

Impact of donor kidney weight and recipient body mass index on long-term renal function decline following living donor kidney transplantation

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Abstract

Background:

Nephron mass mismatch between donor kidney size and recipient body size has been suggested as a crucial determinant of long-term graft outcomes following kidney transplantation. However, large multicenter studies evaluating the combined impact of donor kidney weight and recipient body mass index (BMI) remain scarce.

Methods:

This retrospective multicenter cohort study encompassed 536 recipients who underwent living donor kidney transplantation from 1998 to 2021. Patients were stratified into four groups according to donor kidney weight (median, 200 g) and recipient BMI (cutoff, 25 kg/m²). Graft function decline, defined as the percentage change in estimated glomerular filtration rate from 1 month post-transplantation, was the primary outcome. Group comparisons were performed using analysis of variance with Tukey's post-hoc test. Graft function decline-associated factors were evaluated using linear regression analyses.

Results:

In this multicenter cohort study, we demonstrated that the combination of donor kidney weight and recipient BMI was associated with long-term renal function decline following living donor kidney transplantation. Among these factors, donor kidney weight appeared to play a particularly important role in post-transplant renal outcomes ($p = 0.0067$). Multivariate analysis revealed that the combination of low donor kidney weight and high recipient BMI, rather than BMI alone, was independently associated with graft function decline ($p = 0.0090$). Furthermore, blood group incompatibility was identified as an independent predictor ($p = 0.0016$).

Conclusions:

The combination of donor kidney weight and recipient BMI was associated with long-term renal function decline following living donor kidney transplantation. These findings highlight the clinical significance of nephron mass matching in donor selection and recipient risk stratification.

INTRODUCTION

Kidney transplantation results in superior survival and enhanced quality of life for end-stage renal disease compared with long-term dialysis ^{1,2}. Short-term kidney graft prognosis has markedly improved, especially in the last decade, with more intense immunosuppressive therapies and an increased number

of living donors³. Donor kidney volume and function are indicators reflecting the quality of living donor kidneys involved in post-transplant kidney prognosis^{4–7}. Other factors involved in post-transplantation kidney prognosis have been investigated for donor kidney weight and recipient physique, which has been implicated in the concept of nephron amount mismatch^{8–18}. However, studies that have used body mass index (BMI) as the recipient physique and followed more than 200 cases for more than 5 years are limited. Moreover, studies that have quantitatively investigated the interaction between donor kidney weight and recipient physique using a multicenter large cohort in Japan are scarce. Based on these backgrounds, this study aimed to evaluate the effect of donor kidney weight combined with recipient BMI on kidney prognosis following transplantation. Other factors involved in post-transplantation renal prognosis were also investigated.

MATERIALS and METHODS

1. Study design and population

This retrospective cohort study analyzed 658 patients who underwent living donor kidney transplantation between May 1998 and December 2021 using a database of five institutions and two tertiary care institutions (Michinoku Kidney Transplant Network). Of these patients, 122 with significant missing data for analysis were excluded. The remaining patients were categorized into the following four groups on the basis of renal weight during donor transplantation and recipient BMI:

- (1) Donor kidney weight < Median kidney weight (200 g) and recipient BMI ≥ 25 kg/m² (n = 45)
- (2) Donor kidney weight < Median kidney weight (200 g) and recipient BMI < 25 kg/m² (n = 201)
- (3) Donor kidney weight $\geq$ Median kidney weight (200 g) and recipient BMI ≥ 25 kg/m² (n = 74)
- (4) Donor kidney weight $\geq$ Median kidney weight (200 g) and recipient BMI < 25 kg/m² (n = 216)

Additionally, the patients were classified into the following two groups on the basis of the weight of the donor transplanted kidney:

- (1) Donor kidney weight < Median kidney weight (200 g) (n = 246)
- (2) Donor kidney weight $\geq$ Median kidney weight (200 g) (n = 290)

Moreover, the patients were classified into two groups on the basis of the BMI of the recipients:

- (1) Recipient BMI ≥ 25 kg/m² (n = 119)
- (2) Recipient BMI < 25 kg/m² (n = 417)

2. Data collection

Data on patient demographic characteristics, clinical characteristics, and transplant outcomes were collected from the database. For recipients, age, diabetes, cytomegalovirus (CMV) infection, BK polyomavirus (BKPyV) infection, human leukocyte antigen (HLA) incompatibility, donor-specific antibodies (DSAs), hypertension, blood group incompatible transplantation, BMI, body surface area (BSA), and rejection were investigated. For donors, sex, age, BMI, diabetes, and hypertension were investigated. The estimated glomerular filtration rate (eGFR) was calculated using the estimation formula of the Japanese Society of Nephrology ¹⁹. The rate of kidney function decline following kidney transplantation was calculated by dividing the difference between the eGFR at 1 month post-transplantation and the difference between the eGFR in each postoperative year by the same value.

Renal function decline (%) was defined as:

$$(baseline\ eGFR - follow-up\ eGFR) / baseline\ eGFR \times 100$$

3. Immunosuppressive protocols

The basal immunosuppressive regimen comprised calcineurin inhibitors, mycophenolate mofetil, and corticosteroids. However, the treating physician at each site determined the target trough concentrations, specific drug selection, and combination of these drugs. Furthermore, everolimus was prescribed at the discretion of the treating physician. As induction therapy, basiliximab was intraoperatively administered and on postoperative day 4. Rituximab and/or antibody removal was performed as part of the preoperative desensitization process in cases of blood group incompatible kidney transplantation or in the presence of pre-made DSAs.

4. Diagnosis and management of acute rejection

Acute rejection was diagnosed according to the Banff classification criteria, which have evolved over time, based on clinical and pathological data. Each facility implemented treatment strategies at its own discretion, offering care tailored to individual patient needs.

5. Statistical analysis

The analysis of variance and Tukey test were employed for evaluating the annual rate of renal function decline in each group. When a significant difference in the rate of renal function decline was noted in each group, the recipients (age, diabetes, CMV infection, BKPyV infection, HLA incompatibility, DSA, hypertension, blood group incompatible transplantation, BMI, BSA, and rejection) and donor (sex, hypertension, diabetes, BMI, and eGFR), univariate analysis and multivariate linear regression analysis

were performed. All statistical analyses were performed using JMP version 19.0 (SAS Institute Inc., Cary, NC, USA). For all statistical comparisons, $p < 0.05$ was considered a statistically significant difference.

