

The Prognostic Value of DWI MRI in the Diagnosis of Soft Tissue Sarcomas

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Abstract

Background: DWI is beneficial in evaluation of soft tissue sarcomas, thus improving the diagnostic accuracy, characterization and response to treatment. **Purpose:** The aim of this study was to evaluate the benefit of using quantitative diffusion-weighted imaging (DWI) with apparent diffusion coefficient (ADC) mapping in the diagnosis of soft tissue sarcoma, with emphasis on its prognostic value. **Patients and Methods:** This study included 50 patients with pathologically proven soft tissue sarcoma. The DWI was obtained with 3 b values, including 0, 400, and 800 s/mm². Calculation of the ADC value of the lesion was done by placing the region of interest (ROI) to include the largest area of the lesion. ADC values were compared with the histopathology. **Results:** The most frequent site was thigh (48.0), followed by shoulder, forearm, arm and foot (8.0% for each). The most frequent pathology was synovial sarcoma (32.0%) followed by spindle cell sarcoma (28.0%) then liposarcoma (12.0%). 80% of lesions showed restricted diffusion. Median ADC value was 0.7 and ranged from 0.5 to 2.4. All patients underwent surgery, 48.0% of patients received chemotherapy and 52.0% received radiotherapy. 56.0% of patients showed recurrence, while 44.0% showed metastasis. Mean follow up duration was 13 months with standard deviation of 5 months. Median ADC value was significantly higher in patients with no recurrence (0.9) compared to those with recurrence (0.7). P value was 0.016. **Conclusion:** DWI with ADC mapping of soft tissue sarcoma has additive role to anatomic sequences for lesion characterization and grading as well as treatment response.

Keywords: DWI; MRI; Sarcoma

Introduction:

Soft tissue sarcoma is a heterogeneous group of malignant neoplasms that often shows a high mortality rate ⁽¹⁾. They are rare malignancies of connective tissues that arise from mesenchymal precursors mainly in the extremities and comprise about 1% of cancers in adults ^(2,3).

They include at least 100 different histologic and molecular subtypes, with each subtype having variable clinical behavior ⁽⁴⁾.

Magnetic resonance imaging is the most widely used tool for the detection of soft tissue sarcoma and determination of tumor extent, pre operatively ^(5,6).

Contrast in soft tissues is of higher quality allowing an easier detection of the lesion, and improves delineation of their extent and involvement of neurovascular structures and medullary bone ⁽⁷⁾.

Diffusion-weighted imaging (DWI) is a rapid, non-contrast magnetic resonance (MR) technique. DWI provides information about the extracellular Brownian motion of water molecules in a tissue examined (true diffusion), as well as its microcirculation (perfusion). Hence, tissues with increased cellularity led to decreased Brownian motion or restricted diffusion, while tissues

with decreased cellularity have unrestricted or increased diffusion ^(8,9).

The apparent diffusion coefficient (ADC) value, representing a combination of both true diffusion and perfusion, is a numerical value express degree of movement in a tissue and has been used as a marker for cellularity in soft tissue imaging ⁽⁹⁾.

Unlike morphological MR imaging sequences and DCE, adds functional information about tissue composition without intravenous contrast administration ⁽¹⁰⁾.

Diffusion-weighted imaging is routinely used in several clinical scenarios. Besides still being a hot research topic, it has been tested in almost all cancers to differentiate malignant from benign lesions, and to distinguish different malignant histological types or tumor grades, to predict and/or assess treatment responses, as well as to identify residual or recurrent tumors in follow-up examinations ⁽¹¹⁾.

Patients and methods:

This was a cohort which included 50 patients (30 females and 20 males) referred to MRI Unit, Damanhour Oncology center

for MRI evaluation of soft tissue tumors that further proved pathologically to be soft tissue sarcomas. This study included clinically suspected soft tissue sarcomas with no age or sex predilection. Patients with contraindication to MRI (e.g.: patients who have heart pacemaker, metallic foreign body and metallic device) and patients with severe claustrophobia were excluded. An informed consent from all patients was taken before the MRI examination. Further follow up of these patients were done including management they received either surgery, CTH or RTH and if recurrence occurred or metastasis. This study was done in the time from December 2017 to April 2020. The study was approved by the institutional ethics committee.

