ORIGINAL ARTICLE

Comparative study of functional values related renal calculated with ^{99m}Tc-DTPA and ^{99m}Tc-DMSA on 42 patients in the nuclear medicine department of the hospital général Idrissa Pouye

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ABSTRACT

Background: The assessment of renal function is a major challenge in nuclear medicine, in particular for the diagnosis and follow-up of kidney's pathologies. The technical scans using ^{99m}Tc-DMSA and the ^{99m}Tc-DTPA, are widely used to measure relative renal function (RRF). The ^{99m}Tc-DMSA provides a static analysis of the renal parenchyma and the detection of scars. The ^{99m}Tc-DTPA offers a dynamic approach in assessing the glomerular filtration rate (GFR). This study aims to compare these two methods in order to determine their degree of correlation and their possible interchangeability.

Methods : The study was conducted in the Nuclear Medicine Department of the Hospital General Idrissa Pouye in Dakar, on a sample of 42 patients whose average age was 3.38 years.

Results: The correlation analysis and bivariate analysis revealed a significant positive correlation ($r = 0.996$, $p < 0.001$) between the RRF calculated by the two methods. Following the diagnosis of patients, the ANOVA test showed no significant difference between the RRF calculated for the kidneys (left and right). The Bland-Altman plot analysis indicated a mean difference close to zero between the two methods, estimated at −0.43 for the right kidney and 0.43 for the left kidney. The limits of agreement range from −13.02 to 12.17 for the right kidney and −12.15 to 13.01 for the left kidney.

Conclusion: According to the results obtained in this study, the methods of scintigraphy using ^{99m}Tc-DMSA and the ^{99m}Tc-DTPA provide values of relative renal function on the (RRF) is almost identical, thus making them to be calculated systematically with the two techniques are not essential. The ^{99m}Tc-DMSA could be the choice of first-line for the evaluation of the RRF. However, if a measure of the GFR and an analysis of the curve of the rénogramme are necessary, the ^{99m}Tc-DTPA is a preferred option.

Keywords: Relative renal function, ^{99m}Tc-DMSA, ^{99m}Tc-DTPA, Bland-Altman plot.

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Introduction

Relative renal function is a very important parameter to inform the decision-making process and guide the optimal management of patients with renal pathologies, such as renal atrophy, ureteropelvic junction obstruction, and pyelonephritis sequelae. ^{99m}Tc-DMSA allows static analysis of renal parenchyma and scar detection [1-3]. It is considered as most reliable method for measuring relative renal function and the most appropriate tracer for renal cortical imaging. Dynamic renal scintigraphy using diethylenetriamine pentaacetic acid (DTPA) labeled with metastable technetium 99 (^{99m}Tc), which is a non-invasive physiofunctional isotope imaging modality, allows the assessment of renal function and exploration of the urinary excretory tract [4,5]. The objective of this study was to compare Tc-DMSA scintigraphy and Tc-DTPA scintigraphy in the assessment of RRF.

Material and Method

Type of study

This is a retrospective study, involving a comparative analysis of Relative Renal Function (RRF) was assessed using ^{99m}Tc-DMSA and ^{99m}Tc-DTPA in patients with different kidney diseases performed over the period between January 2022 to December 2024.

Framework of the study

Our study has been performed in the Nuclear Medicine Department of the Hospital
General Idrissa Pouye, in Dakar.

Study protocol

Scans, DTPA and DMSA were performed for all patients with an interval of 10 periods (4 days). A gamma camera Nuclide MEDISO double head, LEHR has been used.

The patients received an injection of 20 -111 MBq (with 0.5 of 4.5 mCi). Static images were acquired with a matrix of 256 × 256 after a period of 2-4 hours, implications later. The images have been stored for up to 500 kilo-counts per view.

The DTPA scan was performed in the supine position. All patients received an injection of 20 MBq of 180 MBq (0.5-7 mCi) of the radiopharmaceutical. The doses are calculated with the Pediatric Dosage Card. The acquisition lasted 30 minutes, generating a series of images in 128 × 128 format, with the protocol Furosemide (F+20).