RESULTS

1. Patients

Of the 658 patients who underwent living donor kidney transplantation between May 1998 and December 2021, 122 who lacked donor kidney weight, recipient physique (BMI), and kidney function data over time following transplantation were excluded. We conducted a retrospective study of 536 patients who underwent living donor kidney transplantation (Table 1).

Table 1
Clinical Characteristics

Characteristic	n (%)				P-value
	Group 1	Group 2	Group 3	Group 4	
Donor kidney weight (g)					
≥ 200g			74 (13.8)	216 (40.3)	
< 200g	45 (8.4)	201 (37.5)			
Recipient BMI					
≥ 25	45 (8.4)		74 (13.8)		
< 25		201 (37.5)		216 (40.3)	
Recipient BSA (m ²) average	1.79	1.56	1.83	1.55	
Recipient baseline eGFR (ml/min/1.73m ²)					
Preoperative	5.1	5.3	5.1	5.1	
One month postoperative	45.8	43.9	45.7	47.9	
Recipient Diabetes	17 (16.7)	31 (30.4)	21 (20.6)	33 (32.3)	0.0006
Recipient Hypertension	36 (80)	128 (63.7)	53 (71.6)	136 (62.9)	0.14
Recipient DSA	2	6	3	5	0.82
Recipient BK virus	0	7	1	11	0.24
Recipient Cytomegalovirus	14	70	33	102	0.027
Recipient mean age (Range)	50 (26–69)	48 (13–72)	44 (20–72)	49 (8–75)	
Donor mean age	53	57	58	49	
Group 1: Donor kidney weight < Median kidney weight (200 g) and recipient BMI ≥ 25 kg/m ² (n = 45)					
Group 2: Donor kidney weight < Median kidney weight (200 g) and recipient BMI < 25 kg/m ² (n = 201)					
Group 3: Donor kidney weight ≥ Median kidney weight (200 g) and recipient BMI ≥ 25 kg/m ² (n = 74)					
Group 4: Donor kidney weight ≥ Median kidney weight (200 g) and recipient BMI < 25 kg/m ² (n = 216)					
eGFR, estimated glomerular filtration rate; BMI, body mass index; BSA: body surface area; DSA, donor-specific antibody; HLA, human leukocyte antigen					

Characteristic	n (%)				P-value
	Group 1	Group 2	Group 3	Group 4	
(Range)	(29–71)	(24–77)	(24–79)	(30–75)	
Donor sex					
Male	10 (4.8)	40 (19.2)	41 (19.7)	117 (56.3)	0.0001
Female	35 (10.7)	161 (49.1)	33 (10.1)	99 (30.1)	0.0001
Donor Diabetes	1 (3.2)	10 (32.3)	8 (25.8)	12 (38.7)	0.19
Donor Hypertension	7 (5.4)	37 (28.7)	24 (18.6)	61 (47.3)	0.016
Donor BMI > 30	1 (3.6)	8 (28.6)	8 (28.6)	11 (39.2)	0.1
Blood group incompatibility	8 (6.1)	46 (34.9)	19 (14.4)	59 (44.6)	0.48
HLA mismatch	39 (7.8)	185 (37.2)	70 (14.2)	203 (40.8)	0.16
Transplant rejection	22 (10.4)	64 (30.3)	26 (12.3)	99 (47)	0.015
Group 1: Donor kidney weight < Median kidney weight (200 g) and recipient BMI $\geq$ 25 kg/m ² (n = 45)					
Group 2: Donor kidney weight < Median kidney weight (200 g) and recipient BMI < 25 kg/m ² (n = 201)					
Group 3: Donor kidney weight $\geq$ Median kidney weight (200 g) and recipient BMI $\geq$ 25 kg/m ² (n = 74)					
Group 4: Donor kidney weight $\geq$ Median kidney weight (200 g) and recipient BMI < 25 kg/m ² (n = 216)					
eGFR, estimated glomerular filtration rate; BMI, body mass index; BSA: body surface area; DSA, donor-specific antibody; HLA, human leukocyte antigen					

2. Decreased renal function following living donor kidney transplantation

No significant difference in the rate of post-transplant renal function decline was observed between the groups for 4 years post-transplantation (year 1, n = 536, p = 0.22; year 2, n = 450, p = 0.06; year 3, n = 416, p = 0.62; year 4, n = 354, p = 0.45) (Fig. 1). However, at 5 years following transplantation, the renal function decline rate was significantly different between the groups based on donor kidney weight and recipient BMI (n = 306, p = 0.006). Comparisons of two subgroups in each group demonstrated significant differences between subgroups 1 and 4 (95% confidence interval [CI], 0.018–0.52, p = 0.03) and between subgroups 2 and 4 (95% CI, 0.016–0.32, p = 0.02) (Fig. 2).

3. Factors associated with the rate of renal function decline at 5 years following living donor kidney transplantation

At 5 years following living donor kidney transplantation, the renal function decline was associated with donor kidney weight, recipient BMI ($p = 0.0067$), donor kidney weight (continuous) (95% CI, 0.00034–0.0016, $p = 0.0023$), recipient diabetes mellitus (95% CI, 0.0019–0.13, $p = 0.044$), and blood group incompatibility (95% CI, 0.046–0.16, $p = 0.005$). Multivariate analysis revealed an association between donor kidney weight, recipient BMI ($p = 0.0090$), and blood group incompatibility (95% CI, 0.036–0.15, $p = 0.0016$) (Table 2). No significant difference in the renal function decline rate at 5 years following living kidney transplantation in blood group-matched transplantation cases was noted between the groups based on donor kidney weight and recipient BMI ($p = 0.055$) (Fig. 3). Other factors that were believed to be involved in the renal function decline underwent univariate analysis and multivariate linear regression analysis; however, none of the factors were associated with the renal function decline rate. Moreover, the kidney function decline rate at 5 years following living donor kidney transplantation was classified into two groups according to the weight of the donor transplanted kidney, showing a significant difference between the groups ($p = 0.0025$) (Fig. 4).