MRI technique:

Patients were examined using 1.5 T closed MRI machine (MR system, GE, SIGNA) using the most optimal surface coil accommodates each lesion. The predetermined examination protocol was applied to all patients that included the following:

- T1-WI (TR/TE = 400–700/14–30; FOV, 20–35 cm) in axial, coronal and/or sagittal.
- T2-WI (TR/TE = 2800–4500/80–120; FOV, 20–35 cm) in axial and coronal

- Fat suppression sequence or short tau inversion recovery (STIR) sequence in axial and coronal planes (TR/TE = 4000–5600/18–40; FOV, 20–35 cm) or PD FS (2000–2500/20–40; FOV, 20–35 cm) in sagittal & coronal view.
- Post IV contrast study (FAT saturation T1WI sequences-in most cases). We use typical contrast medium-based intravenous agents, gadopentate dimeglumine (Magnevist; Schering, Berlin, Germany); at a dose of 0.1 mmol/kg
- Diffusion weighted MR images were taken in the axial plane by single shot, (EPI) imaging sequence : (TR 8000–8500 msec., TE50–60 m sec, 5 mm slice thickness, 1 mm slice spacing, FOV25–30 cm). The strength of Motion Probing Gradient (MPG) is defined by the gradient factor b. The b-values used were 0, 400 and 800 s/mm².

The ADC is numerical value calculated by manually placing a region of interest (ROI) over the solid portion of tumor. The MR imaging results were correlated with the histopathological examination and statistical analysis of the collected data.

ADC calculation

- The section with the largest tumor diameter was selected for ADC calculation including the visibly most restricted diffusion area on the ADC map, with the region of interest (ROI) being large as possible. Measurements were recorded as a representative value for each case.

Interpretation of diffusion-weighted images

- The lesion was determined on DWI and ADC map by using the conventional MR images as a guide.
- The signal intensity of the lesion on DWIs was determined.
- ADC of the minimum, maximum, and average values was obtained.

Statistical analysis:

Data management and statistical analysis were done using SPSS vs.25. (IBM, Armonk, New York, United states). Numerical data was summarized as means and standard deviations or medians and ranges. Categorical data was summarized as numbers and percentages.

All P values were two sided. P values less than 0.05 were considered significant.

Results:

This study included 50 patients, 30 females (60%) and 20 males (20%) (**Fig.1**), regarding in age between 20 and 63 years (mean age: 42+12).

The most frequent site was thigh (48.0), followed by shoulder, forearm, arm and foot (8.0% for each) (**Fig. 2**).

The diagnosis was confirmed after the MRI examination by the histologic biopsy according to standard histopathological procedures in all cases. From the 50 soft tissue mass lesions, cases were synovial sarcoma 16 cases (32.0%), 14 cases were spindle cell sarcoma (28), 6 cases were liposarcoma (12%), 4 cases were cavernous Hemangioma (6.7%), 2 cases were hemangioma (6.7%), 2 cases were fibromyxosarcoma (8%), 2 cases were clear cell sarcoma (4%), 2 cases were Dermatofibrosarcoma protuberance (4%), 2 cases were pleomorphic sarcoma (4%), 2 cases were PNET (4%), 2 cases were undifferentiated sarcoma (4%) (**Fig. 3**).

In our study 80% of lesions showed restricted diffusion. Median ADC value was $0.7 \times 10^{-3} \text{mm}^2$ and ranged from 0.5 to $2.4 \times 10^{-3} \text{mm}^2$ (**Table 1**).

All patients underwent surgery, 48.0% of patients received chemotherapy and 52.0% received radiotherapy (**Fig. 4**).

Table 2 showed that 56.0% of the patients showed recurrence, while 44.0% showed metastasis. Mean follow up duration was 13 months with standard deviation of 5 months. Table 3 showed that median ADC value was significantly higher in patients with no recurrence (0.9) compared to those with recurrence (0.7). P value was 0.016.

Case 1 (Fig. 5)

A -26 - year old male patient presented with a painless swelling at the medial aspect of the right lower thigh proved pathologically to be myxoid liposarcoma. This patient was managed

the right upper thigh proved pathologically to be Biphasic synovial sarcoma.

This patient was managed by surgery and received RTH yet he had local recurrence with lung and inguinal nodal metastasis.

