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ORIGINAL RESEARCH

Post-Transplant Graft Function and Survival Outcomes in Recipients of Standard Versus Marginal Cadaveric Donor Kidneys: A Single Center Experience Over a 10-Year Period

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ABSTRACT

Kidney transplantation is considered the best therapeutic option for end-stage renal disease. This study aimed to evaluate post-transplant graft function and survival outcomes in recipients of standard versus marginal cadaveric donor kidneys. A total of 30 cadaveric kidney transplantations performed with standard donor kidneys were retrospectively evaluated. Data on donor and recipient characteristics, kidney donor risk index (KDRI) and kidney donor profile index (KDPI) values, serum creatinine levels (up to 5th post-transplant year), delayed graft function, acute rejection status, graft and recipient survival rates were recorded. SCD and ECD groups were similar in terms of acute rejection (5.3% vs. 0.0%, p=1.000) and delayed graft function (42.1 vs. 54.5%, p=0.510) rates. Graft survival was significantly higher in the SCD group vs. ECD group (100.0% vs. 72.7%, p=0.041), while two the groups were similar in terms of recipient survival rates (94.7% vs. 90.9%, p=1.000). Graft loss occurred within the first three years in the ECD group. Higher serum creatinine levels were noted in the ECD vs. SCD group for the 1st month, 6th month and 1st year (p=0.042, p=0.015 and p=0.022, respectively) but not in the 3rd and 5th post-transplant years. Donor age (r=0.606 and r=0.602, respectively), KDRI (r=0.737 and r=0.759, respectively) and KDPI (r=0.590 and r=0.593, respectively) were significantly correlated with death-censored and total graft loss (p<0.001 for each). Our findings, although associated with relatively poorer transplantation outcomes, highlight that, marginal cadaveric donor kidneys expand the donor pool for kidney transplantation, are superior alternative to dialysis.

Keywords: Kidney transplantation. Cadaveric donor. Marginal donor. Standard donor. Outcome.

Standart ve Marjinal Kadavra Verici Böbrek Alıcılarında Transplantasyon Sonrası Greft Fonksiyonu ve Sağkalım Sonuçları: 10 Yıllık Tek Merkez Deneyimi

ÖZET

Böbrek nakli, son dönem böbrek yetmezliği için en iyi tedavi seçeneği olarak kabul edilmektedir. Bu çalışmada standart (SCD) ve marjinal (ECD) kadavra verici böbreklerden yapılan nakillerde, transplantasyon sonrası greft fonksiyonu ve sağkalım sonuçları değerlendirildi. Toplam 30 kadaverik böbrek nakli retrospektif olarak incelendi. Donör ve alıcı özellikleri, böbrek donör risk indeksi (KDRI), böbrek donör profil indeksi (KDPI), serum kreatinin düzeyleri (5. yıla kadar), gecikmiş greft fonksiyonu, akut rejeksiyon durumu, greft ve alıcı sağkalım oranları kaydedildi. SCD ve ECD grupları akut rejeksiyon (sırasıyla %5,3 ve %0, p=1,000) ve gecikmiş greft fonksiyonu (%42,1 ve %54,5, p=0,510) açısından benzerdi. Greft sağkalımı SCD grubunda anlamlı derecede daha yüksekti (%100,0'a karşı %72,7, p=0,041). Ancak alıcı sağkalımı açısından fark saptanmadı (%94,7 ve %90,9, p=1,000). Greft kaybı ECD grubunda ilk 3 yıl içinde meydana geldi. Serum kreatinin düzeyleri ECD grubunda 1. ay, 6. ay ve 1. yılda daha yüksekti (p=0,042; p=0,015; p=0,022), ancak 3. ve 5. yıllarda fark görülmedi. Donör yaşı (r=0,606 ve r=0,602), KDRI (r=0,737 ve r=0,759) ve KDPI (r=0,590 ve r=0,593) hem ölüm dışı hem de toplam greft kaybı ile anlamlı ilişkili bulundu (her biri için p<0,001). Bulgularımız, transplantasyon sonuçlarının görece daha zayıf olmasına rağmen, marjinal kadavra verici böbreklerin donör havuzunu genişlettiğini ve diyalize kıyasla üstün bir seçenek olduğunu göstermektedir.