Table 2
Factors associated with renal function decline at 5 years post-transplantation

	n	Univariate analysis		Multivariable analysis	
		95% CI	P-value	95% CI	P-value
Donor kidney weight Recipient BMI (categorical)	306		0.0067		0.009
Donor kidney weight (continuous)	306	0.00034–0.0016	0.0023	-0.0001–0.001	0.098
Recipient BSA	306	-0.29–0.21	0.75		
Recipient Diabetes	46	0.0019–0.13	0.044	-0.057–0.071	0.83
Recipient Hypertension	182	-0.024–0.088	0.26	-0.048–0.063	0.79
Recipient DSA	4	-0.069–0.20	0.33		
Recipient BKvirus	12	-0.045–0.21	0.2		
Recipient Cytomegalovirus	133	-0.044–0.058	0.78		
Recipient age	306	-0.0074–2.6	0.052	-0.0045–0.004	0.85
Donor age	306	-0.0067–0.0031	0.48	-0.0046–0.006	0.79
Donor sex	306	-0.06–0.044	0.75	-0.035–0.075	0.48
Donor Diabetes	18	-0.075–0.14	0.54	-0.078–0.14	0.56
Donor Hypertension	129	-0.026–0.092	0.27	-0.023–0.097	0.23
Donor BMI > 30	28	-0.17–0.049	0.26		
Blood group incompatibility	58	0.046–0.16	0.005	0.036–0.15	0.0016
HLA mismatch	281	-0.036–0.027	0.79	-0.024–0.047	0.5
Transplant rejection	133	-0.077–0.026	0.33	-0.053–0.051	0.96
BMI, body mass index; BSA, body surface area; DSA, donor-specific antibody; HLA, human leukocyte antigen					

Except for donor kidney weight, recipient diabetes mellitus (95% CI, 0.0019–0.13, p = 0.044) and blood group incompatibility (95% CI, 0.046–0.16, p = 0.005) were associated with the rate of post-transplant

renal function decline. Multivariate linear regression analysis revealed that donor kidney weight ($p = 0.0031$) was associated with blood group incompatibility (95% CI, 0.035–0.15, $p = 0.0017$) (Table 3). Based on donor kidney weight in blood group-matched transplantation cases, the rate of renal function decline at the 5th year following living donor kidney transplantation was significantly different between the groups ($p = 0.0084$) (Fig. 5). Other factors deemed associated with the rate of kidney decline were subjected to univariate analysis and multivariate linear regression analysis; however, only donor kidney weight exhibited significant differences in the univariate analysis ($p = 0.0039$) and multivariate linear regression analysis ($p = 0.015$) (Table 4). Conversely, when the rate of renal function decline at 5 years following living donor kidney transplantation was classified into two groups on the basis of the recipient BMI, no significant difference in the rate of renal function decline was noted between the groups ($p = 0.14$) (Fig. 6).

Table 3
Factors associated with renal function decline at 5 years post-transplantation

	n	Univariate analysis		Multivariable analysis	
		95% CI	P-value	95% CI	P-value
Donor kidney weight (categorical)	306		0.0025		0.031
Donor kidney weight (continuous)	306	0.00034–0.0016	0.0023	-0.0009–0.001	0.088
Recipient BSA	306	-0.29–0.21	0.75		
Recipient Diabetes	46	0.0019–0.13	0.044	-0.035–0.093	0.65
Recipient Hypertension	182	-0.024–0.088	0.26	-0.039–0.076	0.74
Recipient DSA	4	-0.069–0.20	0.33		
Recipient BK virus	12	-0.045–0.21	0.2		
Recipient Cytomegalovirus	133	-0.044–0.058	0.78		
Recipient age	306	-0.0074–2.6	0.052	-0.0046–0.004	0.89
Donor age	306	-0.0067–0.0031	0.48	-0.0046–0.006	0.89
Donor sex	306	-0.06–0.044	0.75	-0.039–0.074	0.54
Donor Diabetes	18	-0.075–0.14	0.54	-0.044–0.18	0.23
Donor Hypertension	129	-0.026–0.092	0.27	-0.031–0.093	0.32
Donor BMI > 30	28	-0.17–0.049	0.26		
Blood group incompatibility	58	0.046–0.16	0.005	0.035–0.15	0.0017
HLA mismatch	281	-0.036–0.027	0.79	-0.024–0.048	0.5
transplant rejection	133	-0.077–0.026	0.33	-0.051–0.052	0.99
BMI, body mass index; DSA, donor-specific antibody; HLA, human leukocyte antigen					

Table 4

Factors associated with renal function decline at 5 years in blood group compatible transplantation

	n	Univariate analysis		Multivariable analysis	
		95% CI	P-value	95% CI	P-value
Donor kidney weight (categorical)	66		0.039		0.015
Donor kidney weight (continuous)	66	0.00023–0.0015	0.0083	-0.92–0.0015	0.053
Recipient BSA	66	-0.31–1.1	0.25		
Recipient Diabetes	16	-0.0077–0.15	0.076	-0.045–0.13	0.4
Recipient Hypertension	44	-0.016–0.12	0.14	-0.26–0.11	0.22
Recipient DSA	1	-0.33–0.61	0.56		
Recipient BK virus	5	-0.021–0.32	0.086		
Recipient Cytomegalovirus	40	-0.03–0.093	0.31		
Recipient age	66	-0.0079–0.0066	0.085	-0.006–0.004	0.75
Donor age	66	-0.011–0.0063	0.59	-0.0048–0.006	0.6
Donor sex	66	-0.068–0.12	0.61	-0.065–0.068	0.96
Donor Diabetes	2	-0.075–0.16	0.47	-0.17–0.19	0.29
Donor Hypertension	14	-0.016–0.12	0.13	-0.031–0.11	0.26
Donor BMI > 30	6	-0.17–0.049	0.26		
HLA mismatch	64		0.7	-0.025–0.063	0.39
transplant rejection	31	-0.074–0.049	0.33	-0.038–0.087	0.44
BMI, body mass index; DSA, donor-specific antibody; HLA, human leukocyte antigen					

