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Review Article

Single versus Dual Kidney Transplantation: A Comparative Analysis of Prognosis and Clinical Outcomes

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Abstract

The persistent shortage of suitable donor kidneys has led to increased use of expanded-criteria donors (ECD) and the adoption of dual kidney transplantation (DKT) to compensate for reduced nephron mass. Whether DKT provides superior outcomes compared with single kidney transplantation (SKT) from marginal donors remains a central question in transplant medicine. This narrative review synthesizes evidence from registry analyses, cohort studies, and biopsy-driven allocation protocols to compare graft survival, patient survival, renal function, and perioperative outcomes between SKT and DKT [1-4].

SKT from standard-criteria donors (SCD) achieves excellent outcomes, with 1-year graft survival of 90–95% and 5-year survival of 75–85%. In contrast, ECD-SKT shows reduced performance (1-year 80–85%; 5-year 55–65%). DKT consistently improves outcomes in marginal kidneys, with 1-year graft survival of 88–94% and 5-year survival of 70–80%. DKT reduces hyperfiltration injury (10–15% vs 30% in ECD-SKT) and improves estimated GFR at 1 year (55–70 mL/min vs 40–50 mL/min). Surgical morbidity is higher in DKT, but patient survival remains comparable to SCD-SKT. DKT is an effective strategy to optimize utilization of marginal kidneys and achieve outcomes approaching those of SCD-SKT. Allocation protocols incorporating donor age, comorbidities, and histology remain essential to maximize benefit [5].

Keywords: Kidney transplantation; expanded-criteria donors; renal physiology; hyperfiltration

Introduction

Kidney transplantation remains the optimal treatment for end-stage kidney disease, offering superior survival and quality of life compared with dialysis. However, the widening gap between organ supply and demand has prompted broader acceptance of ECD kidneys and the development of DKT protocols. The rationale for DKT is to offset reduced nephron mass and mitigate hyperfiltration injury, thereby improving long-term graft performance. This manuscript compares SKT and DKT outcomes, focusing on graft survival, renal function, and patient prognosis [6-9].

Donor and Recipient Selection

Single Kidney Transplantation (SKT) is the standard approach for SCD donors and selected ECD donors with preserved renal function. Allocation is typically based on donor age, serum creatinine, comorbidities, and pre-implantation biopsy. Dual Kidney Transplantation (DKT) is considered when donor kidneys exhibit advanced age (>60 years), moderate glomerulosclerosis (15–30%), reduced nephron mass, or multiple ECD risk factors (hypertension, cerebrovascular death, elevated creatinine). Biopsy-driven allocation systems (e.g., Remuzzi scoring) are widely used to determine suitability for DKT [10-12].

When comparing clinical outcomes between single kidney transplantation (SKT) and dual kidney transplantation (DKT), a unifying physiological principle becomes immediately evident: nephron mass matters. The data you provided align remarkably well with this concept, showing how DKT can effectively compensate for the inherent limitations of kidneys procured from expanded-criteria donors (ECD).

Graft Survival: Reconstructing Physiological Reserve

Kidneys from standard-criteria donors (SCD-SKT) continue to set the benchmark, with excellent 1- and 5-year graft survival. In contrast, ECD kidneys transplanted singly exhibit a more pronounced decline over time, reflecting reduced functional reserve, vascular aging, and a heightened susceptibility to hyperfiltration injury. Within this context, DKT acts as a biological equalizer. Two marginal kidneys together recreate an effective nephron mass, producing graft survival curves that closely approximate those of SCD-SKT and clearly surpass ECD-SKT. The observed 20–30% reduction in graft loss risk compared with ECD-SKT is entirely consistent with this physiological rationale.

Patient Survival: Translating Renal Benefit into Clinical Benefit

The advantages of DKT extend beyond graft performance. Patient survival mirrors the improved renal physiology. While ECD-SKT recipients experience a noticeable reduction in long-term survival, DKT recipients achieve outcomes that approach those of SCD-SKT, with minimal differences at 1 year and only modest divergence at 5 years. This pattern suggests that the superior renal function achieved with DKT confers a meaningful clinical benefit to the patient, not merely to the graft [13].

Renal Function: The Core of DKT's Advantage

Renal function provides the clearest demonstration of DKT's physiological strength. At one year, eGFR in DKT recipients not only exceeds that of ECD-SKT but often matches or surpasses SCD-SKT values. This is a direct reflection of restored nephron mass: rebuilding physiology rebuilds function.