Case 2 (Fig. 6)

A -55 - year old male patient presented with a small painless swelling at the posterior aspect of only by surgery and for 1 year no recurrence occurred.

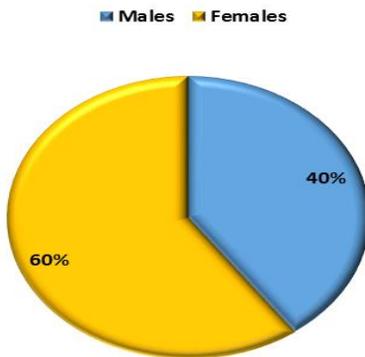


Figure 1: Sex distribution of the study group.

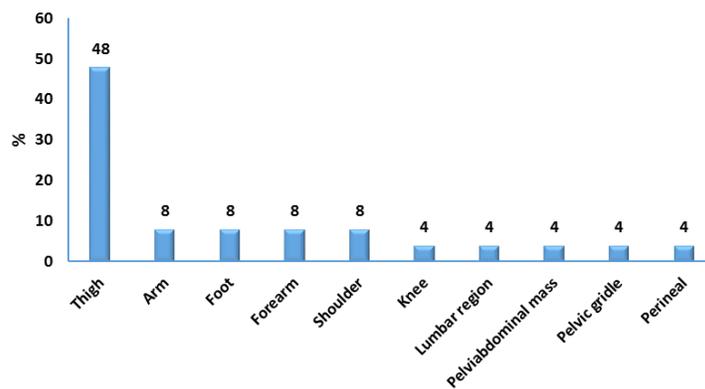


Figure 2: Site distribution of the study group.

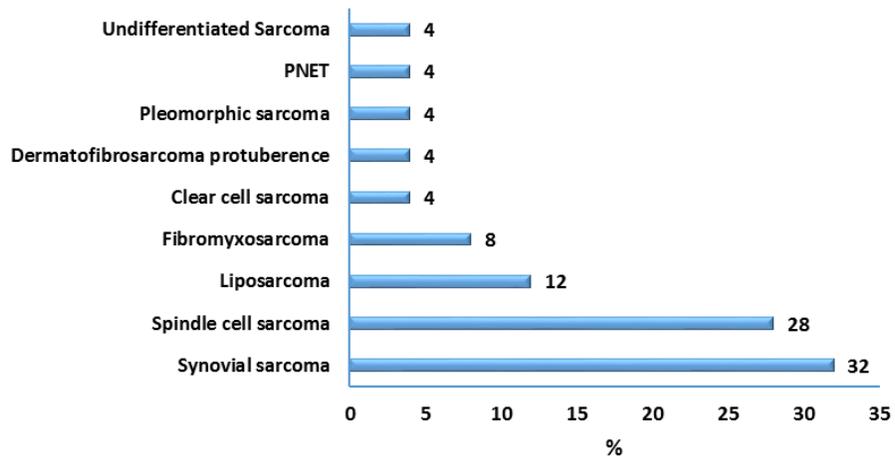


Figure (3) histopathological classification of the study group

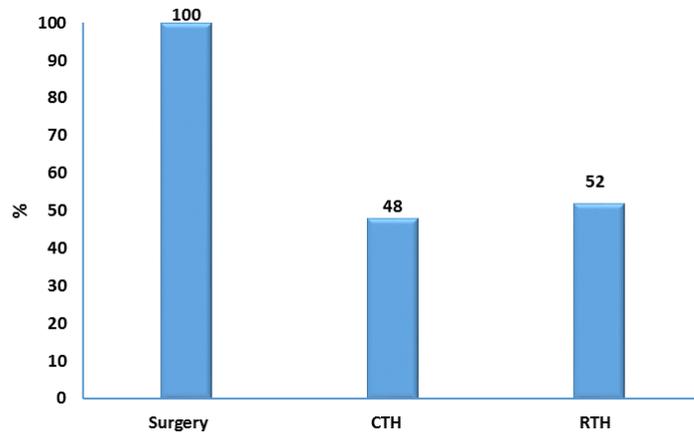
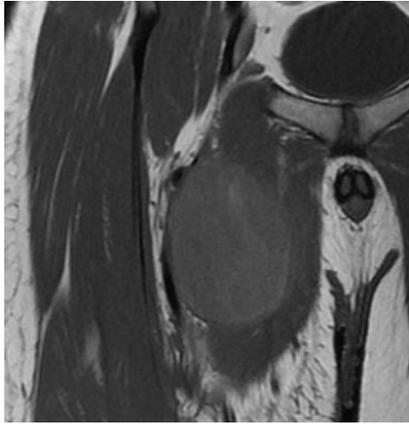
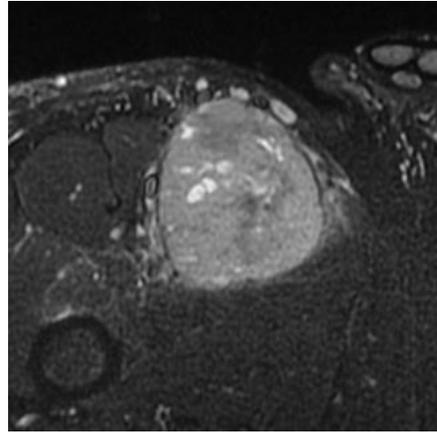