DISCUSSION

We here investigated the effect of donor kidney weight combined with recipient BMI on post-transplant renal prognosis in living donor kidney transplantation using a large multicenter cohort. In this multicenter cohort study, we demonstrated that the combination of donor kidney weight and recipient BMI was associated with long-term renal function decline following living donor kidney transplantation. Among these factors, donor kidney weight appeared to play a particularly important role in post-transplant renal outcomes. These results support the nephron amount–recipient physique imbalance in the transplanted kidney, that is, the likelihood that nephron dose mismatch may significantly affect post-transplant kidney function^{8, 9, 11, 13, 15, 18, 20–26}. The hyperfiltration hypothesis in transplanted kidneys can account for the concept of nephron dose mismatch. In other words, when the number of nephrons is relatively low

compared with the recipient's physique, the load on each nephron is increased, causing long-term renal function decline through increased intraglomerular pressure and glomerular hypertrophy. The results of the present study align with this pathophysiological mechanism¹⁸. It has been previously reported that donor kidney weight and body size differences between donor recipients are associated with post-transplant renal prognosis; however, most studies were single-center and had limitations in the number of cases and follow-up duration. The present study offers significant evidence supporting those of previous studies in that more than 200 cases were followed for more than 5 years and verified using multicenter data from Japan. Moreover, the significance of this study lies in the finding that assessing risks that are easier to interpret clinically is possible by combining donor kidney weight and recipient BMI with stratification. This finding is clinically crucial in pretransplant donor selection and recipient management. In particular, transplantation of a donor kidney with a small kidney weight to a recipient with a high BMI may necessitate cautious follow-up considering the risk of postoperative renal function decline. Moreover, nephron quantity mismatch at the donor selection stage should be minimized if possible. Furthermore, interventions to suppress glomerular hyperfiltration through weight and blood pressure management may be essential in postoperative care. However, this study had some limitations. First, it was a retrospective observational study, and the effects of unmeasured confounding could not be completely ruled out. Second, the nephron amount was not directly measured, and donor kidney weight was used as an alternative indicator. Third, immunosuppressive therapy and perioperative management were not fully uniform across sites, potentially influencing outcomes. Furthermore, although BMI is a simple indicator of physique, it also has limitations in that it does not reflect muscle mass or body fat distribution. From the above, this study demonstrated an association between donor kidney weight–recipient BMI imbalance and post-transplant renal prognosis. Prospective studies using indicators that more accurately reflect nephron amounts (e.g., kidney volume and image analysis) are anticipated to validate these findings and construct a risk stratification model^{7, 27, 28, 29}. Furthermore, this study also identified blood group incompatible transplantation as a factor independently associated with post-transplant renal function decline. Blood group incompatible transplantation is associated with the risk of desensitization therapy and antibody-related rejection, and the results suggest that these immunological factors can impact long-term renal function.

CONCLUSION

This study showed that donor kidney weight combined with higher recipient BMI (particularly donor kidney weight), and blood type incompatibility are crucial determinants of kidney function decline following living donor kidney transplantation. Therefore, the results of this study will assist in maximizing the usefulness of the donated kidney by rendering it possible to match the appropriate donor with the recipient by performing imaging assessment to estimate donor kidney weight in the pretransplant examination for the donor and adjusting the recipient BMI before transplantation. Furthermore, medical staff should closely monitor the implementation of strict self-management to protect the graft for blood group incompatibility and modify immunosuppressive drugs in post-transplant follow-up^{30–32}.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Iwate Medical University (approval number: MH2021-027) and was conducted in accordance with the Declaration of Helsinki. Written informed consent to participate was obtained from all participants. For participants under the age of 16 years, written informed consent to participate was obtained from their parents or legal guardians.

Consent for publication

Not applicable.

Availability of data and materials

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

Competing interests

The authors declare that they have no conflicts of interest relevant to this study.

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The authors received no specific funding for this work.

Author contributions

KI performed the statistical analyses, interpreted the data, and drafted the manuscript. AI provided methodological guidance, contributed to the interpretation of the results, and critically revised the manuscript. WO supervised the overall study and critically reviewed the manuscript. SH, HT, NT, CO, and TH provided academic guidance on the study, contributed to the interpretation of the findings, and critically revised the manuscript. RY, MS, and HN critically reviewed the manuscript and provided important intellectual comments. RS, KF, CK, MM, YA, SM, RM, and HS contributed to data acquisition and reviewed the manuscript. All authors read and approved the final manuscript.

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References

1. Wolfe RA, Ashby VB, Milford EL, et al. Comparison of mortality in all patients on Dialysis, patients on Dialysis awaiting transplantation, and recipients of a first cadaveric transplant. *N Engl J Med*. 1999;341(23):1725–30.
2. Garcia GG, Harden P, Chapman J. The global role of kidney transplantation. *Am J Nephrol*. 2012;35(3):259–64.
3. Hariharan S, Johnson CP, Bresnahan BA, Taranto SE, McIntosh MJ, Stablein D. Improved graft survival after renal transplantation in the United States, 1988 to 1996. *N Engl J Med*. 2000;342(9):605–12.
4. Giral M, Nguyen JM, Karam G, et al. Impact of graft mass on the clinical outcome of kidney transplants. *J Am Soc Nephrol*. 2005;16(1):261–8.
5. Lezaic V, Naumovic R, Marinkovic J, Jaksic E, Djukanovic L. Donor kidney glomerular filtration rate and post-transplant graft function. *Am J Transpl*. 2004;4(10):1669–74.
6. Saxena AB, Busque S, Arjane P, Myers BD, Tan JC. Preoperative renal volumes as a predictor of graft function in living donor transplantation. *Am J Kidney Dis*. 2004;44(5):877–85.
7. Poggio ED, Hila S, Stephany B, et al. Donor kidney volume and outcomes following live donor kidney transplantation. *Am J Transpl*. 2006;6(3):616–24.
8. Oh C-K, Jeon KOCK, Kim HJ, Kim SI, Seun Kim Y, Pelletier SJ. Metabolic demand and renal mass supply affecting the early graft function after living donor kidney transplantation. *Kidney Int*. 2005;67:744–9.
9. Magali G, Yohann F. Kidney and recipient weight incompatibility reduces long-term graft survival. *J Am Soc Nephrol*. 2010;6:1022–9.
10. Provoost AP, Brenner BM. Long-term follow-up of humans with single kidneys: The need for longitudinal studies to assess true changes in renal function. *Curr Opin Nephrol Hypertens*. 1993;2:521–6.
11. Nyengaard JR, Bendtsen TF. Glomerular number and size in relation to age, kidney weight, and body surface in normal man. *Anat Rec*. 1992;232(2):194–201.
12. El-Agroudy AE, Hassan NA, Bakr MA, Foda MA, Shokeir AA, Shehab El-Dein AB. Effect of donor/recipient body weight mismatch on patient and graft outcome in living-donor kidney

