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Type 1 Diabetes Mellitus and Transfer from Pediatric to Adult Care: A Single-Center Experience

Betul Yigit Yalcin[1], Ummahan Tercan[2], Melek Yildiz[2], Hulya Hacisahinogullari[1], Gulsah Yenidunya Yalin[1], Nurdan Gul[1], Ozlem Soyluk Selcukbiricik[1], Ayse Kubat Uzum[1], Sukran Poyrazoglu[2], Firdevs Bas[2], Kubilay Karsidag[1], Ilhan Satman[1], Feyza Darendeliler[2]

[1]İstanbul University, İstanbul Faculty of Medicine, Department of Endocrinology, İstanbul, Türkiye
[2]İstanbul University, İstanbul Faculty of Medicine, Department of Pediatrics, Division of Paediatrics Endocrinology, İstanbul, Türkiye

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ABSTRACT

Objective: Type 1 diabetes mellitus (T1DM) requires lifelong follow-up, and the transition from pediatric to adult care may influence clinical outcomes. To evaluate sociodemographic, clinical, and laboratory characteristics associated with the transition process in patients with T1DM and to compare two different transition models.

Methods: Patients with T1DM transferred to an adult outpatient clinic between 2001 and 2022 were retrospectively assessed. Demographic data, metabolic parameters, complications, and treatment modalities before and after transition were assessed. Transition was performed either as a single-session model (Model 1) or as a gradual process over 4-6 months (Model 2).

Results: A total of 64 patients transitioned over the 21 year study period. The annual number of follow-up visits was significantly lower in adult care (3.0±0.9 vs. 2.1±1.8 visits/year; p=0.009). HbA1c levels were also lower in adulthood (8.9% vs. 8.3%; p=0.007). Total insulin dose was lower (0.95 vs. 0.75 IU/kg/day; p=0.009), whereas the basal insulin ratio was higher (43.1% vs. 52.8%; p<0.0001). Although mean body mass index slightly decreased, obesity prevalence increased. No significant differences were observed between the two transition models in terms of glycemic outcomes, insulin requirements, or complication rates.

Conclusion: A structured transition process was associated with improved glycemic control and treatment adaptation in T1DM, regardless of whether it is implemented as a single-session or gradual model. The absence of major differences between models may support the importance of individualized, patient-centered transition strategies.

Keywords: Type 1 diabetes mellitus, transition, diabetes care

Corresponding Author: Betul Yigit Yalcin, MD, İstanbul University, İstanbul Faculty of Medicine, Department of Endocrinology, İstanbul, Türkiye
E-mail: byigit667@gmail.com **ORCID:** orcid.org/0000-0002-5533-330X
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What is already known on this topic?

Transitioning from pediatric to adult care is a challenging period for patients with type 1 diabetes mellitus (T1DM), often resulting in poor glycemic control and increased dropout rates. Effective transition models are essential to ensure continuity of care and reduce complications.

What this study adds?

This study shows that, regardless of the transition model, patients experienced improvements in hemoglobin A1c levels and insulin management during adult care follow-up. These findings highlight the importance of supporting adolescents with T1D during the transition period with coordinated care models tailored to their individual needs.

Introduction

Type 1 diabetes mellitus (T1DM) is a chronic disease that usually starts in childhood and adolescence, and requires lifelong follow-up and treatment. The transition process refers to the transfer of an individual with diabetes from pediatric care to adult care, and this process may be a difficult period for individuals. Significant changes take place in their school lives, working and financial situations during this process. Perhaps more importantly, they will be struggling with the psychological and physiological changes of adolescence (1). It is also a period in which they gradually take responsibility for their illness from their families. These changes in patients' personal lives and medical care may disrupt diabetes follow-up and treatment (2,3,4). A poorly planned transition has been shown to lead to 60% of these patients dropping out of follow-up (5). Studies have shown that glycemic control worsens during the transition from childhood to adulthood (6). The time when hemoglobin A1c (HbA1c) levels are the highest coincides with the transition period, that is, late adolescence and early adulthood. Poor glycemic control is associated with an increased risk of chronic complications and mortality (7,8). Approximately 50% of young adults with T1DM develop diabetes-related complications such as retinopathy, neuropathy and hypertension in their 20s (9). Shifting from pediatric to adult follow-up is important for enhancing patient compliance and, consequently, improving long-term patient monitoring and health outcomes. The transition from pediatric to adult follow-up should ideally be seamless and well coordinated, and take into account the social and psychological development of the patient (10). The American Diabetes Association recommends that preparations for adult follow-up begin one year before transition and that patients should be encouraged and educated about their diabetes responsibilities during adolescence (11).