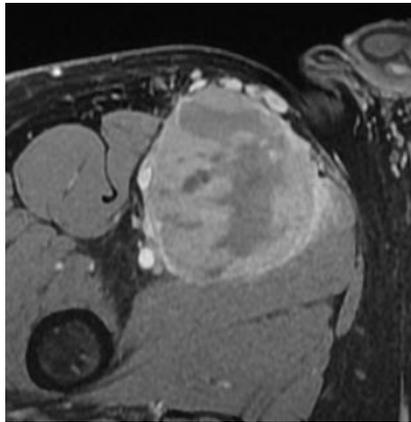
Fig 4: treatment patients received



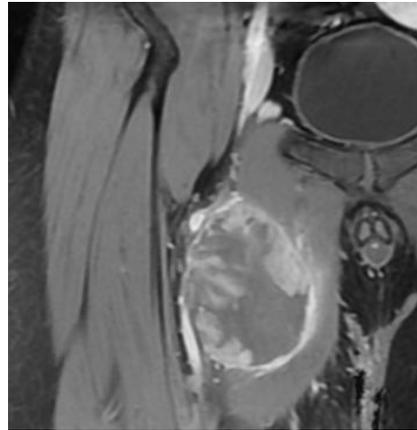
(a) Coronal T1



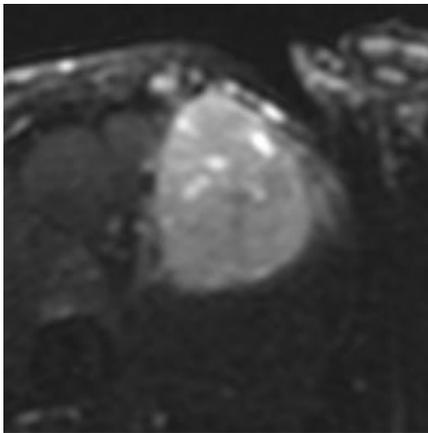
(b) Axial STIR



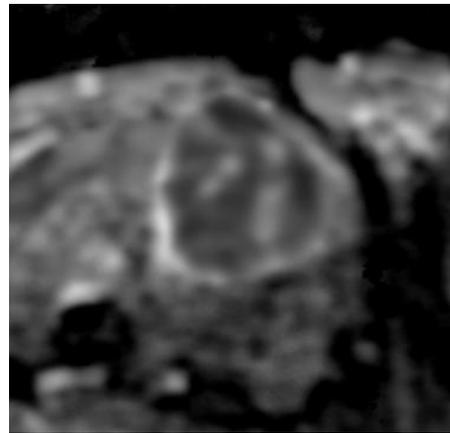
(c) Axial T1 Post contrast



(d) coronal T1 post contrast

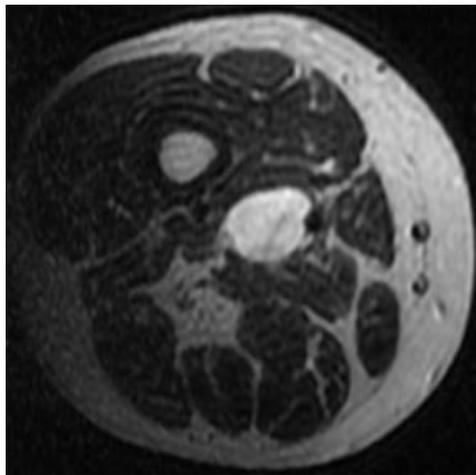


(e) DWI

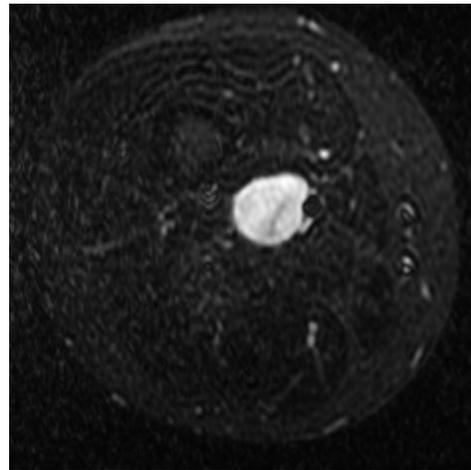


(f) ADC

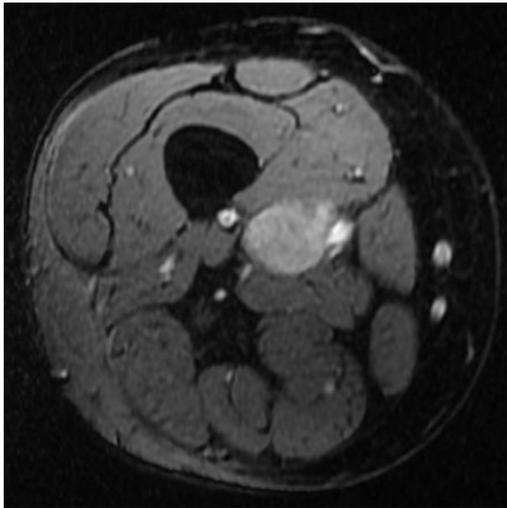
(Figure 5): (a) Coronal T1 showing soft tissue mass with iso to hypo intense signal (b) Axial STIR showing heterogeneous moderately hyperintense signal (c & d) Axial and coronal T1 post contrast fat suppression