Hyperfiltration Data Reinforce this Point

ECD-SKT is associated with hyperfiltration injury in roughly 30% of cases at 5 years, whereas DKT reduces this incidence to 10–15%. By distributing the filtration workload across two kidneys, DKT limits glomerular stress, reduces proteinuria, and protects long-term graft integrity.

Delayed Graft Function: A Risk Softened by Nephron Reserve

Despite the use of marginal kidneys, DKT demonstrates DGF rates much closer to SCD-SKT than to ECD-SKT. Again, the explanation is physiological: two kidneys, each bearing a smaller functional burden, recover more effectively from ischemic insult.

Surgical Considerations: Balancing Complexity and Benefit

From a technical standpoint, DKT requires longer operative time, additional vascular anastomoses, and carries a higher risk of complications such as vascular events and lymphocele formation. However, these surgical challenges are outweighed by the functional and prognostic benefits, particularly when the alternative is transplanting marginal kidneys singly with inferior outcomes.

Table 1 highlights the key donor characteristics and allocation criteria that guide the selection between single-kidney transplantation (SKT) and dual-kidney transplantation (DKT).

Table 1: Donor Characteristics and Allocation Criteria.

Parameter	SKT (SCD)	SKT (ECD)	DKT
Donor age	>60 years or 50–59 with risk factors	>60 years or 50–59 with risk factors	Typically >60 years
Serum creatinine	Normal	Often elevated	Often elevated
Biopsy findings	Minimal sclerosis	Mild–moderate sclerosis	Moderate sclerosis (15–30%)
Nephron mass	Adequate	Reduced	Compensated by dual implantation

As shown, SCD-SKT is generally reserved for donors with favourable clinical profiles—typically younger individuals with normal serum creatinine and minimal histological injury. These features ensure adequate nephron mass and functional reserve, supporting excellent post-transplant outcomes with a single graft. In contrast, ECD-SKT involves kidneys from older donors or those with additional risk factors, often accompanied by elevated creatinine levels and mild to moderate chronic changes on biopsy. Although these organs remain suitable for SKT, their reduced nephron mass and structural alterations are associated with a higher risk of delayed graft function and inferior long-term performance compared with SCD kidneys. DKT occupies a distinct

position within this allocation framework. Donors selected for DKT typically present with advanced age, impaired renal function, and moderate degrees of glomerulosclerosis (15–30%). While each kidney alone may provide insufficient functional reserve, bilateral implantation compensates for reduced nephron mass, restoring adequate filtration capacity and mitigating the risk of hyperfiltration injury. This compensatory effect explains why DKT can achieve outcomes comparable to SCD-SKT and superior to ECD-SKT, despite the marginal nature of the individual organs. Overall, the table underscores the importance of integrating donor age, functional markers, and biopsy findings into allocation decisions. By aligning organ quality with the most appropriate transplant strategy, centers can optimize graft survival, expand the use of marginal kidneys, and enhance overall organ utilization.

Table 2 provides a comparative overview of clinical outcomes across SCD-SKT, ECD-SKT, and DKT, illustrating the performance gradient associated with donor quality and transplant strategy.

Table 2: Comparative Outcomes of SKT and DKT.

Outcome	SCD-SKT	ECD-SKT	DKT
1-year graft survival	90–95%	80–85%	88–94%
5-year graft survival	75–85%	55–65%	70–80%
1-year patient survival	95–98%	90–92%	94–97%
eGFR at 1 year	55–65 mL/min	40–50 mL/min	55–70 mL/min
DGF	20–25%	35–45%	20–30%
Hyperfiltration injury	10–15%	~30%	10–15%

As expected, SCD-SKT demonstrates the most favorable profile, with excellent 1-year and 5-year graft survival, high patient survival, and robust renal function at one year. These results reflect the intrinsic quality of standard-criteria donor kidneys, which possess sufficient nephron mass and minimal chronic injury. In contrast, ECD-SKT shows a clear decline across all major outcome metrics. Lower graft survival at both 1 and 5 years, reduced eGFR, and a markedly higher incidence of delayed graft function (DGF) underscore the limitations of transplanting a single kidney from older donors or those with comorbidities. The elevated rate of hyperfiltration injury (~30%) further highlights the vulnerability of these grafts, as reduced nephron mass forces compensatory hyperfiltration that accelerates structural deterioration. DKT occupies an intermediate yet strategically advantageous position. Despite being derived from marginal donors, DKT achieves outcomes that closely approximate SCD-SKT and clearly surpass ECD-SKT. One-year and five-year graft survival rates remain high, and the eGFR at one year (55–70 mL/min) reflects the functional benefit of increased nephron mass provided by bilateral implantation. The incidence of DGF and hyperfiltration injury mirrors that of SCD-SKT, reinforcing the protective effect of distributing the functional workload across two kidneys rather than overburdening a single marginal graft. Overall, the table underscores the clinical rationale for DKT as a means to optimize the use of marginal kidneys. By compensating for reduced individual organ quality, DKT restores functional reserve, mitigates hyperfiltration-related damage, and delivers outcomes that meaningfully expand the donor pool without compromising patient or graft survival.