To strengthen the support provided to young adults with T1DM, it is essential to determine factors associated with successful transition and continuity of care. In our study, the aim was to retrospectively analyze the sociodemographic, medical, and laboratory features of individuals with T1DM who transitioned from pediatric to adult care at our hospital, and to compare the outcomes of two different structured transition models. We hypothesized that structured and gradual transition models would be associated with better metabolic outcomes and treatment adherence compared to single-session transfers.

Methods

Research Design

This study was conducted as a retrospective cohort analysis to examine the sociodemographic, clinical, and laboratory characteristics of patients with T1DM who transitioned from pediatric follow-up to the adult endocrinology outpatient clinic at Istanbul University, Istanbul Faculty of Medicine, and to compare different transition models. A total of 73 T1DM patients who completed pediatric care and were transferred to adult follow-up between 2001 and 2022, and whose medical records were accessible, were initially considered for inclusion. However, five patients who were lost to follow-up after a single visit and four patients who had only recently been transferred were excluded from the final analysis. As a result, complete pediatric and adult electronic medical records of 64 patients were included in the study. Exclusion criteria were: missing data, discontinuation of care before transfer to adult follow-up, and a diagnosis of type 2 diabetes mellitus. Due to the retrospective nature of the study and the wide time frame (2001-2022), the duration of adult follow-up varied significantly. While some patients had only recently transitioned, others had been under adult care for more than a decade. This variability resulted in a broad follow-up range, from a few months to over 20 years. Sociodemographic characteristics, clinical data, and laboratory findings were obtained retrospectively from patient files. A detailed flowchart illustrating the sample selection process is provided in Figure 1.

Transition Models

In Model 1 (n=36), the transition was conducted through a single structured meeting lasting 90 minutes in the pediatric endocrinology clinic, where the clinical evaluation was carried out by the pediatric endocrinology team. This session was attended by pediatric endocrinologists, adult endocrinology and metabolism specialists, pediatric and adult diabetes nurses and diabetes

