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Research Article

Effect of Nursing Intervention on Self-Management and Quality of Life in Patients with Chronic Kidney Disease Evaluated by Renal Diffusion Tensor Imaging Features Using Image Registration Algorithm

Zongqiong Zhou

Department of Nephrology, Chongqing Fuling Central Hospital, Chongqing 408000, China

Correspondence should be addressed to Zongqiong Zhou; 2018211303@mail.chzu.edu.cn

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The aim of this research was to explore the effect of nursing intervention on self-management and quality of life in patients with chronic kidney disease (CKD) by using the renal diffusion tensor imaging (DTI) feature of image registration algorithm. A total of 100 patients with CKD were randomly divided into experimental group (nursing maintenance guidance intervention) and control group (routine nursing), with 50 cases in each group. The image effect before and after registration, self-management behavior after 6 months, quality of life, DTI-related parameters, and renal function indicators were collected and analyzed. The results showed that the images were clearer than those before registration, the self-management ability in the control group (92.81 ± 19.32) was smaller than that in the experimental group (107.12 ± 18.78), the quality of life in the experimental group (121.47 ± 11.21) was greater than that in the control group (104.89 ± 12.11), and the corresponding magnetic resonance apparent diffusion coefficient (ADC) (2.54 ± 0.28) and fractional anisotropy (FA) (0.28 ± 0.07) in the cortex were greater than those in the control group (2.35 ± 0.21, 0.23 ± 0.04). The differences were statistically significant ($P < 0.05$). The corresponding ADC value (2.32 ± 0.22) and FA value (0.59 ± 0.02) of medulla were greater than those of the control group (2.12 ± 0.24 and 0.41 ± 0.17). The levels of serum creatinine (Scr) (μmol/L) (421.38 ± 42.78) and 24 h urinary protein (24 h-Upro) (mg/d) ($1{,}836.7 \pm 545.98$) were lower than those of the control group, and the differences had statistical significance ($P < 0.05$). In summary, the registration algorithm can enhance the effect of image presentation and nursing intervention has positive significance for the self-management and quality of life of patients with CKD.

1. Introduction

Chronic kidney disease (CKD) is defined as a disease with a duration of more than 3 months, which causes changes in renal structure as well as disturbances in renal function. In the treatment, some existing therapeutic measures mainly include taking drugs for treatment, giving nutritional support to the body, and alternative treatment for severe patients [1]. Therefore, for some end-stage patients, their kidneys have been severely damaged and some corresponding physiological functions have been lost, and replacement therapy will be considered in clinical practice. Replacement therapy is also divided into three categories, including hemodialysis, peritoneal dialysis, and renal transplantation. Some drugs such as angiotensin-converting enzyme inhibitors (ACEI), angiotensin II receptor blockers (ARB), and erythropoiesis-stimulating agents (ESA) are mainly used in the use of drugs [2]. However, the treatment of the disease only using drugs and surgery is not necessarily the best for the rehabilitation effect of patients. The long treatment course of patients with CKD will lead to physical and mental suffering of patients if their daily diet and life are not controlled, and it is also detrimental to the recovery of patients. Therefore, in addition to basic treatment, the addition of nursing intervention will be more helpful for the remission of the patient's condition.

Nursing intervention is proposed based on certain physiological and pathological scientific theories, is through some corresponding scientific experiments, and can indeed help doctors give more comprehensive treatment to patients in clinical practice to a certain extent. Nursing intervention requires comprehensive consideration of many aspects such as disease, family, and psychology according to the specific circumstances of patients in clinical practice and then making the corresponding diagnosis, and the corresponding nursing staff needs sequential, targeted, and scientific nursing according to nursing guidance [3, 4]. In this process, reasonable reference to the existing research results, analysis of various functional indicators of patients and expected degree of recovery, and professional clinical knowledge can achieve a good intervention effect, so as to achieve the expected results of helping the patient's physical and mental recovery, preventing complications and promoting, maintaining, or restoring the patient's physical and psychological function [5]. Interventions can be divided into different processes due to different nursing operators and nursing environments: first, it is necessary to create a rehabilitation environment with comfortable environment and complete equipment; furthermore, it is necessary for nurses with professional literacy and skills to carry out corresponding rehabilitation nursing operations; in this process, it is also necessary to obtain the assistance of family members and provide corresponding health education for family members; in addition to physical care, it is necessary to care for the psychological problems of patients, regularly carry out psychological guidance, timely respond to the consultation from family members and patients, and continue the follow-up of patients after discharge [6, 7]. It brings great help to the physical and psychological rehabilitation of patients to a certain extent.

Diffusion tensor imaging (DTI) is one of the magnetic resonance imaging techniques [8]. DTI is based on the diffusion-weighted imaging (DWI) technology because the water molecules contained in human organs have different presentation characteristics and different diffusion coefficients in all directions, which cannot well reflect the pathological characteristics of the corresponding organs if measured with a scalar. To explore a DTI technique, it is necessary to refer to fractional anisotropy (FA value) and magnetic resonance apparent diffusion coefficient (ADC value), which reflect the direction and rule of diffusion movement [9]. It can control the magnetization state of H_2O molecules and can well ensure the diffusion process of H_2O molecules, so as to obtain the specific diffusion situation, which makes DTI technology gradually rise to occupy an important position. It has also led to the rapid development of this technology in recent years. It is also widely used in cerebral ischemia and leukoaraiosis in clinical practice. Although DTI technology has been mature research and, on this basis, high-angular resolution diffusion magnetic resonance imaging technology has also been derived, there are still some shortcomings in the tensor model, so it is of positive significance to carry out image registration and explore tensor-based registration algorithms to improve the resolution of images and make the registration accuracy higher [10]. In DTI acquisition, although the quality of echo-planar imaging can be improved by improving the hardware, thereby improving the quality of diffusion tensor images, this requires a relatively expensive cost; DWI images can also be used for registration, followed by tensor calculation again, but this also has some limitations. In addition, in some processes, the original data formed cannot be obtained, so it cannot be improved in scalar or imaging. It is very meaningful to improve the image resolution or registration accuracy by using different interpolation methods from the software algorithm. Therefore, the results were analyzed by DTI with effect registration through an image registration algorithm to explore the effect of nursing intervention on the self-management and quality of life of patients with CKD, in order to provide a certain reference for clinical management of patients.