An analysis of the Bland-Altman plot was performed to graphically show the comparison between the values of FRR obtained with the DMSA and DTPA for both kidneys.

Patients

Inclusion criteria

We had to include all the patients who were referred to the Nuclear Medicine Department, and had received a scintigraphic renal dynamic Tc-^{99m}DTPA and static Tc-^{99m}DMSA.

Criteria of non-inclusion

Subjects with a kidney that is non-functional kidney have not been included in our sample.

RStudio version R4.3.1 has been used to analyse the data.

Results

Characteristics of the study population

We have recorded 42 patients: 28 boys (67%) and 14 girls (33%). The average age was approximately 3.38 years old, with extreme ages ranging from 26 days to 20 years and a SD of 5.39 years.

- Analysis of Bland-Altman plots for the Comparison of the Values of Renal Function on (FRR) between the DMSA and DTPA.
- Figure 1 shows the Bland-Altman plot analysis of DMSA and DTPA for the right kidney.
- Figure 2, as well as analyses have been carried out in the following contexts.
- Syndrome of the junction pyélo-ureteral (SJPU) (Figures 3 and 4).

Average of the differences (Mean_diff)

- The average value of the differences between the two methods is 0.43, indicating excellent overall concordance.

Limits of agreement [lower limit (LL) and upper limit (UL)]

- The limits of agreement were calculated as the mean ± 1.96 times the gap-type differences.
  - o LL: −13.02
  - o UL: 12.17

Dispersion of points

- The points are distributed fairly uniform around the mean line (Mean_diff), with no obvious trend for the differences to increase or decrease with the average of the measurements.