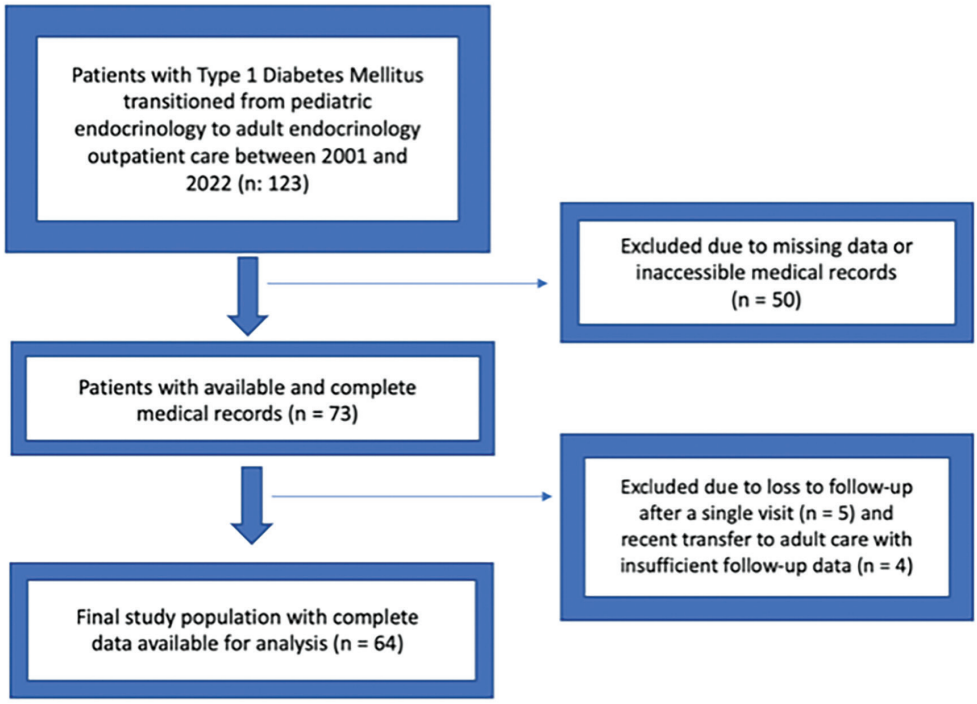

Figure 1. Flowchart of patient screening and selection for the study

dietitians along with the patient and their family. During the meeting, patients received comprehensive education covering: (a) detailed explanation of adult clinic expectations and procedures, including appointment scheduling and emergency protocols; (b) assessment of current clinical status and self-care competencies; and (c) personalized transition goal setting.

In Model 2 (n=24), the transition process involved two structured meetings (60-90 minutes each) conducted over a 4-6 month period by a multidisciplinary team comprising pediatric and adult endocrinologists and dietitians. The first meeting was held in the pediatric endocrinology clinic, while the second took place in the adult endocrinology outpatient clinic. The number of visits was increased in individuals with low cooperation. Specifically, for two patients who were considered not yet ready to assume full responsibility for diabetes self-management, the number of structured visits was increased to three. These additional sessions aimed to enhance self-care competency and support a smoother transition into adult services. These sessions were designed to: (a) provide graduated education on autonomous disease management; (b) reinforce self-monitoring skills and complication prevention strategies; and (c) administer final competency evaluations before adult care transfer. Both meetings incorporated individualized care planning based on continuous glucose monitoring (CGM) data and HbA1c trends.

All transition meetings systematically addressed three core domains: (1) clinical status evaluation, including glycemic control metrics and complication screening; (2) self-management capacity building emphasizing medication adherence and problem-solving skills; and (3) healthcare system navigation training, covering insurance transition and adult service utilization.

During the coronavirus disease-19 pandemic period, four patients were transferred directly to the adult endocrinology outpatient clinic as face-to-face transition meetings could not be held. Instead, these patients received information regarding the transition process via telephone consultation. Since their transfer procedures did not align with the structured models and could introduce bias in group-based statistical comparisons, they were excluded from the model analyses.

Data Collection and Definitions

Sociodemographic data included sex, age, body mass index (BMI) and diabetes education status of the patients. The duration of the disease, number of medical appointments during the transition period, average number of annual visits in pediatric and adult follow-up, insulin treatment dose, use of continuous subcutaneous insulin infusion (CSII) therapy, diabetes-related acute (number of emergency admissions with diabetic ketoacidosis) and chronic complications (retinopathy, neuropathy, hypertension), comorbidities, and HbA1c levels

were also evaluated. Data on the screening, diagnosis, and treatment of microalbuminuria, neuropathy, retinopathy and dyslipidemia were collected for each patient prior to and after the transition. HbA1c levels were evaluated based on the mean values recorded during pediatric and adult follow-up visits. For hyperlipidemia, low density lipoprotein (LDL) ≥100 mg/dL and statin use were recorded as dyslipidemia. Patients with a urine microalbumin/creatinine ratio of ≥30 mg/g were considered to have microalbuminuria. The pre- and post-transition examination records were evaluated for retinopathy and peripheral neuropathy.

Ethical Considerations

The study was approved by the İstanbul University, İstanbul Faculty of Medicine Clinical Research Ethics Committee (approval no.: 2023/785, date: 15.05.2023).

Statistical Analysis

The data obtained in the study were analyzed using SPSS software, version 23 (IBM Inc., Armonk, NY, USA). Descriptive statistics (mean, standard deviation and frequency) and comparative analysis methods (t-test and chi-square test) were used to assess variations between the groups. For statistical significance, a threshold of $p<0.05$ was applied.