Anahtar Kelimeler: Böbrek nakli. Kadaverik donör. Marjinal donör. Standart donör. Sonuç.

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Kidney transplantation is considered the best therapeutic option for end-stage renal disease (ESRD), which offers better long-term quality of life and better survival as well as cost effectiveness than hemodialysis or peritoneal dialysis[1-3]. However, the critical shortage of organs with increases seen in the demand for kidney transplantation procedures and the consequent ever longer recipient waiting lists, has led to alternative strategies to increase the donor pool, such as the concept of marginal donors or the expanded criteria donors (ECD)[3-6]. ECD (marginal donor) approach does not follow the classical allocation system of standard (optimal) kidneys but is based on a wider acceptance of organs from deceased borderline (expanded criteria) donors, which would have been otherwise deemed unsuitable, to shorten the time on waiting list at the expense of a better post-transplant graft function[3,4,6-9].

Expanded criteria (marginal) donors are individuals aged >60 years or those aged 50-59 years with at least two additional risk factors (stroke, history of hypertension, or serum creatinine above 1.5 mg/dl before transplantation, glomerulosclerosis of >15% or pro-longed cold ischemia)[4,6,7,10]. Although this approach increased the number of transplantations and thus increased the life expectancy in the recipients of marginal donor kidneys by 3-9 years compared to wait-listed dialysis patients, decreased long-term graft function due to use of expanded criteria for age or other clinical characteristics, as well as the inferior survival rates, in recipients of marginal donor vs. optimal donor kidneys has become the main challenge[4,6,8,9,11,12].

Use of kidney donor risk index (KDRI)/kidney donor profile index (KDPI) scoring system is a valuable pre-transplant risk stratification tool which is considered likely to help in reducing the difference between graft outcome from patients grafted with marginal and optimal donors[4,9,12-14]. The KDRI estimates the relative risk of failure of a graft from a deceased donor after transplantation versus a donor in the 50th percentile (graded from 0.5 and 3.5), while the KDPI represents the relative risk of graft failure in the case of a particular deceased donor compared to a reference donor, and is derived by ranking the KDRI on a scale of 0-100% with reference to a donor cohort in the network[13-15]. The KDRI and KDPI are strictly related scoring systems with advantages over the current ECD categorization in assessment of donor kidney quality for cadaveric transplants, such as more accurate indication of donor with use of ten donor-related factors (instead of four used to define ECD), use of a continuous scale (instead of a binary indicator) and their emphasis that not all ECDs are alike, as some provide for relatively good grafts; and some SCD may provide for worse grafts than some ECD[9,16.]

Currently, approximately 80,000 patients require renal replacement therapy and 22,000 patients are waitlisted dialysis patients in Türkiye, and in parallel to global situation, there is no remarkable increase in the cadaveric organ donation pool along with inability to transplant all of the donated organs, emphasizing the need for strategies for more effective use of available means as well as the use of marginal donor organs to increase the donor pool[17]. This retrospective study aimed to evaluate the cadaveric kidney transplantations performed over a 10-year period in our clinic in terms of post-transplant graft function and survival outcomes in recipients of standard donor kidneys and marginal donor kidneys, and to determine the potential donor- and recipient-related factors affecting the transplant outcome.

Material and Method

Study population:

A total of 30 cadaveric kidney transplantations performed with standard donor kidneys (SCD group; n=19) and marginal donor kidneys (ECD group; n=11) were retrospectively evaluated in this single center study conducted between 2010 and 2020. All cadaveric donors were those declared brain dead and underwent cadaveric organ donation. None of the transplantations was performed based on the donation after cardiac death. This study was conducted in accordance with the ethical principles stated in the 'Declaration of Helsinki' and approved by the local institutional ethics committee (Date of Approval: 17/04/2025; Protocol No: 2025-06/226).