2. Materials and Methods

2.1. General Information. One hundred patients with CKD (50 males and 50 females, aged 30–65 years) treated in hospital from January 2021 to January 2022 were randomly selected as the subjects. The patients were randomly divided into the experimental group and the control group, with 25 males and 25 females in the experimental group: 19 cases of hypertensive renal arteriosclerosis, 12 cases of diabetic nephropathy, 8 cases of chronic uric acid nephropathy, and 11 cases of glomerulonephritis; there were 25 males and 25 females in the control group: 20 cases of hypertensive renal arteriosclerosis, 11 cases of diabetic nephropathy, 9 cases of chronic uric acid nephropathy, and 10 cases of glomerulonephritis. This research had been approved by the ethics committee of hospital, and patients and their families signed the informed consent form.

The inclusion criteria are as follows: patients meet the diagnostic criteria of CKD, patients aged 30–65 years old, and patients with complete medical records.

The exclusion criteria are as follows: patients younger than 30 years or older than 65 years, patients suffering from other serious diseases and serious complications such as thyroid dysfunction, immune system disease, and acute renal failure, breastfeeding or pregnant women, and patients with mental disorders.

2.2. Treatment Methods. In the control group, in addition to the routine nephrology nursing operation, the patients were regularly transmitted with health knowledge and some specific operations for the prevention and treatment of CKD, guiding the patients to self-manage according to the corresponding measures. In addition to these basic operations in the control group, the experimental group also underwent nursing maintenance guidance intervention, which included preparation before nursing nutrition guidance intervention, development of guidance intervention plan, nursing nutrition guidance, and intervention measures [11] (Figure 1).

2.3. Technical Inspection and Image Processing. A 3.0T magnetic resonance scanner was used for routine MRI

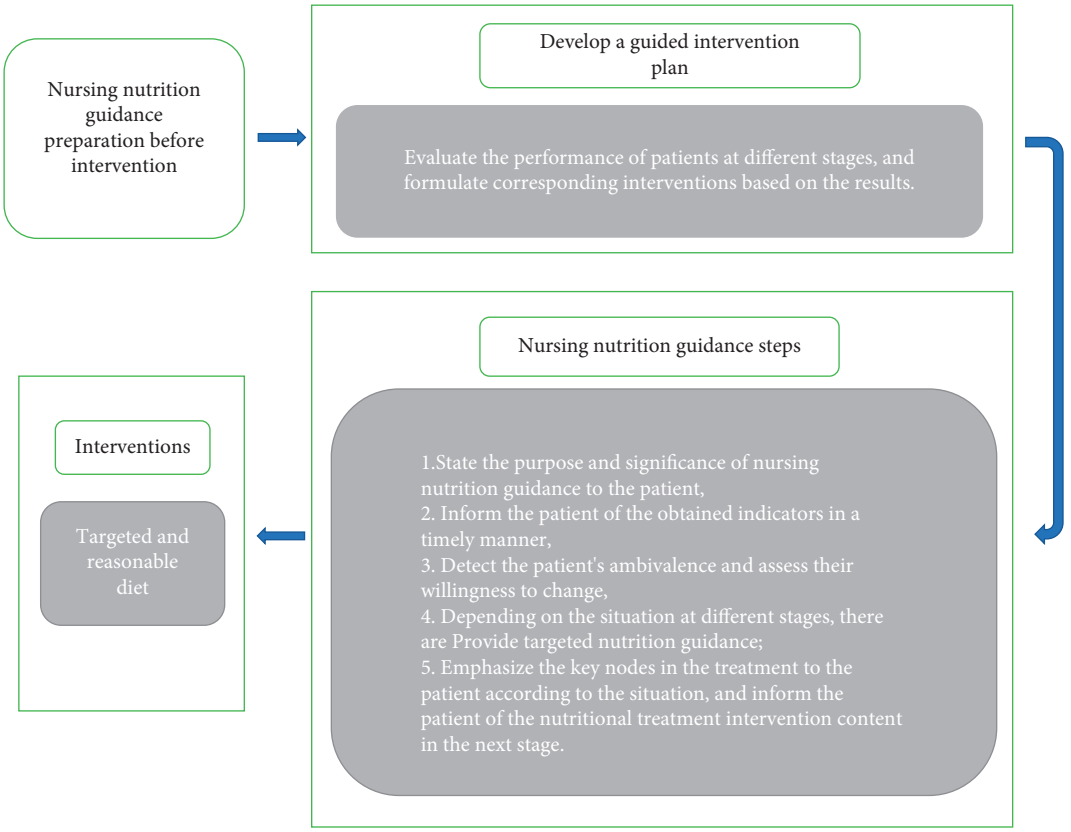


Figure 1: Specific procedure of nursing intervention.