Results

Population Characteristics

The study included the medical records of 64 patients with T1DM who transitioned during the study period. Among the patients enrolled in the study, 43.7% were female, and the median age at diagnosis was 9.25 years (range 0.8-17.5 years). At their last pediatric visit, the mean age of the patients was 19.4±1.2 years (range: 16.6-21.9). The mean age at the time of transition to adult care was 20.2±1.4 years (range: 17.7-23.1), and the mean age at the last adult visit was 23.2±4.2 years (range: 18.4-39.5). The median follow-up duration after transition to adult care was 3.3 years (range 0.3-20.9). Furthermore, 32.8% were seen within the first six months, 51.6% within the first two years, and 75% within four years. BMI decreased from 24.1±1.7 kg/m² at transition to 23.6±3.5 kg/m² at the last adult visit. While the prevalence of obesity was 1.6% (n=1) in the pediatric follow-up, this rate increased to 9.3% (n=6) at the last visit in adult care. Although mean BMI slightly decreased, the proportion of participants classified as obese increased during adult follow-up (Table 1).

Clinical Outcomes

Routine control visits in diabetes care were more frequent during pediatric follow-up (3.0±0.9 vs. 2.1±1.8, p=0.009). Total insulin doses at the time of transition were significantly higher compared to the last visit in adult care (0.95 IU/kg/day at transition vs. 0.75 IU/kg/day in adult care; p=0.009). The proportion of basal insulin was higher in the adult care group (43.1% in pediatric follow-up, 52.8% in adult care; p<0.0001). Although CSII was used more frequently in the adult care group (12.5% vs. 4.7%), this difference was not significant (p=0.11). The mean HbA1c levels were significantly lower in the adult period (8.9% in pediatric follow-up vs. 8.3% in adult care; p=0.007) (Table 2).

To minimise the potential bias introduced by very long adult follow-up times, we re-analysed outcomes in a subgroup with ≤4 years of adult follow-up (n=48; 75% of the study cohort). The direction and magnitude of the main findings remained unchanged. HbA1c decreased from 8.85±1.63% to 8.36±1.86% (p=0.047), daily insulin requirement declined (0.87±0.27 vs. 0.80±0.27 IU/kg; p<0.001), and the basal-insulin ratio increased (44.2±12.4% vs. 51.2±11.6 %; p<0.001). Visit frequency was still lower in adulthood (2.9±0.7 vs. 2.3±0.7 visits/year; p=0.039). Detailed results are provided in Supplementary Table S1.

Table 1. Comparison of demographic and anthropometric data before and after the transfer in individuals with type 1 diabetes mellitus

Demographics and anthropometry	Last pediatric evaluation (n=64)	Post-transition evaluation (n=64)
Gender n (%)		
Female	28 (43.7%)	
Male	36 (56.3%)	
Age (years) (mean±SD)	19.36±1.29	23.3±4.2
Body weight (kg) (mean±SD)	68.5±13.5	71.7±22.0
Body mass index (kg/m²) (mean±SD)	24.1±1.65	23.6±3.5
Body mass index categories n (%)		
Normal	43 (67.2%)	44 (68.7%)
Overweight	20 (31.2%)	14 (21.8%)
Obese	1 (1.6%)	6 (9.3%)

Data are presented as mean±standard deviation or frequency. This table provides descriptive comparisons between the last pediatric evaluation and the last adult visit.
SD: standard deviation

Complications and Comorbidities

There was no difference in the frequency of autoimmune thyroiditis and celiac disease between pediatric and adult care. Microvascular and macrovascular complications were observed more frequently during adult care. However, no significant statistical variation was observed in acute or chronic complications (Table 3).

No significant differences were observed between the two groups in mean HbA1c, annual visit frequency, BMI, insulin dose, carbohydrate-counting knowledge or practice, CSII/multiple daily injections/CGM use, or the prevalence of nephropathy and neuropathy (Supplementary Table S2). The same overall pattern was confirmed in a sensitivity analysis restricted to the sub-group of participants with ≤4 years of adult follow-up (Supplementary Table S3). The only between-model significant differences were a slightly higher pediatric visit frequency and a larger reduction in visit rate after transfer in Model 1 (p=0.025 and p=0.014, respectively).

