

## Comparison of DTPA and MAG3 renal scintigraphies in terms of differential renal function based on DMSA renal scintigraphy

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### ABSTRACT

**Objective:** Renal scintigraphy has privileges in imaging methods in terms of providing functional information. Technetium-99m dimercaptosuccinic acid (Tc-99m DMSA) used in imaging of renal parenchyma is the most reliable radiopharmaceutical in the calculation of differential renal function (DRF). In this study, it was aimed to compare the agents of dynamic renal scintigraphy such as Technetium-99m diethylenetriamine pentaacetic acid (Tc-99m DTPA) and Technetium-99m mercaptoacetyltriglycine (Tc-99m MAG3) based on Tc-99m DMSA in terms of DRF.

**Methodology:** Tc-99m DTPA and Tc-99m DMSA scintigraphies were performed in Group A; Tc-99m MAG3 and Tc-99m DMSA scintigraphies were performed in Group B. There were 57 patients [23 F, 34 M; mean age: 18.8 ± 17.1 years old (range: 3 months-60 years)] in Group A and 30 patients [15 F, 15 M; mean age: 15.7 ± 14.8 years old (range: 3 months-59 years)] in Group B. The DRF values calculated with Tc-99m DTPA and Tc-99m MAG3 were statistically compared with Tc-99m DMSA.

**Results:** Both Tc-99m DTPA and Tc-99m MAG3 were found quite concordant with Tc-99m DMSA in terms of DRF (p= 0.968, R2= 0.94 and p= 0.989, R2= 0.98, respectively).

**Conclusions:** Despite the fact that DMSA is accepted as the most reliable radiopharmaceutical in the determination of DRF, the reliable results are also obtained in dynamic renal scintigraphy which was carried out with DTPA or MAG3. In addition, the functional status of the kidney could be determined with these techniques. MAG3 scintigraphy may be mainly preferred because of giving better information than DTPA about both the function of the kidneys and the structure of the renal parenchyma.

**KEY WORDS:** Tc-99m DMSA, Tc-99m DTPA, Tc-99m MAG3.

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### INTRODUCTION

Differential renal function (DRF) is a relative quantitative measure for cortical involvement in patients with two kidneys. It shows the function of kidneys relative to each other. Although static (DMSA) renal scintigraphy is the main scintigraphic technique to demonstrate parenchymal function, the first 2-3 minutes of the images of the dynamic (DTPA or MAG3) renal scintigraphy can show parenchymal defects. Those images are also used for calculation of differential function. Thus, the advantage is gained to determine both the dynamic function as well as the differential function by using single test.

Recently the most widely used radiopharmaceuticals for dynamic renal scintigraphy are Tc-99m DTPA (diethylenetriamine pentaacetic acid), Tc-99m MAG-3 (mercaptoacetyl triglycine) and Tc-99m EC (ethylendisistein).

Static renal scintigraphy is based on imaging of functional renal parenchyma through the Tc-99m DMSA (dimercaptosuccinic acid) which is the radiopharmaceutical that is linked with intracellular proteins after being tubular extraction.

Static renal scintigraphy is mostly used for determining the cortical damage caused by urinary tract infection and additionally can give relative and absolute kidney functions. The technique is non-invasive and there is no known contraindication.

The aim of this study was to compare DRF values obtained from dynamic renal scintigraphy (Tc-99m DTPA and Tc-99m MAG3) with static renal scintigraphy (Tc-99m DMSA).

### METHODOLOGY

A total of 87 patients within two separate groups were included in this study. Group A consisted of 57 patients [34 M, 23 F; mean age: 18.8 ± 17.1 years old (range: 3 months-60 years)] who had both the dynamic renal scintigraphy with Tc-99m DTPA and the static renal scintigraphy with Tc-99m DMSA. Group B consisted of 30 patients [15 M, 15 F; mean age: 15.7 ± 14.8 years old (range: 3 months-59 years)] who had both the dynamic renal scintigraphy with Tc-99m MAG3 and the static renal scintigraphy with Tc-99m DMSA. Age distribution of the study groups were given at Table-I.

Table-I: Age distribution of patients according to study groups.

Age groups	Number of patients	
	DTPA	MAG3
0-7	17 (%29.8)	9 (%30)
8-17	22 (%38.6)	12 (%40)
≥18	18 (%31.6)	9 (%30)
Total	57	30

Patients had the pre-diagnosis of hydronephrosis mostly (17 patients in Group A, 11 patients in Group B) in both groups and also atrophy-hypoplasia (13 patients in Group A, 5 patients in Group B), ureteropelvic junction obstruction (11 patients in Group A, 4 patients in Group B), recurrent urinary tract infection (6 patients in Group A, 6 patients in Group B) and less often vesicoureteral

reflux, duplex system, the posterior urethral valve, nephrolithiasis, ectopic kidney (Fig.1).