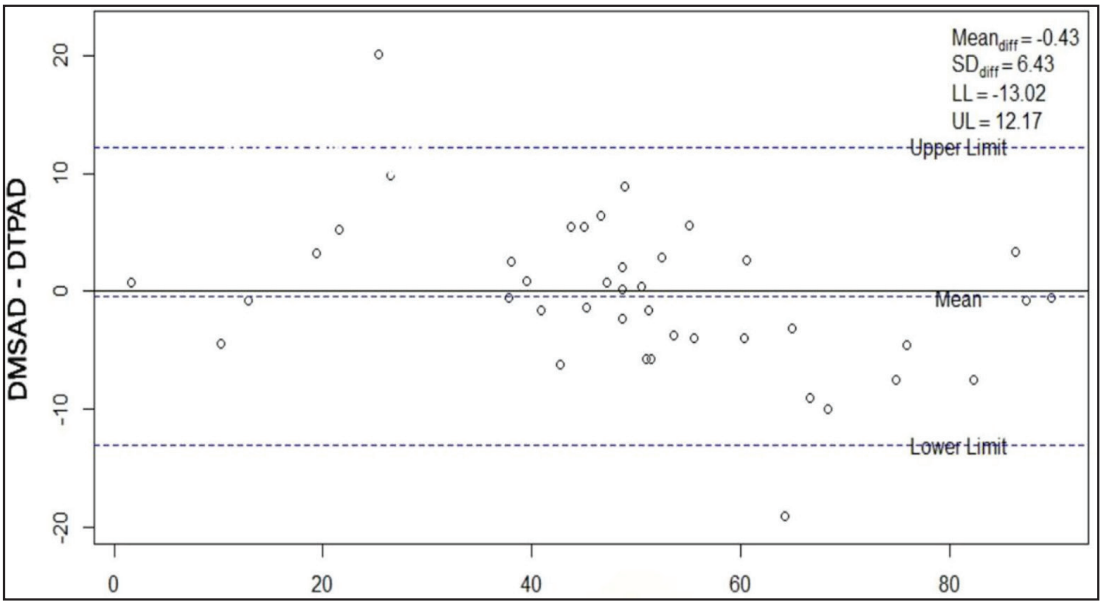

***Figure 1**. Bland-Altman plots for the comparison between DMSA and DTPA for the right kidney.*

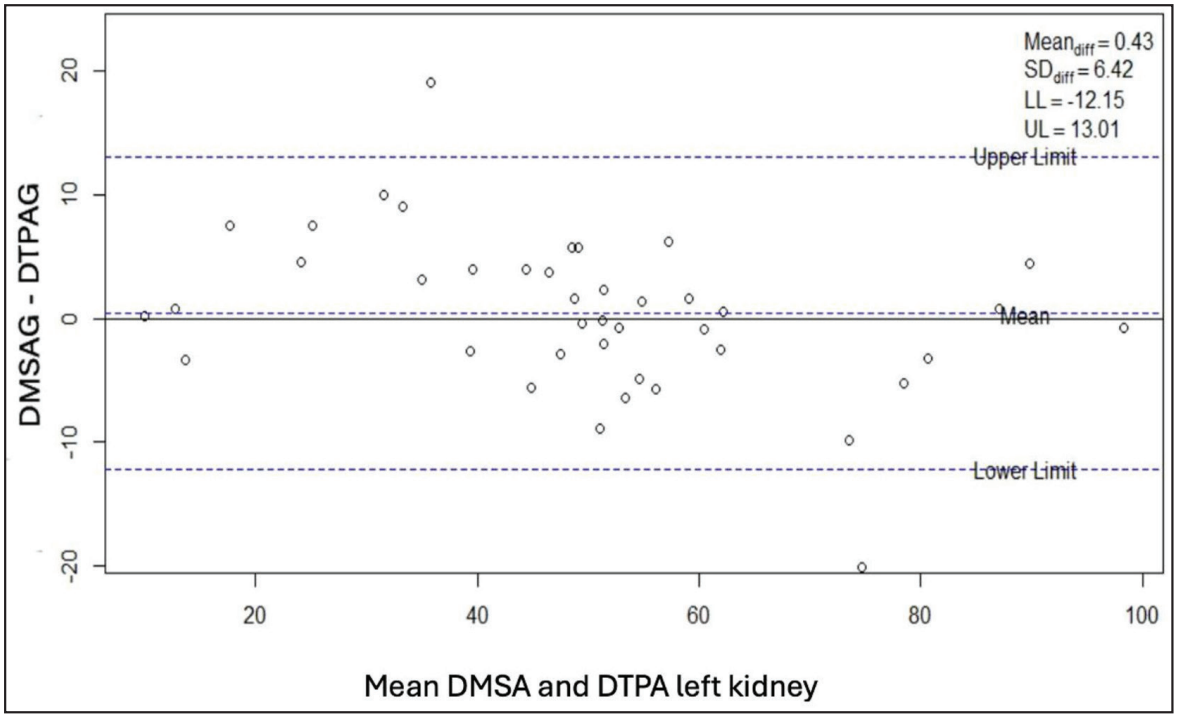

***Figure 2**. Graph of Bland-Altman plots for the comparison between DMSA and DTPA for the left kidney.*

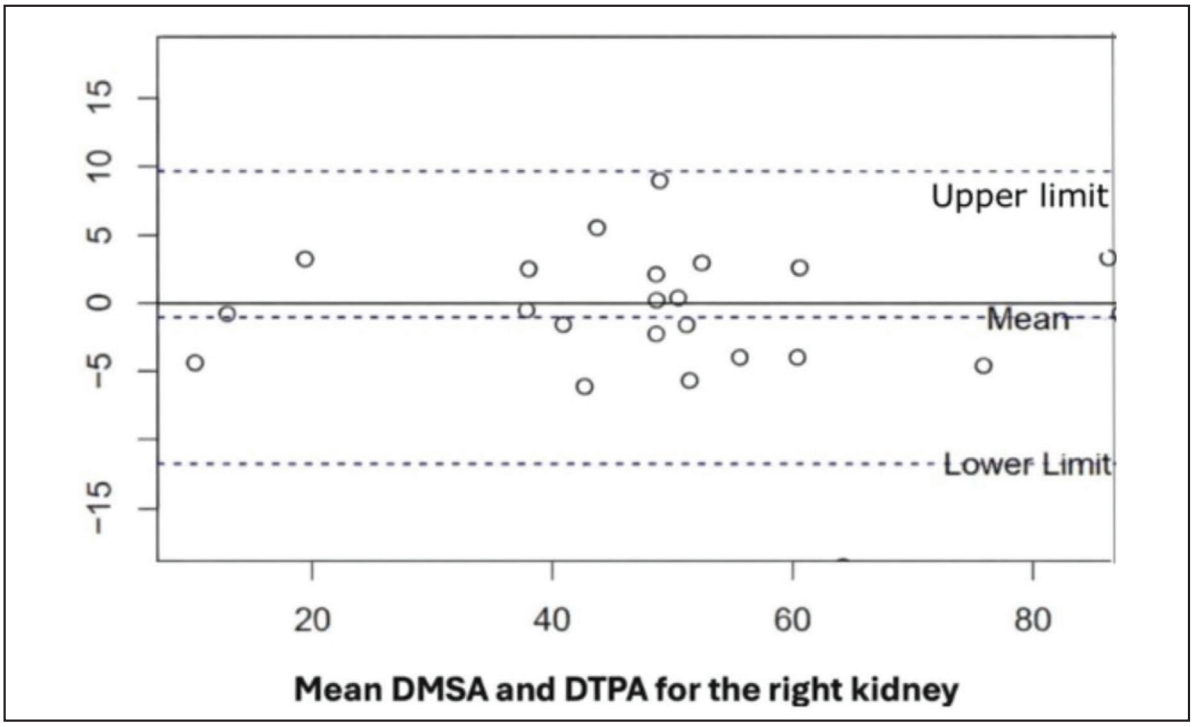

***Figure 3**. Bland-Altman plots for the comparison between DMSA and DTPA in the SJPU.*

Average of the differences (Mean_diff)

- The average difference between the two methods is 0.43, indicating an overall concordance high between 99mTc-DMSA and 99mTc-DTPA for the left kidney. Unlike the right kidney (where the average difference was slightly negative), here, 99mTc-DTPA tends to yield slightly higher values than 99mTc-DMSA.

Limits of agreement (LL and UL)

- The limits of agreement were calculated as the mean ± as 1.96 times the standard deviation of the differences :
  - LL: −12.15
  - UL: 13.01