Discussion

DKT has increasingly established itself as a robust and evidence-based strategy to expand the utilization of marginal kidneys while preserving satisfactory clinical outcomes. The superior graft survival and renal function consistently reported with DKT underscore the physiological advantage of a greater nephron mass, which mitigates hyperfiltration injury and limits the progression of chronic structural damage—mechanisms that often compromise the longevity of single-kidney transplants derived from suboptimal donors. Despite the inherently greater surgical complexity, the net clinical benefit of DKT in appropriately selected recipients is clear. Contemporary experience highlights the importance of rigorous pre-implantation assessment, integrating morphological and functional parameters to identify donors for whom bilateral implantation provides a meaningful advantage. In this context, biopsy-driven allocation systems have emerged as a pivotal tool, enabling more accurate differentiation between kidneys suitable for SKT and those that warrant DKT due to chronic histological changes or reduced functional reserve. Such approaches optimize the use of scarce donor organs and contribute to improved long-term graft performance. While SKT remains the gold standard for high-quality donor kidneys, DKT represents a valuable and increasingly validated alternative for marginal organs. Outcomes comparable to SCD-SKT and superior to ECD-SKT reinforce the role of DKT as a complementary strategy rather than a fallback option. Broader implementation of standardized DKT protocols, supported by multidisciplinary evaluation and harmonized allocation criteria, has the potential to reduce waiting-list mortality and enhance overall organ utilization in the face of persistent organ shortage.

Conclusion

Dual kidney transplantation has emerged as a reliable and effective approach to expand the donor pool while preserving high-quality clinical outcomes. Across the available evidence, DKT consistently compensates for the reduced nephron mass and structural changes typical of expanded-criteria donors, resulting in superior graft survival, improved renal function, and lower rates

of hyperfiltration injury compared with single transplantation of marginal kidneys. Although the procedure entails greater surgical complexity, these challenges are outweighed by the physiological and prognostic advantages conferred by bilateral implantation. When guided by rigorous donor assessment and biopsy-driven allocation protocols, DKT achieves results that closely approximate those of standard-criteria single kidney transplantation and clearly surpass those of ECD-SKT. As organ shortages persist, broader adoption of standardized DKT strategies offers a meaningful opportunity to enhance organ utilization, reduce waiting-list mortality, and improve long-term outcomes for transplant recipients.

Single kidney transplantation remains the standard and most widely adopted strategy for renal replacement in eligible candidates, offering a well-established balance between surgical feasibility, graft availability, and long-term clinical benefit. When donor quality is acceptable and recipient risk is not prohibitive, a single graft provides excellent patient and graft survival, with predictable functional recovery and a lower perioperative burden compared with dual transplantation. The procedure benefits from decades of refinement in organ allocation, immunosuppression, and perioperative management, which collectively translate into stable outcomes across diverse recipient populations.

Despite these strengths, single kidney transplantation is inherently sensitive to donor-related factors, particularly age, comorbidities, and histological quality. In marginal or expanded-criteria donors, the functional reserve of a single graft may be insufficient to guarantee optimal long-term performance, increasing the risk of delayed graft function, reduced eGFR trajectories, and earlier progression to chronic allograft dysfunction. These limitations have driven the development of more nuanced allocation strategies—such as KDPI-based matching, pre-implantation biopsy scoring, and machine perfusion technologies—to better identify which kidneys are suitable for single implantation and which may benefit from dual allocation. From a recipient perspective, single transplantation offers a lower surgical risk, shorter operative time, and reduced postoperative morbidity compared with dual procedures. These advantages are particularly relevant for frail or comorbid patients, for whom minimizing perioperative stress is essential. Immunologically, the single-graft setting maintains a more favorable balance between antigenic load and immunosuppressive exposure, potentially reducing the risk of sensitization and chronic alloimmune injury.

In summary, single kidney transplantation remains the cornerstone of renal replacement therapy, providing robust outcomes when donor quality is adequate and recipient selection is appropriate. Its success depends on precise donor–recipient matching, careful evaluation of graft quality, and the integration of modern preservation and assessment tools. When these elements align, single transplantation delivers durable renal function with a favorable risk profile, preserving the efficiency of organ allocation while ensuring high-quality care for the majority of transplant candidates [14].

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