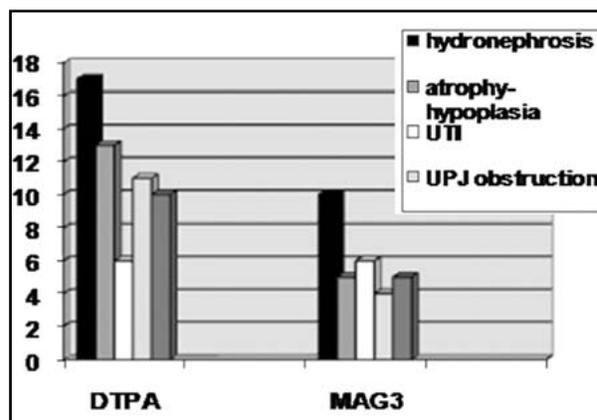


Fig.1: Distribution of the patients in Group A (DTPA group) and B (MAG3 group) according to pre-diagnosis.

Permission was received from Ethical Committee of our Faculty. Signed informed consent was taken from all patients or their parents. Patients' history, clinical information, height and weight measurements were noted.

SPECT gamma camera with double-head detectors (GE Infinia 2, GE Medical Systems, Israel) installed with low-energy high-resolution parallel-hole collimators was used in scintigraphic study. Both dynamic and static renal scintigraphy scans were performed in supine position. DRF was calculated from raw data on Xeleris program which is workstation program of the gamma camera system. Routine static Tc-99m DMSA renal scintigraphy was carried out on 87 patients. Tc-99m DMSA was given intravenously as 185 MBq (5 mCi) for adult patients and calculated according to their body weight for children [minimum 37 MBq (1 mCi)]. Pre-injection, post-injection and injection site counts were performed for 15 seconds in 256x256 matrices. Imaging of the patients was performed at the earliest three hours after injection. Images in 256x256 matrices for five minutes were obtained in anterior, posterior, right and left anterior and posterior oblique projections while the patient lays on supine position. While all the images were visually evaluated, only the anterior and posterior images were used to display quantitative calculation (DRF).

The patient's age, height and weight were recorded. Renal region of interests (ROIs) were drawn out without overflow from parenchyma around on anterior-posterior image of both kidneys. In addition, the perirenal backgrounds' ROIs were drawn besides kidney ROIs to correct background

activity (Fig.2). At the end, DRF was calculated as the value of percentage.



Fig.2: Renal and perirenal background ROI drawing on Tc-99m DMSA scintigraphy.

In Group A, 370 MBq (10 mCi) Tc-99m DTPA, and in Group B, 185 MBq (5 mCi) Tc-99m MAG3 (calculated dose according to the body weight for pediatric patients in both groups) were injected in dynamic renal scintigraphies. Bolus injections were made through a peripheral vein of the patients with consequent saline infusion. Dynamic imaging took 30 minutes in both scintigraphies. The image analysis was performed in "Renal Analysis" program on Xeleris workstation after completing imaging studies. The patient's age, height and weight were recorded. "Camera Based Gates" method for Tc-99m DTPA, "Camera Based ERPF modified Gates" method for Tc-99m MAG3 was used as clearance method in renal analysis program. Kidney and background ROIs were drawn through the dynamic images. The renal ROIs were drawn including the renal pelvis of the kidney and, infrarenal background ROI were also drawn (Fig.3). "Taylor Method" in the program was used in order to correct the depth. DRF was calculated in the

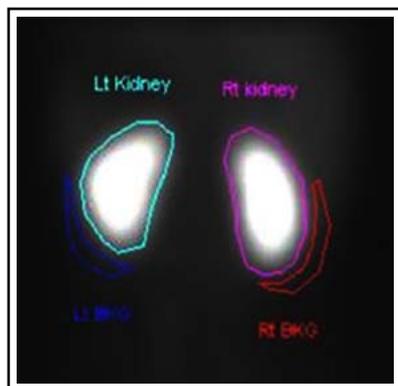


Fig.3: Renal and infrarenal background ROIs in DTPA and MAG3 dynamic renal scintigraphies.

first 2-3 minutes of images by computer program automatically after these process.

Multivariate analysis was used statistically for the comparison of the groups in terms of DRF based on Tc-99m DMSA.  $p < 0.05$  was considered statistically significant. Correlation and regression analysis was used to reveal the direction and functional status of the relationship of DMSA with DTPA and MAG3.

## RESULTS

The average DRF values of DTPA and MAG3 in Group A and B were separately calculated with standard deviations to compare the DRF values of DMSA (Table II and III).

Table-II: The mean DRF values in Group A.