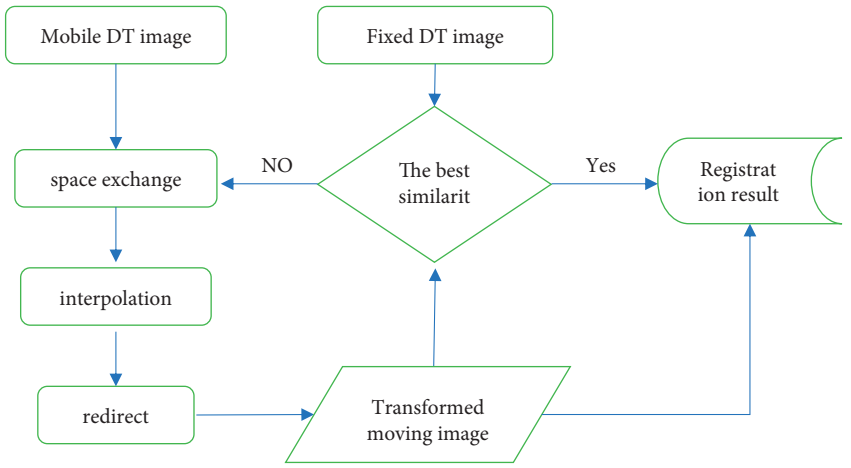
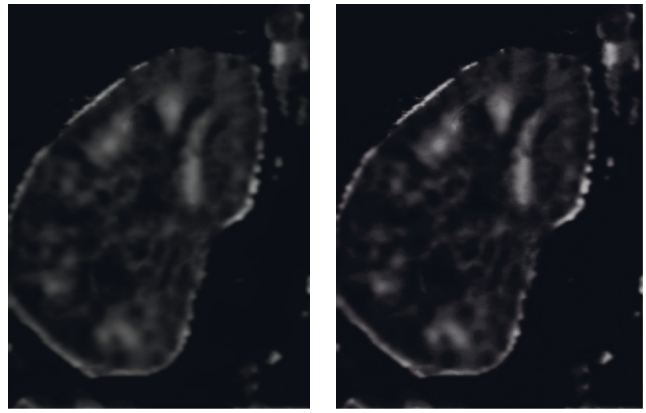


Figure 2: Schematic of diffusion tensor image registration algorithm.

scanning. The patients were examined by the DTI technique. The patients were not allowed to eat for more than 8 hours before the examination. The scanning was performed in the supine position. The scanning position was axial and coronal. Information was collected parallel to the oblique coronal view of both kidneys, and scans were performed continuously to ensure the comprehensiveness of the scans. DTI used single-shot spin echo-planar imaging (SSEPI); the scanning time was about 20 s, the scanning thickness and spacing were 6 mm and 1 mm, the matrix range was 256×256, and the field of view was $25\,\text{cm} \times 25\,\text{cm}$. The obtained images were smoothed and denoised, so as to calculate and generate FA and ADC maps using Extended MR WorkSpace workstation image processing software.

2.4. Diffusion Tensor Image Registration. The diffusion tensor image registration algorithm [12, 13] mainly includes the following flow, which is shown in Figure 2.

First, spatial transformation and reorientation are carried out: reorientation is divided into rigid transformation, affine transformation, and high-order transformation



(a) (b)

Figure 3: Comparison of effect before and after registration. (a) Original image; (b) the image after registration transformation.

according to different spatial transformations. The reorientation under rigid transformation can be expressed as follows:

$$B' = RBR^T. \tag{1}$$

The tensor B of the image after rigid body transformation E is replaced by tensor B' using the microstrain method [14]. R (rotation component of rigid body transformation) represents the rotation transformation matrix of transformation E decomposed by the polar coordinate decomposition method; redirection under affine transformation is as follows:

$$F = UR, \tag{2}$$

$$R = \left(TT^T\right)^{-(1/2)}F. \tag{3}$$

Using the finite strain method [15], according to the polar coordinate decomposition theory, the deformation matrix is decomposed into the rotation component R of the rigid body transformation and another deformation component U, and equation (2) is obtained. The rotation component R is extracted and converted by equation (1) to obtain equation (3).

Then, the similarity is measured: the sum of squared differences (SSD) [16, 17], which is the difference of some scalar properties used in the early image registration. SSD is defined as the sum of squares of the difference of the corresponding elements of two tensor matrices, which is expressed as follows:

$$\mathrm{SSD} = \sum_{a=1}^{3}\sum_{b=1}^{3}\left(B_{ab}^1 - B_{ab}^2\right)^2. \tag{4}$$

The DTI standard is judged, and the average overlap of eigenvalues-eigenvector (AOE) is used for comparison to determine the impact of reorientation on the registration results.

$$\mathrm{AOE} = \frac{1}{n}\sum_{a=1}^{n}\left(\sum_{b=1}^{3}\lambda_b^a\lambda_b^{*a}\left(\vec{e}_b^{\,a}\cdot\vec{e}_b^{*a}\right)^2\cdot\frac{1}{\sum_{b=1}^{3}\lambda_b^a\lambda_b^{*a}}\right), \tag{5}$$

where λ_b^a, $\vec{e}_b^{\,a}$, $\lambda_b^{*\,a}$, and $\vec{e}_b^{*a}$ mean feature vector of the bth eigenvalue of the ath position of the target image and the original image.

2.5. Outcome Measures. Outcome measures mainly included four aspects of observation indicators: self-management behavior, quality of life, DTI-related parameters (ADC and FA values of cortex and medulla), and renal function indicators (serum creatinine (Scr), urinary protein (24 h-Upro), and estimated glomerular filtration rate (eGFR)).

2.6. Statistical Processing. Statistical software SPSS 20.0 was used to process and analyze the data of the experimental data. The measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$). The independent sample t-test was used for comparison. $P < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison before and after Image Registration Algorithm Processing. The results of diffusion tensor object after image registration are shown in Figure 3. Figure 3(a) is the original image, Figure 3(b) is the image after registration transformation, and the image contour and internal texture are clearer than those before registration.

3.2. Self-Management Behavior Scores before and after Intervention. The nursing intervention was maintained for 6 months, and various observation indicators were recovered and statistically analyzed after 6 months. The statistical results showed that the self-management ability was improved to a certain extent compared with that before intervention and the level of self-management ability in the control group (92.81 ± 19.32) was slightly lower than that in the experimental group (107.12 ± 18.78), and the difference had statistical significance ($P < 0.05$) (Figure 4).