Assessments

Data on baseline characteristics including the donor and recipient age, HLA mismatch count, cold ischemia time and KDRI/KDPI values, and the post-transplant outcome including the serum creatinine levels (from 1st week to 5th year), delayed graft function, primary non-function, acute rejection status, graft loss (overall and death-censored), and the graft and recipient survival rates were recorded and compared in recipients of standard vs. marginal cadaveric donor kidneys.

Treatment protocols

All patients received the standard protocol including the perioperative anti-thymocyte globulin (ATG) and methylprednisolone, and the post-operative methylprednisolone, calcineurin inhibitor (tacrolimus) and mycophenolate mofetil. Post-transplant, trimethoprim/sulfamethoxazole (400mg/day) was used for pneumocystis jirovecii prophylaxis for 6 months

and valganciclovir (450mg/day) was used for CMV prophylaxis for 3 months.

Statistical analysis

Statistical analysis was conducted using computer software (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). Student's t-test and Chi-square test (or Fischer exact test) were used for the comparison of numeric and categorical variables, respectively. Data were expressed as mean ± standard deviation (SD) and percent (%) where appropriate. $p<0.05$ was considered statistically significant.

Results

Donor characteristics

Marginal donor age was significantly higher (67.0±9.7 vs. 40.1±11.1 years, $p<0.001$), and hypertension (72.7 vs. 10.5%, $p=0.001$) and cerebrovascular disease (100.0 vs. 52.6%, $p=0.012$) were significantly more common among standard donors (Table I). No significant difference was noted between ECD and SCD groups in terms of donor gender, transplanted kidney (right kidney in 57.9% and 72.7%, respectively) and donor terminal serum creatinine levels ($p > 0.05$ for all). In SCD and ECD groups, multiple renal arteries were noted in 10.5% and 18.2% of donor kidneys, while multiple renal veins were evident in 10.5% and 9.1% of donor kidneys, respectively (Table I).

Baseline recipient characteristics

No significant difference was noted between SCD and ECD groups in terms of recipient age and gender as well as the HLA mis-match count. The mean ± SD waiting time on the dialysis was significantly longer in the ECD vs. SCD group (48±16 months vs 28±14 months, $p=0.01$). Albeit not statistically significant, there was a tendency for longer cold ischemia times in the ECD group when compared to the SCD group (mean ± SD 14.5±4.0 hours vs. 12.1±4.7 hours, $p=0.167$) (Table I).

Post-transplant outcome

The duration of functional graft-follow up was similar in SCD and ECD (median[minimum-maximum] months, 42 [1-99] months, vs 34 [4-92] months) (Table II). Post-discharge immune suppressive therapy was commenced at lower doses in the ECD group, while higher doses of antihypertensives were required in these patients to control the hypertension. No significant difference was noted between SCD and ECD groups in terms of primary nonfunction (0% for

Table I. Baseline donor and recipient characteristics of standard and marginal cadaveric donor transplantation groups

				Standard cadaveric donor transplantation group (n=19)	Marginal cadaveric donor transplantation group (n=11)	p value
Donor characteristics	Age (years), mean±SD			40.1±11.1	68.3±9.1	**<0.001**
	Gender	Female, n(%)		5(26.3)	6(54.5)	0.238
		Male, n(%)		14(73.7)	5(45.5)	
	Diabetes mellitus, n(%)			1(5.2)	3(27.3)	0.126
	Hypertension, n(%)			2(10.5)	8(72.7)	**0.001**
	Cerebrovascular disease, n(%)			10(52.6)	11(100.0)	**0.012**
	Transplanted kidney	Right, n(%)		11(57.9)	8(72.7)	0.466
		Left, n(%)		8(42.1)	3(27.3)	
	Terminal donor serum creatinine (mg/dL), mean±SD			1.16±0.54	1.23±0.50	0.729
	Number of renal arteries		Single, n(%)	17(89.5)	9(81.8)	N/A
			Multiple, n(%)	2(10.5)	2(18.2)	
	Number of renal veins		Single, n(%)	17(89.5)	10(90.9)	N/A
			Multiple, n(%)	2(10.5)	1(9.1)	
Recipient characteristics	Age (years), mean±SD			43.9±9.1	41.5±11.4	0.530
	Gender	Female, n(%)		4(21.1)	4(36.4)	0.238
		Male, n(%)		15(78.9)	7(63.6)	
	Waiting time on dialysis (months), mean±SD			28±14	48±16	**0.01**
	HLA mismatch count, (n)			2.4±1.42	3.16±1.19	0.130
	Cold ischemia time (hours), mean±SD			12.1±4.7	14.5±4.0	0.167