	Mean $\pm$ SD
DMSA left	55.78 $\pm$ 21.34
DTPA left	54.84 $\pm$ 19.59
DMSA right	44.22 $\pm$ 21.34
DTPA right	45.16 $\pm$ 19.59

Table-III: The mean DRF values in Group B.

	Mean $\pm$ SD
DMSA left	50.12 $\pm$ 24.84
MAG3 left	50.49 $\pm$ 23.98
DMSA right	49.88 $\pm$ 24.84
MAG3 right	49.51 $\pm$ 23.98

DRF values which were calculated with Tc-99m DMSA static renal scintigraphy and Tc-99m DTPA or Tc-99m MAG3 dynamic renal scintigraphy were also compared statistically without group discrimination for left kidney and right kidney and also by gender and age separately. No significant difference was found between DRF in both groups according to gender and age (in Group A  $p = 0.725$ ,  $p = 0.329$ , respectively; in Group B  $p = 0.666$ ,  $p = 0.434$ , respectively). In correlation test which was carried out to assess the relationship between the results of DMSA-DTPA and DMSA-MAG3 in terms of DRF for left and right kidney, both the DTPA and MAG3 were found to be correlated with DMSA ( $p = 0.968$ ,  $p = 0.989$ , respectively). The values were also compared with regression analysis. Regression analysis also revealed that DMSA value was compatible with the values of DTPA and MAG3 ( $R^2: 0.94$  and  $R^2: 0.98$ , respectively) (Fig. 4 and 5).

## DISCUSSION

Differential renal function is calculable and reliable parameter can be achieved both in dynamic and static renal scintigraphies easily. It is an important

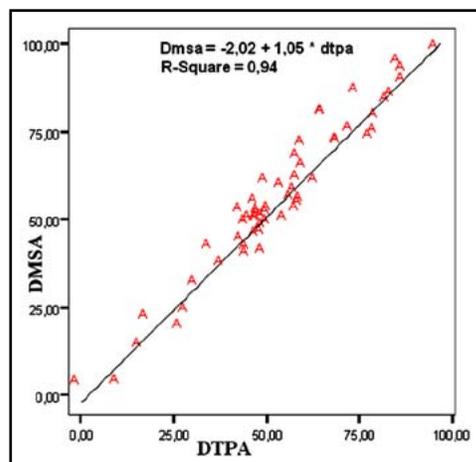


Fig.4: Regression analysis result of Group A.

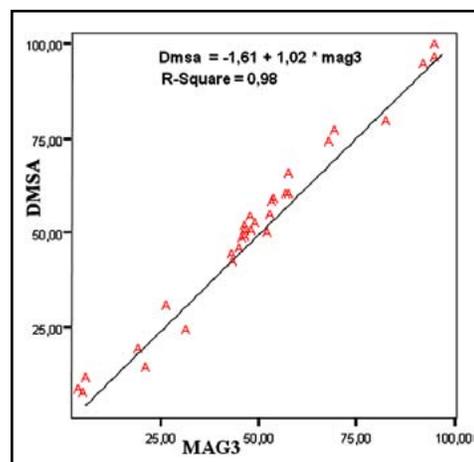


Fig.5: Regression analysis result of Group B.

factor affecting the decision of surgical procedure for repair or nephrectomy of patients especially with poor kidney function. It provides follow-up facility to the clinician after surgery in terms of determination of the effect of surgical procedure on kidney function. It also allows a more objective comparison possibility via the quantitative values and visual evaluation for the scintigraphic follow-up of diseases that can cause cortical damage.

DRF can be calculated with scintigraphical techniques by using static (cortical) renal scintigraphy with Tc-99m DMSA as the radiopharmaceutical and, using dynamic renal scintigraphy with Tc-99m DTPA, Tc-99m MAG3, Tc-99m EC or iodine-131 orthoiodohippurate (I-131 OIH) as the radiopharmaceuticals.

It is possible to assess parenchymal function of the kidneys both visually and quantitatively by Tc-99m DMSA scintigraphy and also to calculate differential and absolute renal function.<sup>1,2</sup> DRF can be calculated accurately by using some radiopharmaceuticals which are excreted by glomerular filtration or tubular secretion. Parenchyma can be evaluated by means of dynamic scintigraphy almost as good as Tc-99m DMSA scintigraphy. In the previous studies, no clinically significant difference was found between Tc-99m DMSA and Tc-99m MAG3 in terms of differential functions. In addition, it has been shown that Tc-99m MAG3 able to detect parenchymal damage with 88% specificity and sensitivity.<sup>3,4</sup>

Glomerular filtration rate can be calculated with Tc-99m DTPA as a glomerular agent and the effective renal plasma flow with Tc-99m MAG3 or with Tc-99m EC as tubular agents.<sup>5</sup> Among these radiopharmaceuticals there may be some advantages and disadvantages against each other. For example, in a

study including patients with renal dysfunction or kidney transplantation, Tc-99m DTPA and Tc-99m MAG3 were compared; Tc-99m MAG3's plasma clearance was faster than Tc-99m DTPA, parenchymal transit time was usually slower and because of Tc-99m DTPA's signal-to-noise ratio was high Tc-99m MAG3 images were better.<sup>6</sup> It was concluded that in case of transplanted kidney or renal failure, Tc-99m MAG3 is more advantageous than Tc-99m DTPA but Tc-99m DTPA cannot be replaced with Tc-99m MAG3, because of its opportunity of calculation of glomerular filtration rate.