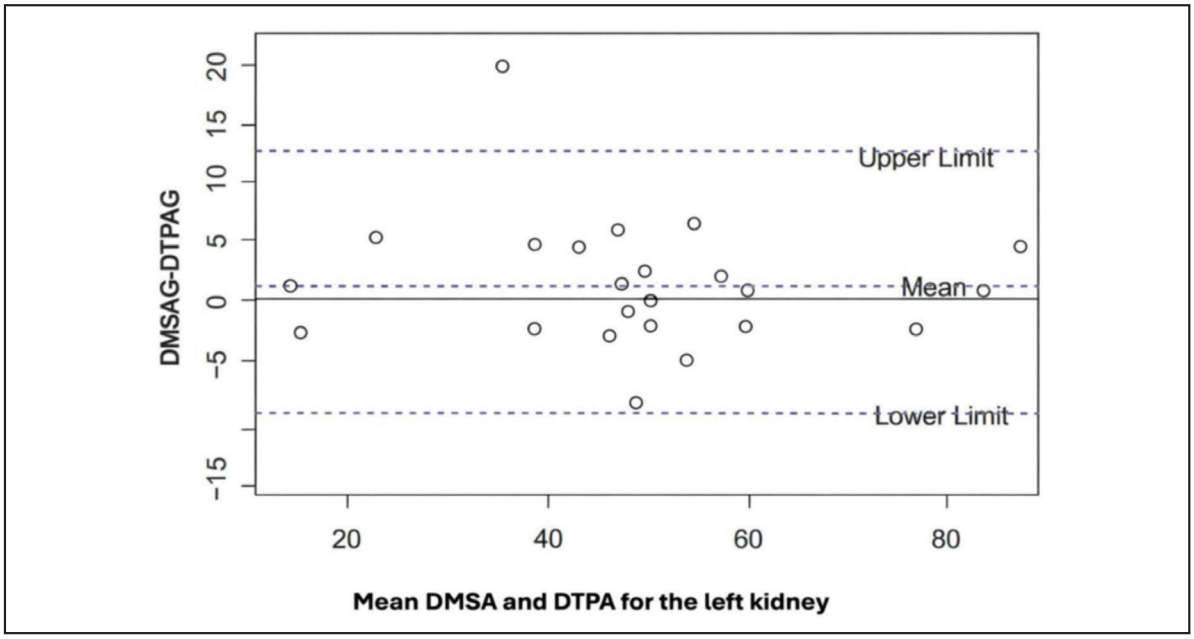

Figure 4*. Graph of Bland-Altman plots for the comparison between DMSA and DTPA in the SJPU.*

Dispersion of points

- The points are distributed evenly around the mean line (Mean_diff), without a significant link between the average of the measured values and the difference.
- Right kidney (Figure 3): The mean difference was −1.04, with a SD of 5.44. The limits of agreement were 9.62 to −11.71.
- Left kidney (Figure 4): The mean difference was 1.03, with a SD of 5.45. The limits of agreement were −9.66, 11.72.

Correlational analysis

A significant positive correlation ($r = 0.9702$, $p < 0.001$) was found between the values of Relative Renal Function (RRF) calculated with the ^{99m}Tc-DMSA and the ^{99m}Tc-DTPA. The ANOVA test was conducted, and it was found that there was no difference between renal function when calculated with the ^{99m}Tc-DTPA or ^{99mT}c-DMSA between the kidneys, left and right. The results are presented graphically in Figures 5 and 6.

- Right kidney (Figure 5): The linear regression line has an equation of the form y = 0.9497 x + 2.5193, with a coefficient of determination R2 = 0.9701.
- Left kidney (Figure 6): The linear regression line has an equation of the form y = 0.9501 x + 2.4964, with R2 = 0.9701.

Discussion

Relative Renal Function (RRF) is an essential step in the evaluation of kidney disease to quantify the functional contribution of each kidney. This study compared two methods of scintigraphy thare are widely used ^{99m}Tc-DTPA and ^{99m}Tc-DMSA.

The Bland-Altman plots for the kidneys, right and left (Figures 1 and 2) shows a comparative assessment of the accuracy of renal function relative (RRF) when measured with ^{99m}Tc-DMSA or ^{99m}Tc-DTPA. These graphs provide essential information on the alignment of two techniques, highlighting the global trends and specific cases where gaps can occur [6].

In the studies of ^{99m}Tc-DMSA, the RRF is calculated using the geometric mean, and taking into account the depth of the kidney by acquiring images anterior and posterior [7-9]. In contrast, in the studies of ^{99m}Tc-MAG and the ^{99m}Tc-DTPA, the RRF is calculated on the images obtained on a posterior position [10].

The scan using ^{99m}Tc-DMSA has been considered as a reliable method to evaluate the RRF because of the radiotracer used, principally in the convoluted tubules, proximal, for a period long enough to allow a static visualization of the activity tubular and can be done in several minutes [11-13]. This improves the statistical values of a number of counts for a given activity. However, the estimation of the RRF using the ^{99m}Tc-MAG$_3$ and ^{99m}Tc-DTPA should be carried out in the first minutes of a dynamic imaging, which usually lasts for 20-30 minutes in most of the centres. The count limitation decreases and also the statistical value of the measurement [11].