t-test; $\chi 2$ test

each), acute rejection (5.3% vs. 0.0%, p=1.000) and delayed graft function (42.1% vs. 54.5%, p=0.510) rates. Graft survival was significantly higher in the SCD group than in the ECD group (100.0% vs. 72.7%, p=0.041), while two the groups were similar in terms of recipient survival rates (94.7% vs. 90.9%, p=1.000) (Table II). Graft loss occurred in 3 (27.3%) of 11 patients within the first 3 years in the ECD group at 13th, 28th and 35th months, respectively. The remaining patients did not develop graft loss during the follow-up period. The only death in the SCD group occurred after 5 years and in the ECD group in the first year. Mortality with functional kidney occurred in 1 recipient in each group (5.3% in SCD and 9.1% in ECD groups), which was due to myocardial infarction (MI) at the 64th month of functional graft follow up in the SCD group, and occurred due to vertebral abscess at the 6th month of follow up in the ECD group. In terms of serum creatinine levels, while the 1st month (1.42±0.41 vs 2.03±1.10, p=0.042), 6th month (1.25±0.38 vs 2.42±1.21, p=0.015) and 1st year (1.32± 0.53 vs 2.76± 2.09, p=0.022) measurements were significantly higher in the ECD group than in the SCD group, no significant difference was noted between serum creatinine levels measured at 3rd year and 5th year (Table II).

Table II. Post-transplant outcomes of standard amd marginal cadaveric donor kidney recipients

		Recipients of standard donor kidneys (n=19)	Recipients of marginal donor kidneys (n=11)	p-value
Duration of follow up (months), median (minimum-maximum)		42 (1-99)	34 (4-92)	0.477
Serum creatinine (g/dL), mean±SD	1st month	1.42±0.41	2.03±1.10	**0.042**
	6th month	1.25±0.38	2.42±1.21	**0.015**
	1st year	1.32± 0.53	2.76± 2.09	**0.022**
	3rd year	1.44± 0.48	1.64±0.39	0.498
	5th year	1.29±0.47	1.87±0.38	0.219
Primary non-function, n(%)		0(0.0)	0(0.0)	-
Acute rejection, n(%)		1(5.3)	0(0.0)	1.000
Delayed graft function, n(%)		8 (42.1)	6(54.5)	0.510
Graft survival, n(%)*		19(100.0)	8(72.7)	**0.041**
Recipient survival, n(%)		18(94.7)	10(90.9)	1.000

*death censored graft survival, Kaplan Meier analysis

Correlation between donor characteristics and graft loss

Donor age (r=0.606 and r=0.602, respectively, p<0.001), KDRI (r=0.737 and r=0.759, respectively, p<0.001 for each) and KDPI (r=0.590 and r=0.593, respectively, p<0.001 for each) showed significant positive correlations with death-censored and total graft loss (Table III). No significant correlation of donor serum creatinine levels was noted with death-censored or total graft loss (r=0.223, p>0.05) (Table III). No significant correlation was noted between graft loss and the cold ischemia time (r=0.772), HLA mismatch count (r=0.955) or delayed graft function (r=0.813) parameters (p>0.05 for each). Also, no correlation was noted between the cold ischemia time and the delayed graft function (r=0.980, p>0.05).