- transplantation. *Am J Nephrol*. 2003;23(5):294–9.
13. Gaston RS, Hudson SL, Julian BA, et al. Impact of donor/recipient size matching on outcomes in renal transplantation. *Transplantation*. 1996;61(3):383–8.
 14. Kasiske BL, Snyder JJ, Gilbertson D. Inadequate donor size in cadaver kidney transplantation. *J Am Soc Nephrol*. 2002;13(8):2152–9.
 15. Moreso F, Seron D, Anunciada AI, et al. Recipient body surface area as a predictor of posttransplant renal allograft evolution. *Transplantation*. 1998;65(5):671–6.
 16. Miles AM, Sumrani N, John S et al. The effect of kidney size on cadaveric renal allograft outcome. *Transplantation* 61(6):894–7.
 17. Nicholson ML, Metcalfe MS, White SA, et al. A comparison of the results of renal transplantation from non-heart-beating, conventional cadaveric, and living donors. *Kidney Int*. 2000;58(6):2585–91.
 18. Brenner BM, Milford EL. Nephron underdosing: A programmed cause of chronic renal allograft failure. *Am J Kidney Dis*. 1993;21(5):66–72.
 19. Matsuo S, Imai E, Horio M, et al. Revised equations for estimated GFR from serum creatinine in Japan. *Am J Kidney Dis*. 2009;53(6):982–92.
 20. Eschwege P, Trifa M, Randrianjohany A, et al. Effects of donor and recipient weight differences on serum creatinine levels in renal transplantation. *Transpl Proc*. 1995;27:2456–2456.
 21. Meier-Kriesche HU, Vaghela M, Thambuganipalle R, Friedman G, Jacobs M, Kaplan B. The effect of body mass index on long-term renal allograft survival. *Transplantation*. 1999;68:1294–7.
 22. Nicholson ML, Windmill DC, Horsburgh T, Harris KP. Influence of allograft size to recipient body-weight ratio on the long-term outcome of renal transplantation. *Br J Surg*. 2000;87(3):314–9.
 23. Kim SI, Kim YS, Kim MS, Moon JI, Park K. True living donor kidney weight-to-recipient body weight ratio influences posttransplant 1-year renal allograft function. *Transpl Proc*. 1998;30(7):3120.
 24. Moon IS, Kim YG, Park JH, et al. Influence of donor kidney size on immediate renal function (1 month) in kidney transplantation. *Transpl Proc*. 1998;30(7):3666.
 25. Lee SW, Hong IC, Kang SW. The mismatch of donor/recipient size influences development of proteinuria in allograft kidney transplants. *Transpl Proc*. 1996;28:1480–1.
 26. Hu M-K, Arndorfer JA, Kaplan B. The impact of body mass index on renal transplant outcomes: A significant independent risk factor for graft failure and patient death. *Transplantation*. 2002;73:70–4.
 27. Jones TB, Riddick LR, Harpen MD, Dubuisson RL, Samuels D. Ultrasonographic determination of renal mass and renal volume. *J Ultrasound Med*. 1983;2:151–4.
 28. Janoff DM, Davol P, Hazzard J, Lemmers MJ, Paduch DA, Barry JM. Computerized tomography with 3-dimensional reconstruction for the evaluation of renal size and arterial anatomy in the living kidney donor. *J Urol*. 2004;171:27–30.
 29. Kim YS, Moon JI, Kim DK, Kim SI, Park K. Ratio of donor kidney weight to recipient bodyweight as an index of graft function. *Lancet*. 2001;357:1180–1.

30. Montgomery RA, Lonze BE, King KE, Kraus ES, Kucirka LM, Locke JE. Outcome of desensitization in HLA- and ABO-incompatible kidney transplantation. *N Engl J Med*. 2011;365(4):318–26.
31. Toki D, Ishida H, Setoguchi K, et al. Acute antibody-mediated rejection in living ABO-incompatible kidney transplantation: long-term impact and risk factors. *Transplantation*. 2009;9(3):567–77.
32. Takahashi K, Saito K. ABO-incompatible kidney transplantation-current status and uncertainties. *Nat Rev Nephrol*. 2011;7(7):394–403.