3.3. Scores of Quality-of-Life Indicators before and after Intervention. The scores of all indicators of quality of life in

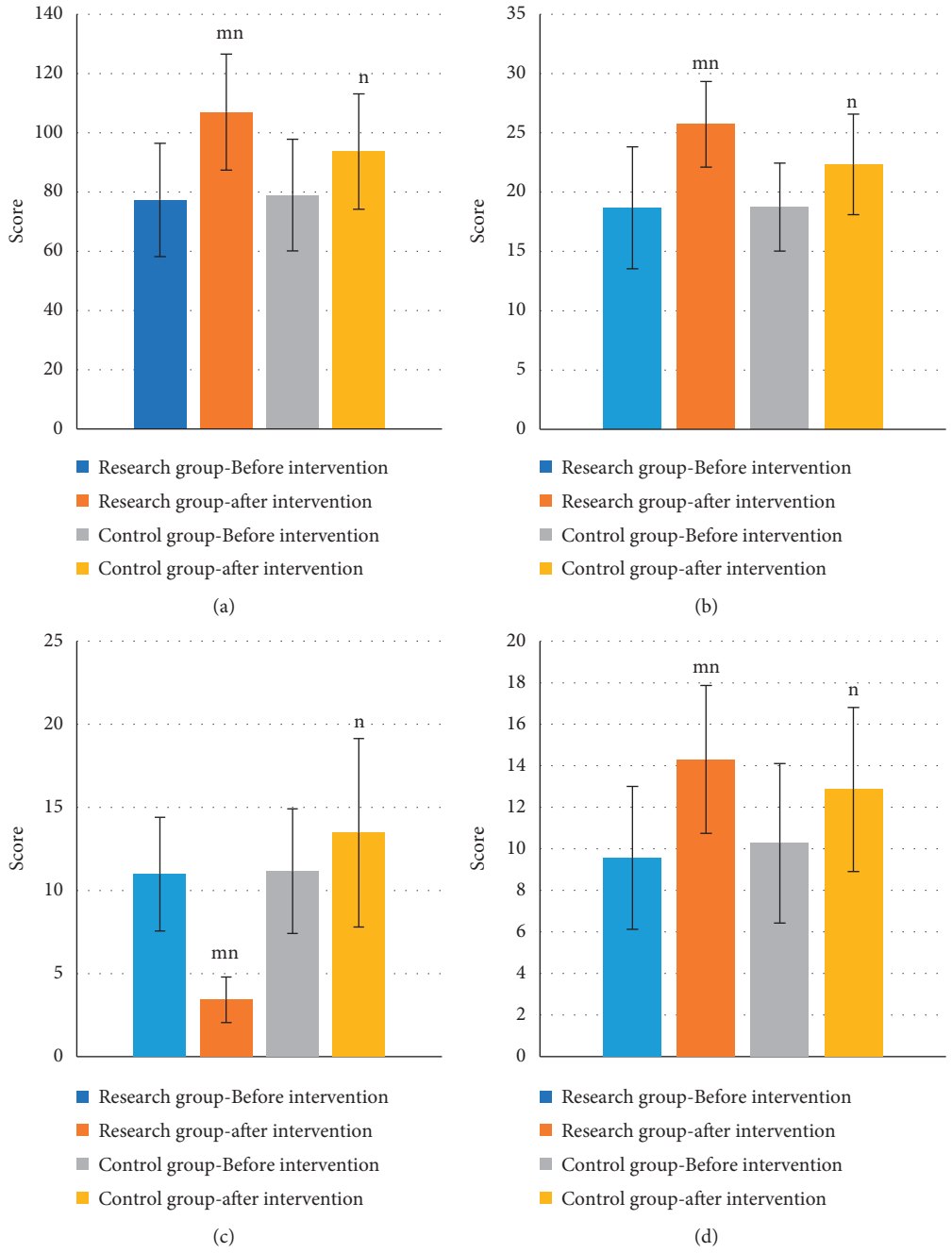


Figure 4: Comparison of self-management behavior scores before and after intervention between the two groups. (a–d) The self-management skills, diet control, regular exercise, and the ability to follow doctor's orders before and after the intervention in the experimental group and the control group, respectively. [m]Compared with that before intervention, $P < 0.05$; [n]compared with the control group after 6 months of intervention, $P < 0.05$.

the experimental group and the control group showed a certain degree of improvement after 6 months of intervention, and the comparison revealed that the experimental group (121.47 ± 11.21) had certain advantages over the control group (104.89 ± 12.11), with a slightly higher score, and the difference had statistical significance ($P < 0.05$) (Figure 5).

3.4. Comparison of ADC and FA Values of Cortex and Medulla before and after Intervention. According to statistical data, compared with the control group, the corresponding ADC value (2.54 ± 0.28) and FA value (0.28 ± 0.07) of the cortex in the experimental group were significantly greater than those in the control group (2.35 ± 0.21 and 0.23 ± 0.04), and the differences had statistical significance ($P < 0.05$). The corresponding ADC value (2.32 ± 0.22) and FA value (0.59 ± 0.02) of the medulla in the experimental group were also greater than those in the control group (2.12 ± 0.24 and 0.41 ± 0.17), and the differences had statistical significance ($P < 0.05$) (Table 1 and Figure 6).