Table III. Correlation between donor characteristics and the graft loss

		Graft Loss	
		Death-censored	Total
Donor serum creatinine levels	r	0.134	0.223
	p	>0.05	>0.05
Donor age	r	0.606	0.602
	p	**<0.001**	**<0.001**
Kidney donor risk index (KDRI)	r	0.737	0.759
	p	**<0.001**	**<0.001**
Kidney donor profile index (KDPI)	r	0.590	0.593
	p	**<0.001**	**<0.001**

r: Pearson correlation coefficient

Discussion and Conclusion

Our findings revealed favorable transplantation outcome with use of marginal and standard cadaveric donor kidneys in terms of long-term (beyond 3 years) creatinine levels, primary non-function, acute rejection and delayed graft function rates as well as the recipient survival. However, the graft survival rates were significantly lower in recipients of marginal vs. standard cadaveric donor kidneys. Donor age, KDRI and KDPI were found to be the parameters that showed significant positive correlation with both the death-censored and total graft loss.

Similar to our results, the marginal (ECD) donor transplantation has consistently been associated with increased risk of post-transplant allograft failure than the ideal reference group, as estimated to be ≥70% at 2 years[5,7,9,12,18]. Long-term studies also reported a lower graft survival at 7 years post-transplantation with the ECD kidneys than the SCD kidneys. In the ECD group, cold ischemia, and presence of donor-specific alloantibodies at transplantation were found to predict the graft failure in the multivariate analysis adjusted for donor type (deceased vs. living), diabetes mellitus presence, graft rank, and the number of HLA-A/B/DR mismatches[19,20].

In our cohort, mortality with functional kidney occurred in 1 recipient in each group (5.3% in SCD group vs. 9.1% in ECD group) at the 64th month and

6th month of functional graft follow up. ECD and SCD groups were also similar in terms of the acute rejection and delayed graft function rates and the long-term serum creatinine levels. In a study comparing ECD and SCD cadaveric kidney transplantations groups, ECD kidneys had worse graft function (lower baseline, 3rd month, 6th month and 1st year glomerular filtration rate (GFR) values), while patient and graft survival in both groups were found to be comparable, with similar rates of grafts loss (12.9 % vs 6.2%, respectively) and mortality (7.4% vs. 8.3%, respectively)[21]. Other studies also reported no significant differences in the survival of recipients who received kidneys from ECDs and those who received SCDs, as well as excellent results of ECD transplantation which revealed similar 1-year acute rejection rates and 5-year death-censored survival rates with the SCD transplantation[22-24]. Nonetheless, many other studies indicated poorer survival in recipients of marginal cadaveric donor kidneys than those of standard cadaveric donor kidneys, besides the lower graft survival in the former group. In a study from Türkiye by Cicek et al, no significant difference was found in the acute rejection and postoperative complication rates of the standard and marginal cadaveric kidney recipient groups, whereas serum creatinine levels were significantly higher in the marginal group at 6, 12, and 24 months, and the graft and recipient survival were both significantly longer in the standard group[12]. Also, Mota et al. reported no significant difference between the deceased donor transplants performed with SCD and ECD in terms of the prevalence of delayed graft function, whereas ECD group had significantly lower GFR and survival rate along with a tendency for lower graft survival at the end of the 1st year when compared to the SCD group[9]. However, no significant difference was seen in graft survival between ECD and SCD with exclusion of cases of mortality with a functioning kidney[9].