Figures

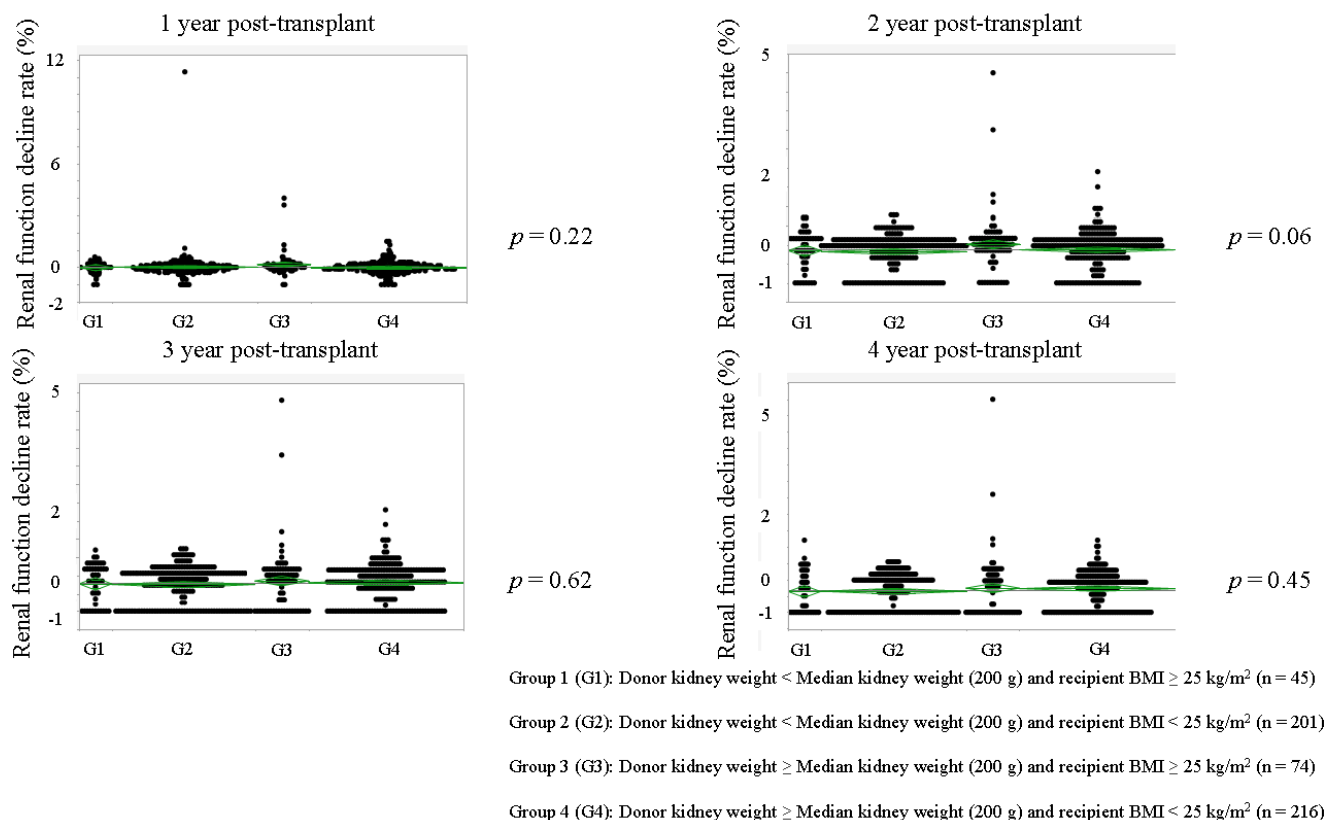


Figure 1

Renal function decline during 1-4 years after transplantation

Renal function decline rates at 1, 2, 3, and 4 years after living donor kidney transplantation were compared among the four groups stratified according to donor kidney weight and recipient body mass index (BMI). No significant differences were observed among the groups at any of these time points.

Group 1: Donor kidney weight < Median kidney weight (200 g) and recipient BMI ≥ 25 kg/m² (n = 45)

Group 2: Donor kidney weight < Median kidney weight (200 g) and recipient BMI < 25 kg/m² (n = 201)

Group 3: Donor kidney weight $\geq$ Median kidney weight (200 g) and recipient BMI ≥ 25 kg/m² (n = 74)

Group 4: Donor kidney weight $\geq$ Median kidney weight (200 g) and recipient BMI $< 25 \text{ kg/m}^2$ (n = 216)