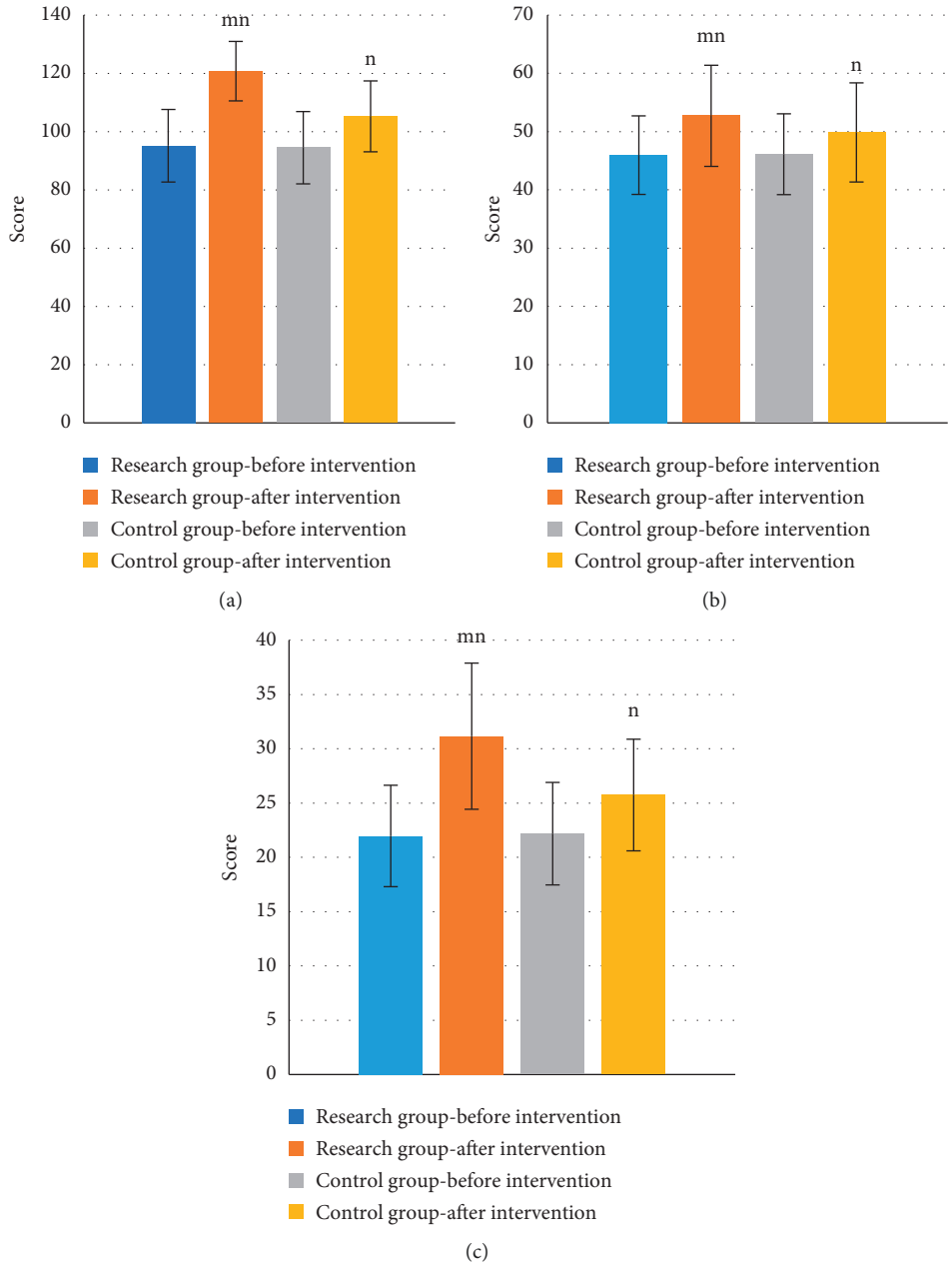


Figure 5: Comparison of scores of quality-of-life indicators before and after intervention between the two groups. (a–c) The level of quality-of-life mental function and physiological function before and after intervention in the experimental group and control group, respectively. [m]Compared with that before intervention, $P < 0.05$; [n]compared with the control group after 6 months of intervention, $P < 0.05$.

3.5. Comparison of Renal Function Parameters. One-way ANOVA showed that compared with the experimental group, the levels of Scr (μmol/L) (421.38 ± 42.78) and 24 h-Upro (mg/d) (1,836.7 ± 545.98) were higher in the control group, and the eGFR (mL/min) (22.56 ± 2.35) was lower in the control group than in the experimental group. The difference had statistical significance ($P < 0.05$) (Figure 7).

4. Discussion

In recent years, with the changes in living environment and dietary structure, CKD has become a major disease endangering human health and has become a public health problem that is concerned and strongly solved worldwide [18, 19]. CKD refers to the gradual damage of renal function under the influence of various adverse factors, forming developmental damage to the structure of the kidney. Popularly speaking, CKD is not a sudden attack, but a consequence of long-term neglect of the accumulation of kidney disease by patients. There are three types of CKD that mainly endanger the health of the population in China: hypertension, glomerulonephritis, and diabetic nephropathy [20, 21]. According to Liu Wenhu, director of the Nephrology Department of Beijing Friendship Hospital, "only

Table 1: Comparison of ADC and FA values of cortex and medulla.

Group	Cortex		Medulla	
	ADC value	FA value	ADC value	FA value
Experimental group	2.54 ± 0.28*	0.28 ± 0.07*	2.32 ± 0.22*	0.59 ± 0.02*
Control group	2.35 ± 0.21	0.23 ± 0.04	2.12 ± 0.24	0.41 ± 0.17
F	20.987	6.768	20.141	32,523
P	<0.001	<0.001	<0.001	<0.001

*Compared with the control group, $P < 0.05$.