Discussion

The transition from pediatric to adult care is a difficult process in many respects, and patients with diabetes are currently prepared for the transition period from pediatric to adult care in limited centers (12). For patients to undergo a smooth transition, the distinctions between pediatric and adult care should be appropriately addressed. In the present study, patients with T1DM who switched from pediatric to adult follow-up were examined using pre- and post-transition data, and two different transition models were compared. Our findings show that the mean age at the time of transition to adult care was 20.2±1.4 years (range 17.7-23.1). Early transition age may be advantageous for individual adaptation; however, many authors suggest that transition occur after psychosocial maturity (13). Therefore, transition age should be determined in relation to the patient's social and clinical status, and pediatric endocrinologists should make individualized decisions based on these factors.

Table 2. Comparison of clinical parameters between pediatric and adult follow-up periods

Clinical parameters	Pediatric follow-up (n=64)	Adult follow-up (n=64)	p value
Follow-up duration (years) (mean±SD)	10.6±4.1	3.1±4.2	<0.0001
Number of visits/year (mean±SD)	3.0±0.9	2.1±1.8	0.009
HbA1c (last year) (%) (mean±SD)	8.95±1.6	8.3±1.6	0.007
Knows carbohydrate counting n (%)	34 (53.1%)	35 (55.6%)	0.78
Practices carbohydrate counting n (%)	25 (39.7%)	24 (38.1%)	0.85
Insulin dose (IU/kg/day) (mean±SD)	0.95±0.3	0.75±0.34	<0.0001
Basal insulin ratio (%) (mean±SD)	43.1±10.8	52.8±11.3	<0.0001
Insulin therapy modality			
Multiple daily doses n (%)	61 (95.3%)	56 (87.5%)	0.011
Continuous subcutaneous insulin infusion therapy n (%)	3 (4.7%)	8 (12.5%)	

Follow-up duration and annual number of visits represent average values across the pediatric and adult care periods. HbA1c refers to the mean of the final year in each period. Knowledge and practice of carbohydrate counting, insulin treatment model, insulin dose, and basal insulin ratio were assessed based on the last recorded visit in each setting.
SD: standard deviation, HbA1c: hemoglobin A1c.

Table 3. Evaluation of comorbidities and complications before and after the transition in individuals with type 1 diabetes mellitus

Comorbidities	Before transition	After transition	p value
Celiac disease n (%)	2 (3.1%)	2 (3.1%)	0.96
Hashimoto thyroiditis n (%)	15 (23.4%)	14 (21.9%)	0.75
Complications	**Before transition**	**After transition**	**p value**
Nephropathy n (%)	8 (12.5%)	11 (18%)	0.389
Retinopathy n (%)	1 (1.6%)	3 (4.9%)	0.286
Neuropathy n (%)	2 (3.1%)	4 (6.6%)	0.369
Hyperlipidemia n (%)	8 (12.5%)	13 (21.3%)	0.187
DKA episodes per year (mean±SD)	0.2±0.64	0.2±0.64	0.103

DKA: diabetic ketoacidosis

In the present study, a comparison of patients' mean HbA1c levels before and after transfer demonstrated a significant (p=0.007) reduction in HbA1c levels during the adult period. Young people have been reported to make up the largest proportion among groups with poor diabetes management (HbA1c≥9.5%), and high HbA1c levels have been detected in 25% of patients older than 12 years (14,15). In a review, HbA1c improved significantly after transition to adult care in five of the eight studies examined. Although care centers and transition methods differed in these studies, it was thought that the transition facilitated adult care (16). In adult care, individuals assuming greater responsibility for disease management and engaging more in follow-up and treatment may contribute to the decrease in HbA1c levels (15,17). However, in a retrospective study by Walch et al. (18), no notable alteration in HbA1c levels was detected after the transition to adult care. Another study examined standard and intervention transition methods, enrolling 101 patients under routine care and 102 individuals in the intervention-based transition group. Although HbA1c levels were similar 12 and 18 months after transition, participation in health services was higher in the intervention transition group (19). Our findings are in line with the systematic review by DeLacey et al. (20), which highlighted that while structured transition programs or provider-led interventions may yield modest improvements in glycemic control after transfer, the overall evidence base remains limited and inconsistent. Most existing studies lack long-term follow-up or standardized outcome reporting, making it difficult to draw strong conclusions regarding the effectiveness of transition strategies (20).