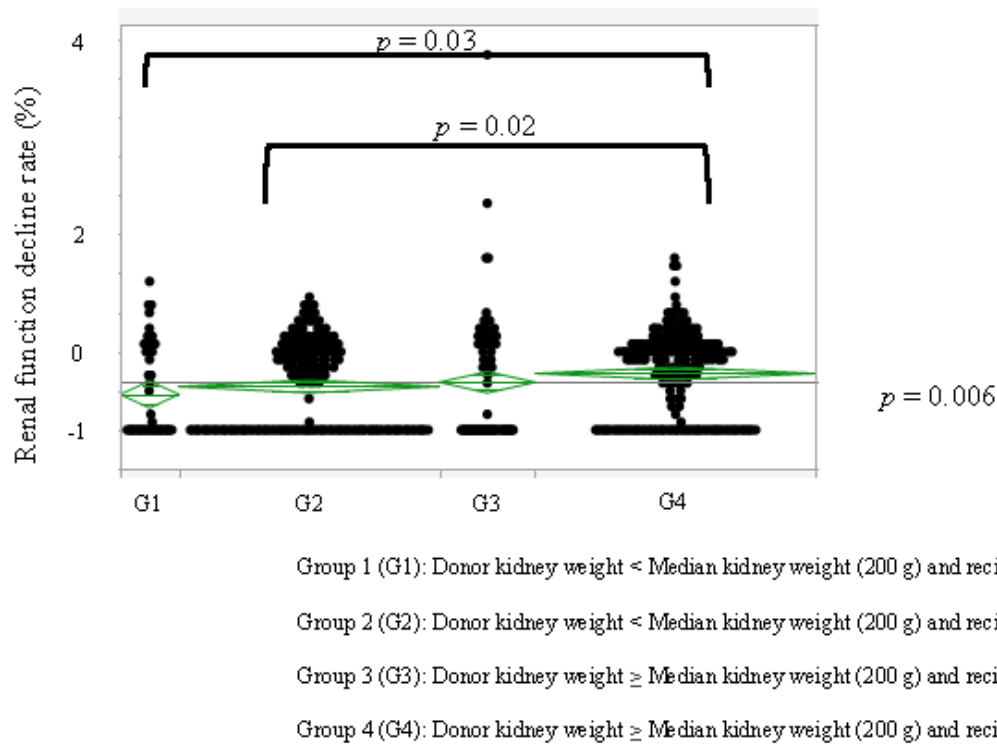


Figure 2

Renal function decline at 5 years according to kidney weight and recipient BMI

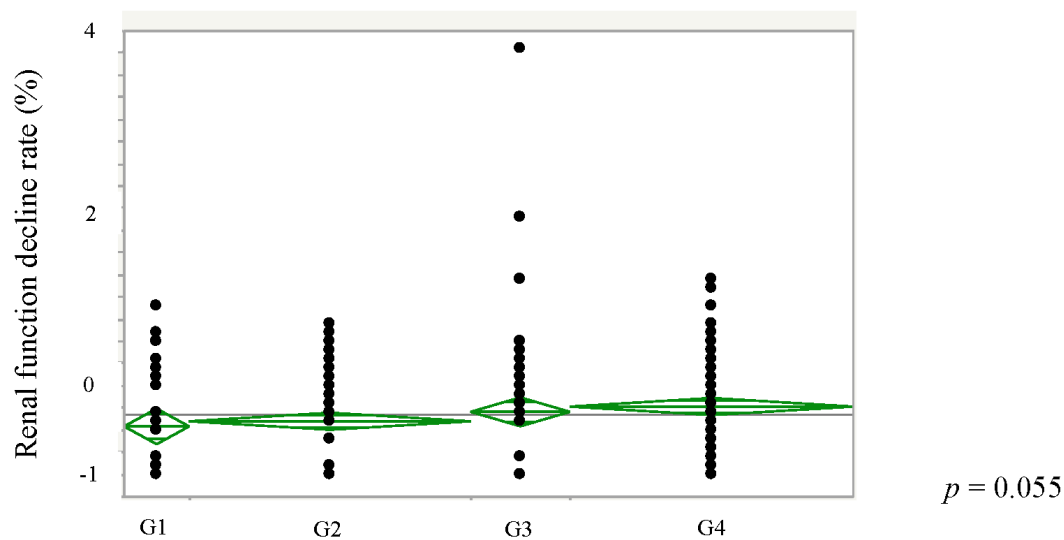
Renal function decline rates at 5 years after living donor kidney transplantation were compared among the four groups stratified according to donor kidney weight and recipient body mass index (BMI). A significant difference was observed among the four groups ($p = 0.006$). Post-hoc comparisons showed significant differences between Groups 1 and 4 ($p = 0.03$) and between Groups 2 and 4 ($p = 0.02$).

Group 1: Donor kidney weight $<$ Median kidney weight (200 g) and recipient BMI $\geq 25 \text{ kg/m}^2$ (n = 45)

Group 2: Donor kidney weight $<$ Median kidney weight (200 g) and recipient BMI $< 25 \text{ kg/m}^2$ (n = 201)

Group 3: Donor kidney weight $\geq$ Median kidney weight (200 g) and recipient BMI $\geq 25 \text{ kg/m}^2$ (n = 74)

Group 4: Donor kidney weight $\geq$ Median kidney weight (200 g) and recipient BMI $< 25 \text{ kg/m}^2$ (n = 216)



Group 1 (G1): Donor kidney weight < Median kidney weight (200 g) and recipient BMI ≥ 25 kg/m² (n = 45)

Group 2 (G2): Donor kidney weight < Median kidney weight (200 g) and recipient BMI < 25 kg/m² (n = 201)

Group 3 (G3): Donor kidney weight $\geq$ Median kidney weight (200 g) and recipient BMI ≥ 25 kg/m² (n = 74)

Group 4 (G4): Donor kidney weight $\geq$ Median kidney weight (200 g) and recipient BMI < 25 kg/m² (n = 216)

Figure 3

Renal function decline at 5 years in blood group-matched transplantation

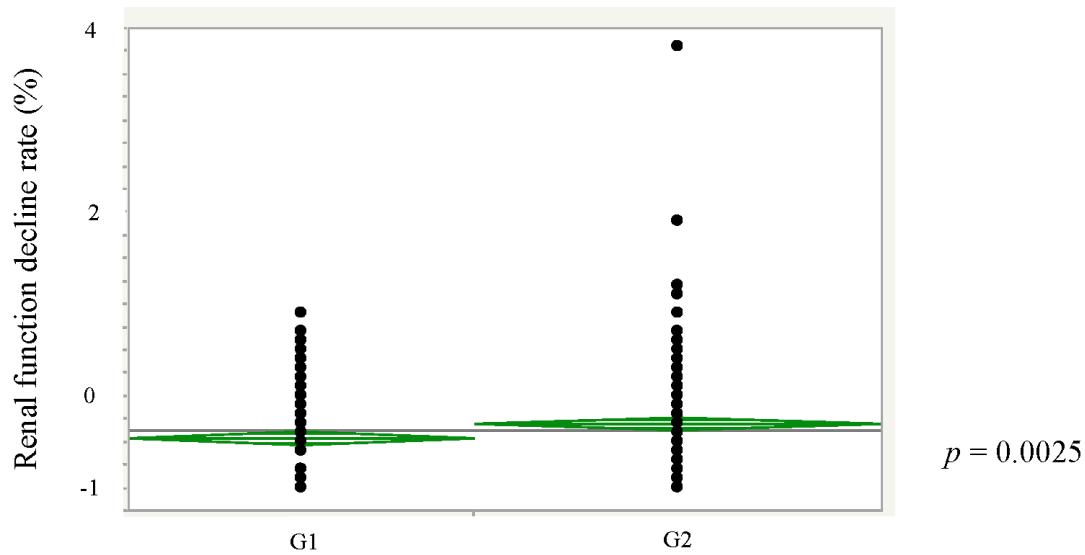
Renal function decline rates at 5 years after living donor kidney transplantation were compared among the four groups stratified according to donor kidney weight and recipient body mass index (BMI) in recipients undergoing blood group-matched transplantation. No statistically significant difference was observed among the four groups ($p = 0.055$).