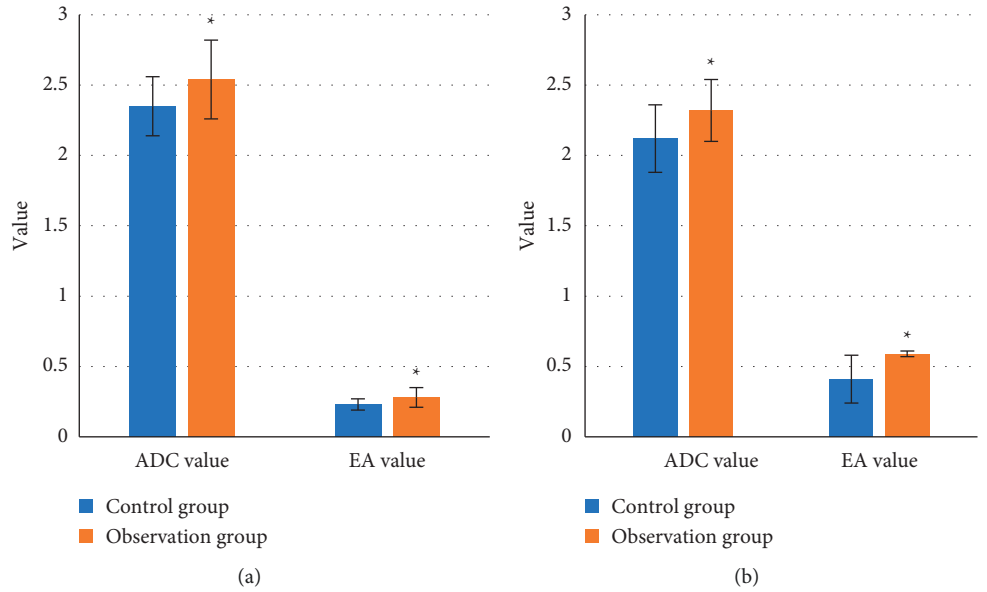


Figure 6: ADC and FA values of cortex and medulla before and after intervention. (a) Comparison between the ADC value of the cortex and the FA value; (b) comparison of the ADC value of the medulla and the FA value. *Compared with the control group, $P < 0.05$.

about 12.5% of Chinese patients with CKD have been diagnosed." This also maps to the phenomenon from the side that only one in eight of these patients is aware of their disease and thus obtains the corresponding treatment [22, 23]. DTI, as a special form of magnetic resonance imaging, plays a crucial role in the diagnosis of kidney disease. Image registration technology can help phase to a certain extent and play a quite important and indelible role in medical image processing. Moreover, it helps doctors to accurately find lesions with the help of images. With the continuous progress of the technology, the corresponding functions of medical image extraction equipment have been improved to a great extent, not only the images containing detailed image information such as CT and MRI can be collected, but also a large number of images about functional information such as SPECT can be collected [24]. Since image registration technology can capture and collect dynamic images at different time points and use the equation for registration, the resulting image of registration is more accurate and facilitates the doctor to carefully analyze the size of the lesion site and the lesion condition, so that the medical diagnosis, surgical planning, and radiotherapy planning become more accurate and reliable [25, 26]. Nursing intervention can help patients to recover to a certain extent, so the characteristics of renal DTI with an image registration algorithm are used to explore the effect of nursing intervention on self-management and quality of life in patients with CKD.

The image registration algorithm was used to optimize the phase of DTI. By observing various indicators, it was found that the subjects were randomly divided into the experimental group and the control group. The control group was mainly given routine nephrology nursing and health education, while the experimental group carried out nursing guidance intervention based on the control group. The data of self-management behavior, quality of life, DTI-related parameters, and renal function indicators after 6 months were collected and analyzed. The results showed that the image outline and internal texture of the diffusion tensor image were clearer after image registration. After 6 months of nursing intervention, the self-management ability score of the control group was 92.81 ± 19.32, while that of the experimental group was 107.12 ± 18.78, which was lower in the control group than in the experimental group, and the difference had statistical significance ($P < 0.05$). The scores of all indicators of quality of life in the experimental group and the control group showed a certain degree of improvement after 6 months of intervention. The experimental group (121.47 ± 11.21) was greater than the control group (104.89 ± 12.11), and the difference had statistical