Differences in insulin treatment were observed in adult care compared to those before transition. During the adult care period, the total daily insulin dose was noticeably lower than the dose at the time of transition (0.75 IU/kg/day vs. 0.95 IU/kg/day p=0.009). This decrease in insulin dose after transition to adult care may reflect age-related changes in insulin requirements and improvements in self-management during adulthood (1,21,22). A structured transition process can support improved glycemic control in T1DM management, whether implemented through single-session or stepped models. Our protocolized transition approach, which features standardized training modules, multidisciplinary team involvement, and competency assessments, was associated with clinically meaningful HbA1c reduction and decreased insulin requirements, though whether this reflects the transition process itself or improved care quality in the adult setting cannot be determined from our retrospective data. In our cohort, we found a significantly increased basal insulin ratio in the adult group (p<0.0001) and this finding is consistent with the literature, which reports that basal insulin requirements in children usually do not exceed 30-45% of the total daily insulin dose, whereas this ratio usually exceeds 50% in adults. This is noteworthy in view of the fundamental changes in the insulin regimen during the transition to adulthood (23,24,25,26). This increase in basal insulin rate may be due to the need for more frequent insulin dose adjustments at meals and higher bolus insulin requirements during childhood (25,27,28). Positive effects of CSII on glycemic control have been reported in the literature (29). We found that the rate of CSII use in adult care was relatively higher than in pediatric care, suggesting that access to emerging technologies and individualized treatment options in diabetes care may be more prevalent in adult patients. Moreover, time passing while patients were growing up was concordant with more widespread use of this technology. Our finding was not significant but this result should be re-evaluated with a larger sample groups. Furthermore, although follow-up durations varied widely in our cohort, a sensitivity analysis limited to patients with ≤4 years of adult follow-up did not alter the main findings for HbA1c, insulin requirements, or the other key outcomes. Nevertheless, it remains possible that very long follow-up periods could partially obscure the true impact of the transition process.

Studies on the effect of transition on the frequency of follow-up in T1DM have yielded variable results (30,31). In a study comparing interventional transition with standard transition, 104 patients were included in the transition program, while 101 patients underwent a standard transition plan. Follow-up frequency and patient satisfaction were found to be higher in the intervention transition group. However, these benefits were not sustained in the 12-month period after the completion of the intervention and it was suggested that strategies are needed to sustain long-term benefits (3). In an Australian study involving 60 participants in the intervention group and 60 in the control group, no difference was found in the average frequency of appointments between the two groups over 12 months. Although the number of visits decreased in adult follow-up, HbA1c was found to be lower in the present study (30). Our findings are consistent with the study by Busse et al. (31), who observed a decrease in outpatient visits during adulthood and interpreted this as adults taking responsibility for their own care.

Diabetes-related complications before and after transition have been investigated less frequently. Walch et al. (18) retrospectively analyzed the medical records of 54 patients with T1DM. Complications including hypertension, dyslipidemia, nephropathy, and neuropathy were examined in patients who switched from pediatric care to adult follow-up, and no significant difference was found in the rate of complications before and after transition (18). A study conducted in Canada showed that the frequency of retinopathy screening did not change before and after transition, while at the same time, there was no significant difference in the rate of hospitalization due to diabetes before and after transition (32). Although micro- and macrovascular complications were observed more frequently

in adult care in our study, the difference between acute and chronic complications in the pre-transition period was not significant. This may be due to the longer pediatric follow-up period (10.6±4.1 years) compared to the adult follow-up period (3.1±4.2 years). The shorter follow-up period in adult care suggests that some complications may not have fully emerged in these young adult patients, or that complications may not have been recognized early. Future research with an extended monitoring period is required to validate these results. Furthermore, given the wide range in adult follow-up durations (from less than one year to over 20 years), complication-related outcomes should be interpreted with caution. In patients with shorter follow-up durations, chronic complications may not have had sufficient time to manifest or be detected.