Group 1: Donor kidney weight < Median kidney weight (200 g) and recipient BMI ≥ 25 kg/m² (n = 45)

Group 2: Donor kidney weight < Median kidney weight (200 g) and recipient BMI < 25 kg/m² (n = 201)

Group 3: Donor kidney weight $\geq$ Median kidney weight (200 g) and recipient BMI ≥ 25 kg/m² (n = 74)

Group 4: Donor kidney weight $\geq$ Median kidney weight (200 g) and recipient BMI < 25 kg/m² (n = 216)



Group 1 (G1): Donor kidney weight < Median kidney weight (200 g) (n = 246)

Group 2 (G2): Donor kidney weight $\geq$ Median kidney weight (200 g) (n = 290)

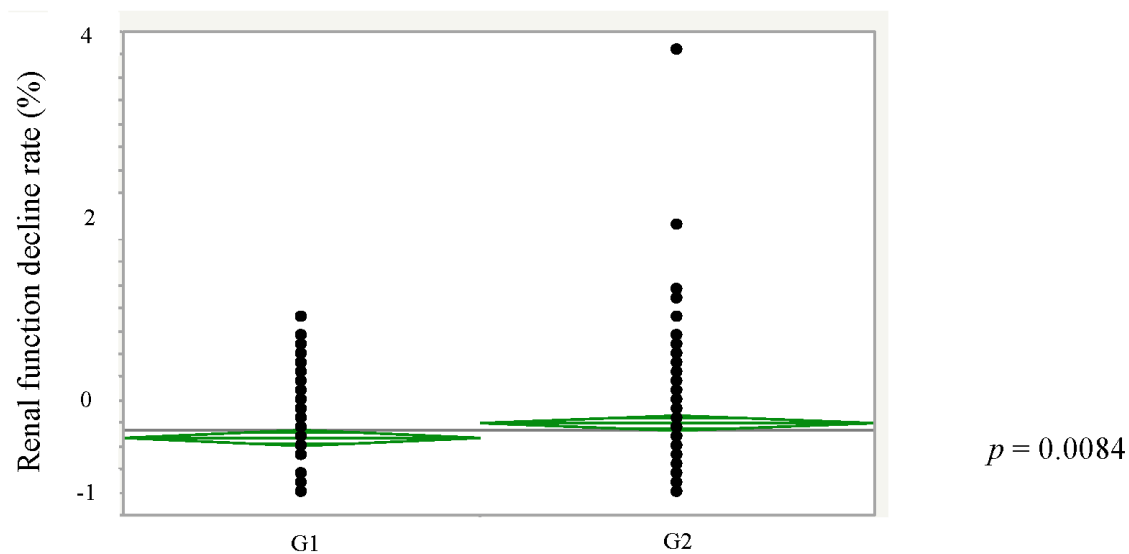
Figure 4

Renal function decline at 5 years according to donor kidney weight

Renal function decline rates at 5 years after living donor kidney transplantation were compared between recipients stratified according to donor kidney weight. A significant difference in renal function decline was observed between the two groups ($p = 0.0025$).

Group 1: Donor kidney weight < Median kidney weight (200 g) (n = 246)

Group 2: Donor kidney weight $\geq$ Median kidney weight (200 g) (n = 290)



Group 1 (G1): Donor kidney weight < Median kidney weight (200 g) (n = 246)

Group 2 (G2): Donor kidney weight $\geq$ Median kidney weight (200 g) (n = 290)

Figure 5

Renal function decline at 5 years according to kidney weight in blood group-matched transplantation

Renal function decline rates at 5 years after living donor kidney transplantation were compared between recipients stratified according to donor kidney weight among those undergoing blood group-matched transplantation. A significant difference in renal function decline was observed between the two groups ($p = 0.0084$).

Group 1: Donor kidney weight < Median kidney weight (200 g) (n = 246)

Group 2: Donor kidney weight $\geq$ Median kidney weight (200 g) (n = 290)

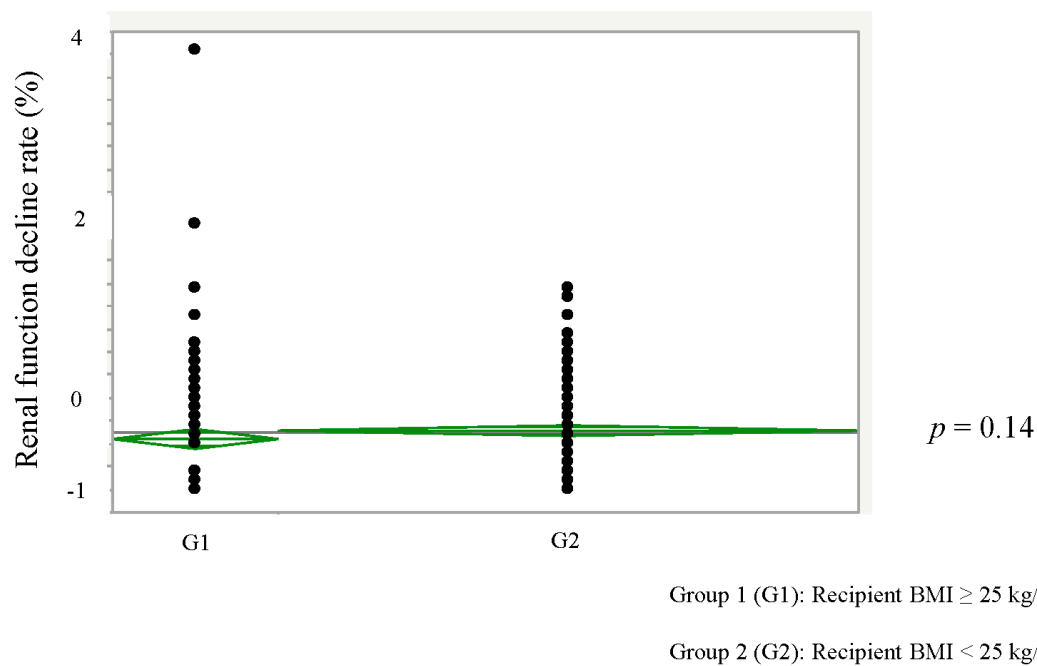


Figure 6

Renal function decline at 5 years according to recipient BMI

Renal function decline rates at 5 years after living donor kidney transplantation were compared between recipients stratified according to recipient body mass index (BMI). No statistically significant difference in renal function decline was observed between the two groups ($p = 0.14$).

Group 1: Recipient BMI ≥ 25 kg/m² (n = 119)

Group 2: Recipient BMI < 25 kg/m² (n = 417)