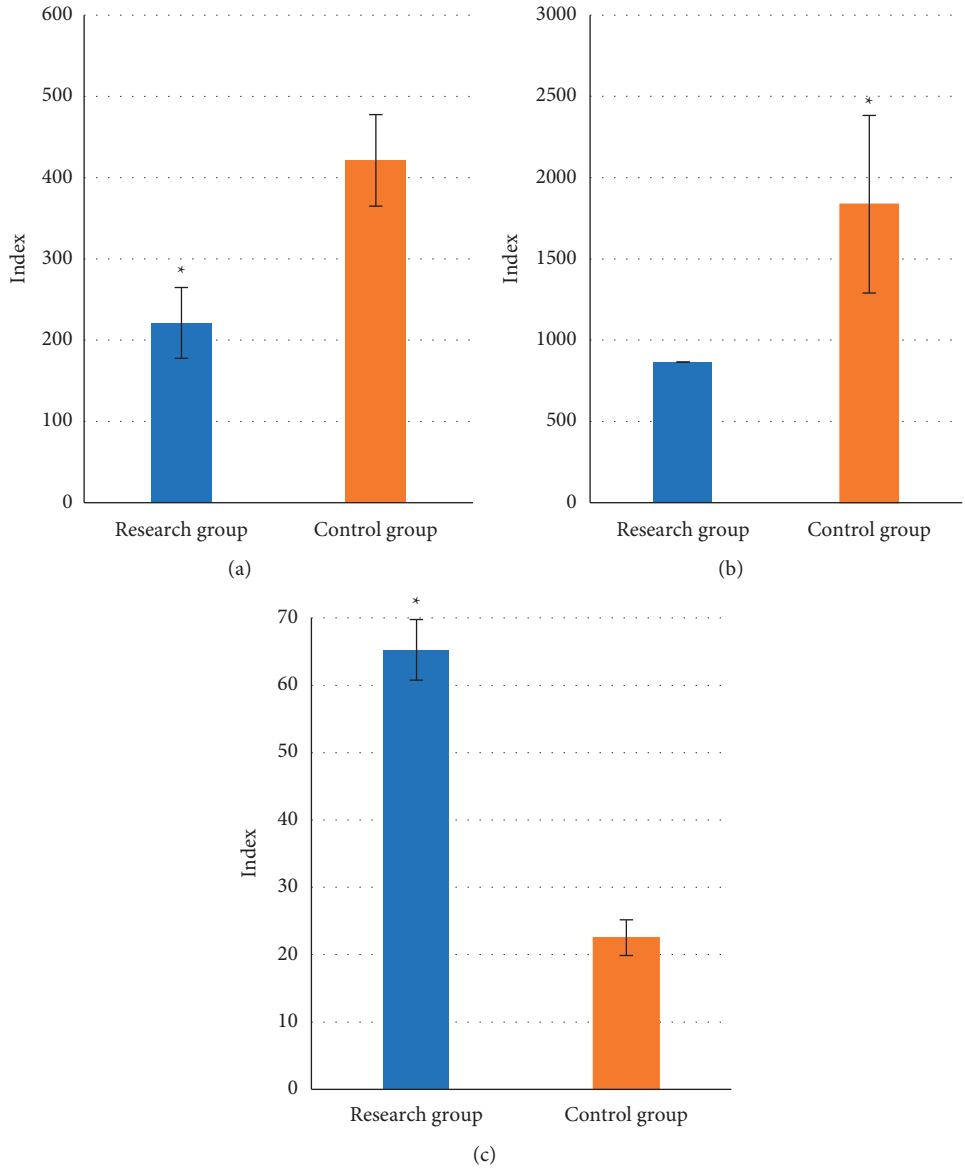


Figure 7: Comparison of renal function parameters in CKD patients. (a–c) The serum creatinine, 24 h urine protein, and estimated glomerular filtration rate of the experimental group and control group, respectively. *Compared with the control group, $P < 0.05$.

significance ($P < 0.05$). The self-management ability and quality of life of the experimental group showed a certain degree of improvement, which indicated that under the nursing intervention, the lifestyle of the patients had a certain change and the cognition about the disease and the coping strategies were more scientific. The physical performance status through exercise had also changed, and these comprehensive changes made the patients' recovery superior to the common treatment. Compared with the control group, the corresponding ADC value (2.54 ± 0.28) and FA value (0.28 ± 0.07) of the cortex in the experimental group were significantly greater than those in the control group (2.35 ± 0.21 and 0.23 ± 0.04), and the differences had statistical significance ($P < 0.05$). The corresponding ADC value (2.32 ± 0.22) and FA value (0.59 ± 0.02) of the medulla were also numerically greater than those of the control group (2.12 ± 0.24 and 0.41 ± 0.17), and the differences had statistical significance ($P < 0.05$). The ADC value and FA value show the performance of the direction of water molecule transport in organs. In patients with kidney disease, due to the change in renal function and structure, the corresponding water molecule movement direction will be changed and the ADC value and FA value will also be reduced. In this experiment, the corresponding ADC value and FA value in the cortex and medulla in the experimental group were greater than those in the control group. This result was caused by the reduction of renal necrosis, the gradual recovery of renal structure, and the reduction of the change degree of internal water molecule movement direction under the intervention treatment compared with the common treatment method. One-way ANOVA showed that compared with the experimental group, the levels of Scr

(μmol/L) (421.38 ± 42.78) and 24 h-Upro (mg/d) ($1{,}836.7 \pm 545.98$) were higher in the control group and the eGFR (mL/min) (22.56 ± 2.35) was lower in the control group than in the experimental group. The difference had statistical significance ($P < 0.05$). It is reported in the relevant literature that Scr, 24 h-Upro, and eGFR can reflect the change in renal function. The greater the Scr and 24 h-Upro values, the more severe the renal injury, and the smaller the eGFR, the more severe the renal injury [27]. The experimental results showed that the Scr and 24 h-Upro values in the experimental group of nursing intervention were less than those in the control group and the eGFR value was greater than that in the control group, that is, the better the recovery of renal function under nursing intervention.

5. Conclusion

DTI through image registration, image outline, and internal texture is clearer. Nursing intervention has certain positive significance for self-management and quality of life of patients with CKD. However, the sample size of this experiment is limited and adjustment is needed in the extensiveness of the study subjects. In conclusion, this experiment can provide some reference value for the clinical treatment of CKD.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] Kidney Disease: Improving Global Outcomes (KDIGO) Diabetes Work Group, "KDIGO 2020 clinical practice guideline for diabetes management in chronic kidney disease," *Kidney International*, vol. 98, 2020.

[2] S. Erraez, M. López-Mesa, and P. Gómez-Fernández, "Mineralcorticoid receptor blockers in chronic kidney disease," *Nefrología (English Edition)*, vol. 41, no. 3, pp. 258–275, 2021.

[3] Y. Wang, Y. Sun, N. Lu et al., "Diagnosis and treatment rules of chronic kidney disease and nursing intervention models of related mental diseases using electronic medical records and data mining," *Journal of Healthcare Engineering*, vol. 2021, Article ID 5187837, 13 pages, 2021.

[4] Z. M. Jenkins, E. J. Tan, E. O'Flaherty et al., "A psychosocial intervention for individuals with advanced chronic kidney disease: a feasibility randomized controlled trial," *Nephrology (Carlton)*, vol. 26, no. 5, pp. 442–453, 2021.

[5] Y. Zhou and X. Li, "Effect assessment of the application value of evidence-based nursing intervention in operating room nursing," *Medicine*, vol. 100, no. 32, Article ID e26867, 2021.