with heterogeneous post Gadolinium enhancement (e) DWI most of the lesion show restriction (f) Corresponding ADC map with mean value of $0.5 \times 10^{-3} \text{ mm}^2/\text{sec}$



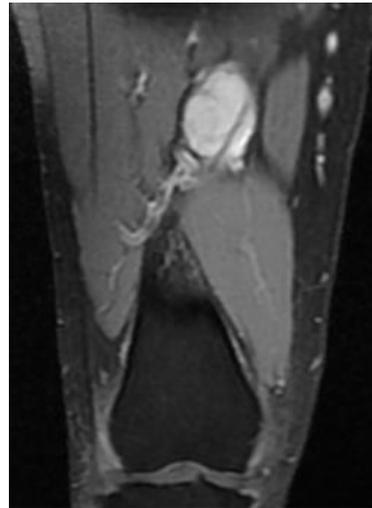
(a) Axial T2



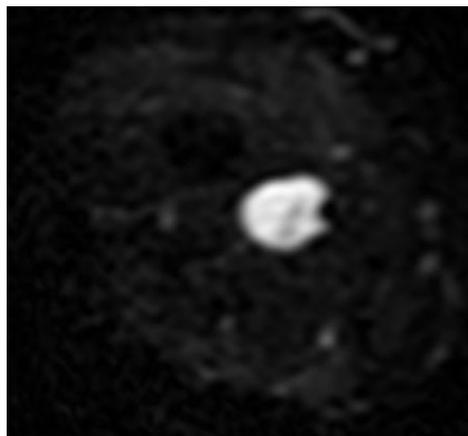
(b) Axial STIR



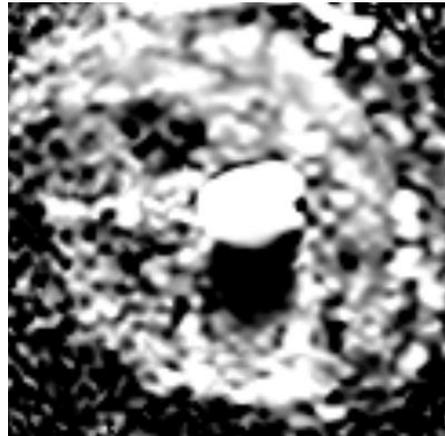
(c) Axial T1 post contrast



(d) coronal T1 post contrast



(e) DWI



(f) ADC

(Figure 6): (a) Axial T2 showing soft tissue mass at the posterior aspect of the thigh with hyper intense signal (b) Axial STIR showing hyper intense signal (c & d) Axial and coronal T1 post contrast fat suppression with