Research has shown that single-session transitions can increase patient satisfaction and engagement. In one study, a single-session transition clinic model positively affected patient and parent satisfaction and made the transition process more effective (33). However, for some patients, this rapid transition can be stressful. In contrast, gradual transitions have been shown to facilitate patient compliance and increase treatment adherence, but it has also been emphasized that such gradual transitions require more resources. For the gradual transition model, it has been reported that this method can facilitate the adaptation process of young people. A study by the American Diabetes Association found that young people prefer a delayed or gradual transition to adult care. In this research, young people expressed that they found it more comfortable to transition to adult care with a longer transition period, especially due to their relationship and commitment to pediatric care providers (34,35). However, in our study there was no difference with respect to transition models. In the ≤4-year sensitivity comparison, we found no clinically meaningful differences between the two structured transition models in metabolic control or complication rates. The only divergence was a slightly higher pediatric visit frequency and a more pronounced decline in visit rate after transfer in Model 1, a pattern that did not translate into any adverse clinical outcomes.

Study Limitations

The single-center design and the restricted patient cohort (64 patients) were two limitations of our study. This may limit the applicability of the findings to larger or more diverse populations. Moreover, because structured transition care has been mandatory for all young people with T1DM at our centre since 2000, it was impossible to assemble a control group that underwent an unstructured transfer. The absence of such a comparator limits our ability to quantify the added value of the transition models. In addition, our study did not include assessments of psychosocial readiness, patient satisfaction, or family involvement, which are increasingly recognized as critical components of successful transition. This limits our ability to capture the broader patient experience and evaluate non-medical outcomes related to the transition process. Finally, adult BMI is reported as mean±SD together with weight-status categories because a validated adult BMI-SDS reference is not available and paediatric SDS could not be calculated uniformly for all participants; this will hinder direct comparison with studies that report z-scores.

Conclusion

Considering the difficulties and varying outcomes of transitioning from pediatric to adult care, developing individualized approaches can significantly improve patient experiences and long-term diabetes management. However, transition outpatient clinics present several challenges in daily practice, including resource limitations, multidisciplinary work, compliance and additional time for both healthcare professionals and patients. Therefore, further research is required to evaluate the long-term impact of transition outpatient clinics and to assess the effectiveness of different models in managing blood glucose levels, preventing complications, and enhancing patient experience, improving the transition process and ultimately improving patient health outcomes.

Ethics

Ethics Committee Approval: The study was approved by the İstanbul University, İstanbul Faculty of Medicine Clinical Research Ethics Committee (approval no.: 2023/785, date: 15.05.2023).

Informed Consent: Retrospective cohort analysis study.

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Footnotes

Authorship Contributions

Surgical and Medical Practices: Betul Yigit Yalcin, Ummahan Tercan, Hulya Hacisahinogullari; Concept: Gulsah Yenidunya Yalin, Nurdan Gul, Ozlem Soyluk Selcukbiricik, Ayse Kubat Uzum, Sukran Poyrazoglu, Firdevs Bas, Kubilay Karsidag, Ilhan Satman, Feyza Darendeliler; Design: Melek Yildiz, Hulya Hacisahinogullari; Data Collection or Processing: Betul Yigit Yalcin, Ummahan Tercan; Analysis or Interpretation: Melek Yildiz, Firdevs Bas, Ilhan Satman; Literature Search: Betul Yigit Yalcin, Ummahan Tercan, Ayse Kubat Uzum, Sukran Poyrazoglu; Writing: Betul Yigit Yalcin, Ayse Kubat Uzum, Feyza Darendeliler.

Conflict of Interest: One author of this article, Feyza Darendeliler, is a member of the Editorial Board of the Journal of Clinical Research in Pediatric Endocrinology. However, she was not involved in any stage of the editorial decision process for this manuscript. The editors who evaluated this manuscript are from different institutions. The other authors declared no conflict of interest.

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Supplementary Tables: https://d2v96fxpocvxx.cloudfront.net/cf9d60d6-523c-458a-a2e6-78728d3ffbb0/content-images/20508f89-22f5-47d0-871b-f454f6145583.pdf

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