In a meta-analysis of 29 studies to assess the results of ECD transplantation, the non-adjusted pooled risk ratio of patient survival at 5 years was estimated at 1.62 and of death-censored graft survival at 1.69 in favor of SCD as compared to ECD[25]. In an analysis of 3,062 kidney recipients (619 received a ECD kidney, 2,433 received a SCD kidney) after 7.8 years of follow-up in a European population, recipients from de-ceased ECD donors had a higher risk of death-censored graft failure and death as compared to other recipients (deceased donors with SCD criteria and living donors), while ECD criteria was associated with an absolute risk of 16.9% for graft lost and 10.1% for death at 10 years, as compared to SCD[26]. In our study, while use of ECD donor kidneys was associated with worse graft survival and higher serum creatinine levels within the 1st year of follow up than the SCD donor kidneys, recipient survival rates were similar across the groups, and serum creatinine levels decreased over the next years, becoming closer to serum creatinine levels in the SCD group. These findings seem to indicate that the kidney transplantation with use of ECD donor kidneys, although it is associated with relatively poorer transplant outcomes, represents a treatment choice superior to the dialysis. In fact, while marginal (ECD) kidneys were associated with worse long-term graft function and survival outcomes than SCD kidneys (first year: 87.4 % vs. 93.7%, $p<0.05$; 5-year: 66.4% vs. 79.4%, $p<0.05$, respectively)[11,18,27], they provide acceptable function and significantly better patient survival when compared to dialysis [9,11,12,27-29].

According to 2019 data from the Turkish Society of Nephrology registry, dialysis and transplantation in Türkiye, the mortality rate in patients on hemodialysis was 15.4% compared with 9.7% in the recipients of cadaveric donors[30]. Other studies also indicated the association of marginal donor (ECD) kidney transplantation with significant survival advantage over the maintenance dialysis treatment, increasing the 5-year life expectancy which was reported to be 83.6% in recipients of ECD kidney but 67.4% in those who remained on the waiting list[5,11,31,32]. The rate of ECD cadaveric kidney transplantations was 37,5% over a 10-year transplantation period (from 2010 to 2020) in our clinic. Each year, ~30% of potential donors in Europe and ~24% of potential donors in North America are considered to be ECD, and nearly 40% of these kidneys are discarded[5,33]. Hence, post-transplant outcomes in our marginal and standard donor groups emphasize the importance of marginal cadaveric donor kidneys as a favorable option in offering a chance of survival to patients on hemodialysis, by increasing the donor pool and shortening the time on waiting list [ß3,4,6-9,12].

Indeed, the significantly higher serum creatinine levels within the 1st year of post-transplant follow up in recipients of marginal vs. standard cadaveric kidney donors in our study are in consistence with the results of previous studies reporting that serum creatinine level above 1.5 mg/dL six months after transplantation is an important risk factor for graft loss[9,34]. Nonetheless, there was a tendency for decreasing serum creatinine levels in the ECD group beyond the 3rd post-transplant year. The similar rates of delayed graft function in marginal vs. standard donor groups in our study seems consistent with the fact that the mean time of cold ischemia was also not different between the groups. Indeed, while the utilization of kidneys from deceased donors with serum creatinine levels $\geq$ 1.5 mg/dL has been associated with a 10% risk of graft loss regardless of donor age, multivariate analysis of the data from the Scientific Registry of Transplant Recipients (SRTR) indicated that serum creatinine levels $\geq$ 2mg/dl do not increase the risk of graft loss[18].

The quality of the donor organ is considered as the strongest predictor of graft survival[35,36]. In this regard, decreasing the prognostic difference between kidneys from marginal donors and standard criteria donors via adoption of appropriate strategies before, during, and after the transplantation (i.e., reduction of cold ischemia times, careful recipient selection, improved graft selection and adequate immunosuppression therapy) are considered to be of critical importance in transplant success[4,9]. In our country, cadaveric donor kidney recipients are identified via a score based on tissue and blood group compatibility, recipient's age, dialysis and waiting list time assessed by the regional coordination centers working under the National Coordination Center. The similarity of cold ischemia times, as well as terminal donor serum creatinine levels between marginal and standard cadaveric donor kidneys in our cohort seem to be a positive outcome of this regional distribution policy. Notably, along with the donor age, KDPI and KDRI were the only parameters that showed significant positive correlation with death-censored and total graft loss in our study. Although the correlations between KDPI and death-censored and total graft loss were statistically significant, it should be kept in mind that the correlation coefficient was less than 0.7, i.e., less than the value being considered as a good correlation. Nonetheless, pre-transplant risk stratification via KDRI/KDPI scoring system may help to reduce the difference be-tween graft outcome of patients grafted with marginal and optimal donors[4]. Likewise, previous studies documented the correlation of the high donor KDRI/KDPI scores with the risk of graft failure, and the higher serum creatinine levels of the recipients, particularly in case of marginal donor transplantation, emphasizing that evaluation of KDRI/KDPI scores might be required in marginal donors[16,37-39]. Also, graft and patient survival rates in cadaveric donor kidney transplantations from Türkiye were reported to be higher in patients with a KDPI of 0 to 60 than in those with a KDPI of 81 to 100[12], while 2004−2011 data from the Organ Procurement and Transplantation Network revealed that 5-year graft survival in primary, solitary and adult cadaveric kidney transplants was 83.3% in patients with a KDPI of 1% and reduced to 46.9% in patients with a KDPI of 99%[14].