In a study comparing plasma clearance and renograms of Tc-99m MAG3 with I-123 and I-131 OIH, differential functions obtained from Tc-99m MAG3 and I-123 OIH scintigraphies parenchymal transit time indexes were correlated.<sup>7</sup> It was concluded that Tc-99m MAG3 have some advantages over Tc-99m DTPA in terms of the image quality; it can replace I-123 OIH for routine renogram, DRF and parenchymal transit time evaluation, but it can't replace I-123 OIH for the evaluation of renal plasma flow. Similar to that study, in patients with obstructive renal disease Tc-99m EC, Tc-99m MAG3 and I-131 OIH were compared in terms of  $t_{max}$ ,  $t_{1/2}$  and DRF; all of the radiopharmaceutical was found correlated well with each other. Because of its low radiation dose and high quality images Tc-99m EC, like Tc-99m MAG3, can replace I-131 OIH.<sup>8</sup> Easier preparation of Tc-99m EC kit and a lower hepatobiliary uptake was emphasized as advantages against Tc-99m MAG3. However, Tc-99m MAG3 is more commonly used nowadays because Tc-99m EC is more expensive. In a similar study of us, Tc-99m DTPA and Tc-99m EC were compared with Tc-99m DMSA in terms of DRF.<sup>9</sup> There was no statistically

significant difference between Tc-99m EC with Tc-99m DMSA, but there was significant difference between Tc-99m DTPA with Tc-99m DMSA. In a recent experimental study in rabbits, after 1, 2, 3 and 4 weeks of unilateral ureteral ligation, Tc-99m DMSA static, Tc-99m DTPA and Tc-99m MAG3 dynamic renal scintigraphy were performed and these radiopharmaceuticals were compared with each other in terms of DRF. There was no significant difference between these radiopharmaceuticals and it was emphasized that Tc-99m DTPA and Tc-99m MAG3 can replace Tc-99m DMSA to determine the DRF.<sup>10</sup> We included patients with different kinds of renal pathologies to the study and compared DRF estimation for these radiopharmaceuticals.

Using different analyzing methods in calculation of quantitative parameters may lead different results. According to a study which included 30 patients without renal impairment, DRF was calculated with different analysis programs for Tc-99m DMSA and Tc-99m MAG3 scintigraphies.<sup>11</sup> Applying integral and Rutland-Patlak methods with subrenal or perirenal background activity correction was considered more accurate and reliable DRF results in normal and renal insufficiency patients. Slope method was found less reliable than these two methods. In another study, DRF with no background correction and with drawing different ROIs for background correction was compared for Tc-99m MAG3 and Tc-99m DMSA scintigraphies.<sup>12</sup> Tc-99m DMSA and Tc-99m MAG3 were in good correlation with each other but right kidney functions were higher for suprarenal and C form perirenal ROIs. In all groups, especially in patients with DRF below 35%, results showed variety. It was emphasized that this was especially important for follow-up of patients and renal analysis of those patients has to be performed with same background activity corrections.

We used background activity correction methods both in dynamic and static scintigraphy in our study. Automated perirenal background ROI was used in the calculation of DRF in Tc-99m DMSA static scintigraphy. Infrarenal ROIs were drawn manually in the Tc-99m MAG3 and Tc-99m DTPA scintigraphy. Tc-99m DTPA and Tc-99m DMSA scintigraphy showed a fairly statistically good correlation in terms of DRF ( $p = 0.968$ ,  $R^2 = 0.94$ ). Tc-99m MAG3 and Tc-99m DMSA scintigraphy was also found almost completely compatible with each other ( $p = 0.989$ ,  $R^2 = 0.98$ ). There wasn't statistically significant difference in terms of age and sex in each group.

## CONCLUSION

In the dynamic renal scintigraphy carried out with DTPA or MAG3, DRF can be determined as reliable as with DMSA scintigraphy which is considered the gold standard. In addition, the functional status of the kidneys can be determined by these investigations.

MAG3 scintigraphy may be more preferable since it gives better information than DTPA about both the functional status and the parenchymal visualization of the kidneys. Neither age nor gender influences the determination of DRF by static or dynamic renal scintigraphy.

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