[6] E. S. Mousavinasab, S. R. N. Kalhori, N. Zarifsanaiey, M. Rakhshan, and M. Ghazisaeedi, "Nursing process education: a review of methods and characteristics," *Nurse Education in Practice*, vol. 48, Article ID 102886, 2020.

[7] J. M. Mancuso, "Perceptions of distance education among nursing faculty members in North America," *Nursing and Health Sciences*, vol. 11, no. 2, pp. 194–205, 2009.

[8] S. J. Cheng, P. H. Tsai, Y. T. Lee, Y. T. Li, H. W. Chung, and C. Y. Chen, "Diffusion tensor imaging of the spinal cord," *Magnetic Resonance Imaging Clinics of North America*, vol. 29, no. 2, pp. 195–204, 2021.

[9] A. T. Mazal, O. Ashikyan, J. Cheng, L. Q. Le, and A. Chhabra, "Diffusion-weighted imaging and diffusion tensor imaging as adjuncts to conventional MRI for the diagnosis and management of peripheral nerve sheath tumors: current perspectives and future directions," *European Radiology*, vol. 29, no. 8, pp. 4123–4132, 2019.

[10] M. Perri, M. D'Elia, G. Castorani et al., "Assessment of lumbar disc herniaton using fractional anisotropy in diffusion tensor imaging along with conventional T2-weighted imaging," *Neuroradiology Journal*, vol. 33, no. 1, pp. 24–31, 2020.

[11] D. A. Richards, A. Hilli, C. Pentecost, V. A. Goodwin, and J. Frost, "Fundamental nursing care: a systematic review of the evidence on the effect of nursing care interventions for nutrition, elimination, mobility and hygiene," *Journal of Clinical Nursing*, vol. 27, no. 11-12, pp. 2179–2188, 2018.

[12] J. Gerhardt, N. Sollmann, P. Hiepe et al., "Retrospective distortion correction of diffusion tensor imaging data by semi-elastic image fusion - evaluation by means of anatomical landmarks," *Clinical Neurology and Neurosurgery*, vol. 183, Article ID 105387, 2019.

[13] F. Machado-Rivas, O. Afacan, S. Khan et al., "Spatiotemporal changes in diffusivity and anisotropy in fetal brain tractography," *Human Brain Mapping*, vol. 42, no. 17, pp. 5771–5784, 2021.

[14] F. G. Zöllner, A. Šerifović-Trbalić, G. Kabelitz, M. Kociński, A. Materka, and P. Rogelj, "Image registration in dynamic renal MRI-current status and prospects," *MAGMA*, vol. 33, no. 1, pp. 33–48, 2020.

[15] J. S. Giudice, A. Alshareef, T. Wu et al., "An image registration-based morphing technique for generating subject-specific brain finite element models," *Annals of Biomedical Engineering*, vol. 48, no. 10, pp. 2412–2424, 2020.

[16] A. Ghaffari and E. Fatemizadeh, "Image registration based on low rank matrix: rank-regularized SSD," *IEEE Transactions on Medical Imaging*, vol. 37, no. 1, pp. 138–150, 2018.

[17] X. Liu, D. Jiang, M. Wang, and Z. Song, "Image synthesis-based multi-modal image registration framework by using deep fully convolutional networks," *Medical & Biological Engineering & Computing*, vol. 57, no. 5, pp. 1037–1048, 2019.

[18] B. S. Reynolds and H. P. Lefebvre, "Feline CKD," *Journal of Feline Medicine & Surgery*, vol. 15, pp. 3–14, 2013.

[19] A. Gafter-Gvili, A. Schechter, and B. Rozen-Zvi, "Iron deficiency anemia in chronic kidney disease," *Acta Haematologica*, vol. 142, no. 1, pp. 44–50, 2019.

[20] D. C. Wheeler, B. V. Stefánsson, N. Jongs et al., "Effects of dapagliflozin on major adverse kidney and cardiovascular events in patients with diabetic and non-diabetic chronic kidney disease: a prespecified analysis from the DAPA-CKD trial," *Lancet Diabetes & Endocrinology*, vol. 9, no. 1, pp. 22–31, 2021.

[21] H. W. Kim, J. T. Park, Y. S. Park et al., "Systolic blood pressure and chronic kidney disease progression in patients with primary glomerular disease," *Journal of Nephrology*, vol. 34, no. 4, pp. 1057–1067, 2021.

[22] X. N. Ng, C. C. Tang, C. H. Wang, J. P. Tsai, and B. G. Hsu, "Positive correlation of serum resistin level with peripheral artery disease in patients with chronic kidney disease stage 3

to 5," *International Journal of Environmental Research and Public Health*, vol. 18, no. 23, Article ID 12746, 2021.

[23] GBD 2017 DALYs and HALE Collaborators, "Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017," *Lancet*, vol. 392, no. 10159, pp. 1859–1922, 2018.

[24] H. Dai, C. Jiang, G. Wu et al., "A combined DTI and resting state functional MRI study in patients with postherpetic neuralgia," *Japanese Journal of Radiology*, vol. 38, no. 5, pp. 440–450, 2020.

[25] C. Lock, J. Kwok, S. Kumar et al., "DTI profiles for rapid description of cohorts at the clinical-research interface," *Frontiers of Medicine*, vol. 5, p. 357, 2019.

[26] M. Liu, Y. Wu, X. Wu et al., "White matter microstructure changes and cognitive impairment in the progression of chronic kidney disease," *Frontiers in Neuroscience*, vol. 14, Article ID 559117, 2020.

[27] R. L. Chevalier, "Evolution, kidney development, and chronic kidney disease," *Seminars in Cell & Developmental Biology*, vol. 91, pp. 119–131, 2019.