In addition to the correlation analysis and regression, we performed an analysis of Bland-Altman to show a visual representation of the level concordance of the methods [14,15] (Figures 1 and 2). In the Bland-Altman plots, if both methods are totally consistent, all measured values are to be located on the line of mean difference and this line should coincide with the zero line (line of equality) [16,17]. The

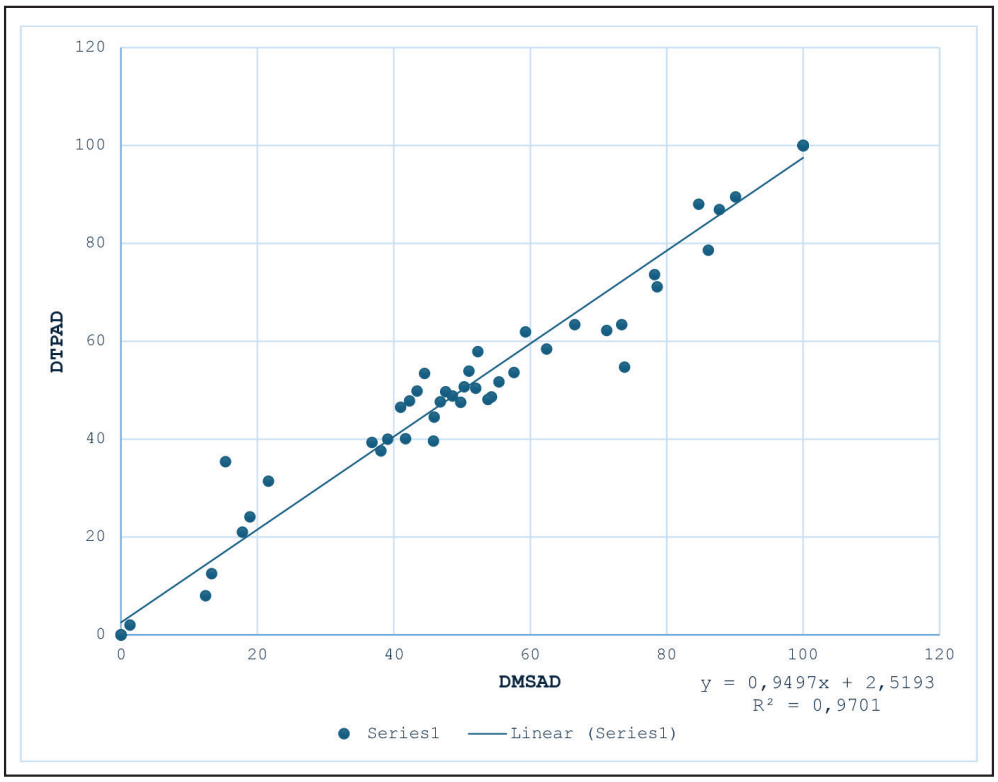

***Figure 5**. Correlation between DTPA and DMSA for the right kidney.*

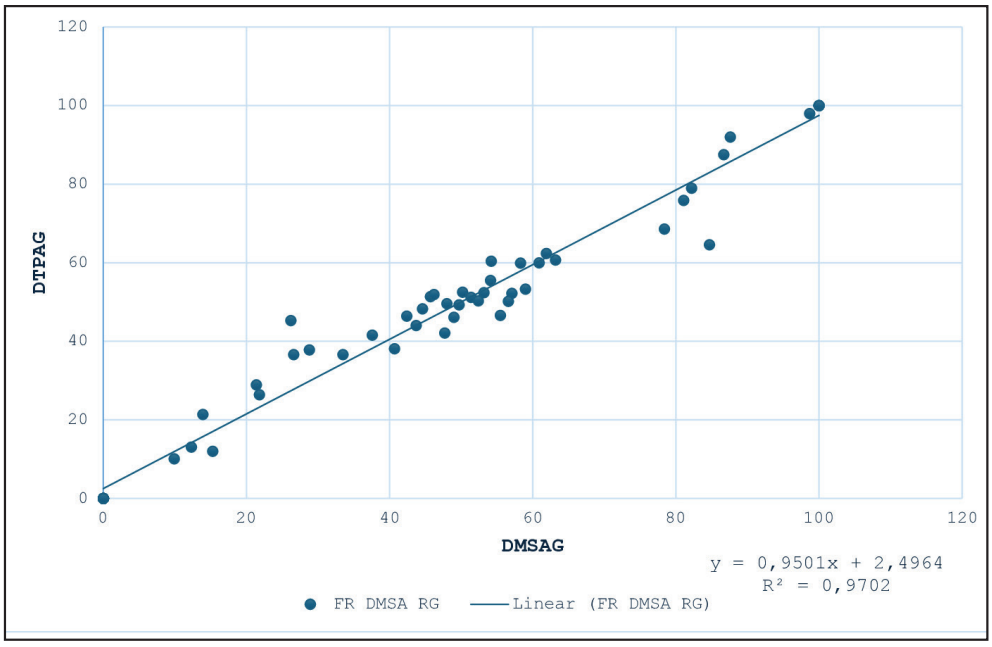

***Figure 6**. Correlation between DTPA and DMSA for the left kidney.*

^{99m}Tc-DTPA and ^{99m}Tc-DMSA, which are used in the calculation of the RRF for the Bland-Altman plots, showed that the line of mean difference was situated very near the line zero (Figures 1 and 2). This indicates a perfect agreement of the two methods in the calculation of the RRF [14].

In our study, the Bland-Altman plots showed mean differences between the two methods are close to zero: 0.43, with limits of agreement between −13.02 and 12.17 to the right kidney and between −12.15 and 13.01 for the left kidney. These values indicate a strong agreement between the two techniques, confirming that the two methods provide interchangeable values and are reliable for the clinical evaluation of RRF. These observations are in agreement with the work of Lee et al [18], Domingues et al. [19] and Çelik et al. [20], who also reported high correlations between DMSA and DTPA in the evaluation of the RRF.

Another study conducted in 2001 by Sari et al. [21] comparing the functional values obtained with DTPA and

DMSA in 42 children aged 10.5 years old. This study had shown no statistical difference in the functional values obtained by both tracers.