In fact, young and healthy patients benefit significantly more from living donor (27.6 years) and standard donor (26.4 years) transplants in terms of survival compared to marginal donor (17.6 years) transplants[40]. In contrast, older (> 65 years) and frailer transplant candidates are suggested to accept lower quality organs early after ESRD in terms of longer life expectancy (5.6 year) compared with waiting for a standard kidney (5.3 year) or a living donation (5.5 year) after 4 years of dialysis[40]. Accordingly, given the current waiting times for deceased donor organs, the distribution of ECD kidneys to older recipients early in the waiting list period and delayed transplantation of SCD kidneys to healthier patients is considered likely to be the best approach for resource utilization and survival optimization from an allocation perspective[40].

In this regard, the KDRI/KDPI scoring system is considered helpful for the longevity matching, by allocating kidneys with a higher KDPI to patients on dialysis with a long waiting list time and a lower life expectancy, and allocating kidneys with a very high KDPI (>80%) to older (>70 years) patients to enable the documented longer life expectancy compared to remaining on dialysis[16,41,42]. The correlation of KDRI/KDPI scores, which has been developed by the American Registry of Transplants, with total and death-censored graft loss in our cohort seems notable. The KDPI/KDRI scoring system provides a prediction of the benefit to be obtained from the transplantation based on kidney transplantation data in the USA. In fact, our study also shows that this scoring system is a useful predictor of transplantation success in Turkish population. On the other hand, the original scoring system was optimized for the US population and some of the parameters were very limitedly useful in our population since in Türkiye African American/Black individuals were very few and HCV positive donors were not accepted. Until the revision in October 2024[43], while the donor race or HCV status were taken into account in US and many other countries, in our practice, these parameters were not meaningful. Hence, we emphasize that optimizing the KDPI/KDRI for different populations and countries is essential to increase its predictive and guiding power.

Also, although there was no statistically significant correlation between graft loss and the cold ischemia time, HLA mismatch count, and delayed graft function, as well as between the cold ischemia time and delayed graft function, high correlation coefficients were observed. These discrepancies between significant p values and low correlation coefficients and vice versa could be explained by the small sample size.

One of the main limitations of this study is the retrospective design preventing to establish temporality between the cause and effect. Also, as it is well known that small sample size affects reproducibility of data and the small sample size of the study limits reproducibility. Finally, since this was a single center study, generalizability of the findings is also lacking.

In conclusion, our results highlight the potential of marginal cadaveric donor kidneys as an alternative technique that is better than dialysis and not inferior to standard donor kidneys in terms of recipient survival, even though they are linked to comparatively worse transplant outcomes. A pre-transplant risk

stratification based on the KDRI/KDPI scoring system (preferably adapted for the Turkish population) may help in increasing the graft survival and transplant success in recipients of marginal donor kidneys. The increased risk of graft loss in marginal donor kidneys seems notable given the significant positive correlation of the donor age and the KDRI/KDPI scores with the risk of total and death-censored graft loss. Further large scale studies including patients from different countries are necessary to evaluate the long-term transplant outcome in recipients of marginal cadaveric donors, particularly in terms of longevity matching.

Researcher Contribution Statement:
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