heterogeneous post Gadolinium enhancement (e) DWI most of the lesion show no restriction (f) Corresponding ADC map with mean value of 2.0×10^{-3} mm²/sec

Table (1): DWI with ADC value

Diffusion & ADC		
Restricted diffusion	n (%)	40 (80.0)
ADC value ($\times 10^{-3}$)	Median (range)	0.7 (0.5 - 2.4)

Table (2): follow up of the study group

Follow up findings		
Recurrence	Yes n (%)	26 (52.0)
Metastasis	Yes n (%)	22 (44.0)
Follow up (months)	Mean \pm SD	13 \pm 5

Table (3) : Value of ADC which showed Recurrence

		Recurrence		P value
		Yes	No	
ADC value	Median (range)	0.7 (0.5 - 1.4)	0.9 (0.5 - 2.4)	0.016

Discussion:

Magnetic resonance imaging is indispensable in the evaluation of soft tissue tumors and become modality of choice. It offers improved soft tissue contrast when compared to other modalities⁽¹²⁾.

It was concluded in study done in 2018⁽¹³⁾ that addition of DWI & quantitative ADC mapping to routine MR examination is advised for evaluation of soft tissue tumors especially in the inconclusive cases.

The DWI now is used in association with conventional MRI with the objective of improving diagnostic accuracy and treatment evaluation. DWI allows quantitative and qualitative analysis of tissue cellularity and cell membrane integrity and has been widely used for tumor detection and characterization to monitor treatment response⁽¹⁴⁾.

In the study in our hands, 80% of lesions showed restricted diffusion. Median ADC

value was $0.7 \times 10^{-3} \text{ mm}^2/\text{sec}$ and ranged from 0.5 to $2.4 \times 10^{-3} \text{ mm}^2/\text{sec}$.

Our results matched with a study done in 2017 ⁽¹⁵⁾ which revealed ADC value of benign tumors which ranged between 2.21×10^{-3} & $2.58 \times 10^{-3} \text{ mm}^2/\text{sec}$ and it was significantly higher than that of malignant soft tissue tumors which ranged between 0.90×10^{-3} & $1.82 \times 10^{-3} \text{ mm}^2/\text{sec}$, where the mean ADC value of all benign soft tissue tumors was $2.21 \pm 0.27 \times 10^{-3} \text{ mm}^2/\text{sec}$, while the mean ADC value of all malignant soft tissue tumors was $0.90 \pm 0.32 \times 10^{-3} \text{ mm}^2/\text{sec}$ with statistically significant difference ($p < 0.001$).

It also matched another study published in 2015 ⁽¹⁶⁾ in which the mean ADC value of benign masses was $2.31 \pm 1.29 \times 10^{-3} \text{ mm}^2/\text{sec}$ and mean ADC value of malignant masses was $0.90 \pm 0.70 \times 10^{-3} \text{ mm}^2/\text{sec}$ with statistically significant difference ($p < 0.001$).

Our results in that ADC has a role in predicting response therapy, being supported by a study done in 2019 ⁽¹⁷⁾ as in their study to evaluate neo-adjuvant therapy efficacy in accordance with response evaluation criteria in solid tumors (RECIST 1.1). ADC values in the non-progressive group were higher than those of the progressive group after neo-adjuvant treatment (1.63 ± 0.42 vs. 1.24 ± 0.35) with ($p < 0.005$). An increase in the

ADC value was not always associated with a reduction of tumor volume.

Conclusion:

Diffusion-weighted imaging (DWI) is a fast, non-contrast technique that is available and easy. DWI with apparent diffusion coefficient (ADC) mapping offers a quantitative method for soft tissue evaluation and has the value of regarding the cellularity of tumor. This article had highlighted the additive role of DWI in assessment of soft tissue sarcoma with emphasis on its prognostic value.

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