Similarly study conducted by Yalçin et al. [22] conducted on 144 patients showed an average of RRF in the DTPA 52.54% ± 23.09% and 47.25% ± 23.09%, with the DMSA 52.85% ± 21.80% and 47.07% ± 21.77% for right and left kidneys. The bivariate correlation analysis showed a significant positive correlation between the two tracers with $r = 0.937$, $p < 0.001$). The Bland-Altman plot analysis showed the difference between the two methods was 0.3 and the limits of correlation between 16.2 and 15.5.

Despite the overall alignment of the results, some values are outside of the limits of agreement, both for the right and left kidney. These outliers could be due to specific pathologies such as kidney atrophic, renal scarring, or obstructions unilateral.

For example:

- Right kidney: The case outside of the boundaries may reflect a reduced sensitivity of 99mTc-DTPA to evaluate minor morphological alterations. These observations are consistent with the findings of Itoh et al. [23], which showed that DTPA sometimes underestimating the differences in kidney pathological.
- Left kidney: The differences could also be related to functional alterations and were more pronounced with 99mTc-DMSA [24].

These results emphasize that, although the two methods are interchangeable in a normal context, reviews and more detailed information with DMSA are often necessary in the case of complex diseases.

The homogeneous dispersion of points around the line of average, observed for the two kidneys, indicates an absence of systematic bias. This suggests that the alignment between ^{99m}Tc-DTPA and ^{99m}Tc-DMSA remains constant over the entire range of values of RRF. In other words, the arrangement is not dependent on the severity of renal impairment or the relative function of the kidney assessed, reinforcing the robustness of these two techniques in the clinical assessment.

The results of the analysis of the correlation between ^{99m}TcDTPA and ^{99m}Tc-DMSA (Figures 5 and 6) showed a strong linear correlation between measures of RRF obtained by ^{99m}Tc-DTPA and ^{99mTc}-DMSA for the right and left kidneys. The regression equations for each kidney are similar.

