor and malignant parotid gland tumors (especially low grade MCC) as regard the measured ADC value and time to peak (TTP) value.

III. Conclusion :

According to the literature, these methods cannot be used individually to differentiate benign from malignant salivary gland tumors. An effective approach could be to combine the aforementioned methods to increase the accuracy of discrimination between different tumor types. The main objective of this study is to explore the application of DCE-MRI and DWI for assessment of salivary gland tumor types.

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