The regression coefficient (~0.95) and the coefficient of determination (R^2~97%) for both kidneys show a concordance almost perfect between the two techniques. These results confirm that the two methods are highly proportional and interchangeable to assess RRF.

For the two kidneys, the constants in the regression equations show a slight systematic bias (~+2.5), where the values of ^{99m}Tc-DTPA tend to be slightly higher than those of ^{99m}Tc-DMSA for low values of RRF. This bias is low and remains constant, which does not significantly affect the overall accuracy.

The correlation analysis reveals a minimum spread around the regression line, indicating a strong coherence between the methods over the entire range of values of RRF (0-100). A few points that deviate slightly from the regression line may be related to factors such as anatomical abnormalities, renal scarring, or differences between observers. These differences are, however, weak and non-significant at the clinical level.

In reference to the literature, our results show a strong correlation is very between the values of RRF obtained with ^{99m}Tc-DTPA and ^{99m}Tc-DMSA ($r = 0.996$, $p < 0.001$). These data lend support to the work of Çelik et al. [20], who reported similar results in 128 children who were analyzed retrospectively. The mean values measured with the ^{99m}Tc-DTPA and ^{99m}Tc-DMSA were, respectively, 51.58 ± 14.95 and 51.96 ± 14.99 for the right kidney, and 47.87 ± 15.27 and 47.94 ± 15.17 for the left kidney. A significant positive correlation was observed between renal function-related ($r = 0.963$, $p < 0.001$). Muller-Suur and Gutsche [25], as well as Britton et al. [26] were also aligned with our results. In the Bland-Altman plots, the mean difference between the two methods was 0.7, with limits of correlation ranging between 10.1 and −10.8. However, although the method DMSA is known for its accuracy in the evaluation of the morphology of the cortical and renal scarring [1,24,27], the DTPA method offers advantages for measuring the Glomerular Filtration Rate (GFR), and to generate renogram curves.

Despite this high correlation, some studies, such as those of Domingues et al. [19] and Itoh et al. [23], have suggested that the accuracy of the RRF obtained with ^{99m}Tc-DTPA is slightly lower than that obtained with ^{99m}Tc-DMSA in some specific cases. This could be attributed to the dynamic nature of the ^{99m}Tc-DTPA, which is influenced by factors such as renal blood flow and GFR, as opposed to the static attachment and extended ^{99m}Tc-DMSA in the renal cortex.

The Bland-Altman plots showed values consistent with the results of Taniju Çelik et al. [20], which have also noted an increased variability in patients with structural abnormalities severe. These cases require careful interpretation and could justify the joint use of the two methods, or other imaging techniques, such as Doppler ultrasound or MRI.

The clinical implications of these results show that the use of ^{99m}Tc-DMSA appears to be ideal for the scenario requiring a morphological evaluation, in particular, to detect renal scarring after pyelonephritis, acute [1,24,28]. On the other hand, ^{99m}Tc-DTPA is preferred when a functional measurement dynamic range is required, such as the evaluation of the Glomerular filtration Rate (GFR) or the follow-up of patients with pathologies obstructive [29,30].

Conclusion

According to the results obtained in this study, the methods of scintigraphy using ^{99m}Tc-DMSA and the ^{99m}Tc-DTPA provide nearly identical RRF values, thus making them to be calculated systematically with the two techniques are not essential. The ^{99m}Tc-DMSA could be the choice of first-line for the evaluation of the RRF. However, if a measure of the GFR and an analysis of the curve of the rénogramme are necessary, the ^{99m}Tc-DTPA is a preferred option.

List of abbreviations

DMSA	dimercaptosuccinique acide
DTPA	diethylenetriamine pentaacetic acid
GFR	Glomerular Filtration Rate
MAG3	mercapto acetyl tri glycine
MRI	Magnetic Resonnance imaging
RRF	Relative Renal Function
SJPU	Syndrome of the junction pyélo-ureteral

Conflict of interests

The authors declare that there is no conflict of interest regarding the publication of this article.

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Consent to participate

Not applicable.

Ethical approval

Not applicable.

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