ORIGINAL PAPER

Changes in glucose variability and diabetes control in children and young adults with type 1 diabetes on routine continuous glucose monitoring and continuous subcutaneous insulin therapy following a switch to hybrid closed-loop therapy (MiniMed 780G) – retrospective study

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ABSTRACT

INTRODUCTION: Advanced hybrid closed loop (AHCL) insulin delivery systems offer considerable benefits to individuals with type 1 diabetes (T1D) in terms of glucose control and quality of life. With increasing numbers of regular users, real-life long-term data on long-term AHCL effectiveness become available.

MATERIAL AND METHODS: This was a single-centre retrospective study. We included children and young adults (age 5–25 years) with established T1D (≥ 3 m) who started MiniMed780G therapy between January 2021 and April 2022. We excluded those naïve to continuous glucose monitoring (CGM) or insulin pumps, as well as those without good-quality baseline CGM data. Included patients were followed for 12 months, with CGM and pump data retrieved from 14-day periods before transition and 3, 6, 9, and 12 months following the start of automode. Clinical data (body weight, height, glycated haemoglobin concentration) were recorded from the most recent outpatient visits.

RESULTS: Among 81 patients who started AHCL therapy, 46 met the criteria for analysis (mean age 11.5 ±4.4 years, diabetes duration 4.4 ±3.6 years, mean glycated haemoglobin 7.0 ±1.0%). Over the year following transition, we noted a significant improvement in time in target range 70–180 mg/dl (TIR, baseline: 69.1 ±12.0% to 12 m: 76.9 ±8.5%, $p < 0.0001$) and time in tight range 70–140 mg/dl (baseline: 45.3 ±14.2% to 12 m: 53.3 ±10.4%, $p < 0.0001$). Time below target range 70 mg/dl (TBR70 mg/dl) decreased significantly for 24-hour records ($p = 0.0020$). Importantly, those improvements were not accompanied by an increase in daily dose of insulin or body mass index.

CONCLUSIONS: A prolonged 12-month-long observation in a routine care setting demonstrates that for young CGM- and pump users with T1D, switch AHCL offers sustained benefits in glucose variability.

KEY WORDS: type 1 diabetes, paediatric patients, continuous glucose monitoring, hybrid closed-loop therapy, MiniMed 780G.

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Introduction

Type 1 diabetes (T1D) is a chronic disease characterised by impaired glucose regulation caused by autoimmune destruction of pancreatic β-cells. To prevent its micro- and macrovascular complications, tight and near-physiological glucose control is advised and pursued from the disease onset [1]. The tools of functional intensive insulin therapy in children are personal insulin pumps, which allow very precise insulin delivery, as well as continuous glucose monitoring (CGM) systems that provide detailed and real-time monitoring of glucose concentrations. Both technologies resulted in significant improvement in principle T1D glycaemic control outcomes: glycated haemoglobin (HbA_{1c}) concentration and time spent in target glucose range 70–180 mg/dl (TIR) [2–4]. Those achievements were followed by integration of CGMs and insulin pumps and concluded in the introduction of hybrid closed loop systems (HCL). The hybrid closed loop systems automate delivery of basal and corrective insulin based on CGM input, aiming to maintain blood glucose close to the designed target and preventing both hypo- and hyperglycaemia. Diabetes Poland scientific association's guidelines from 2022 recommend striving for < 1% time below range < 54 mg/dl (TBR < 54 mg/dl), < 4% time below range < 70 mg/dl (TBR < 70 mg/dl), > 70% TIR, < 25% time above range < 180 mg/dl (TAR < 180 mg/dl), and < 5% time above range > 250 mg/dl (TAR > 250 mg/dl) [5]. Recommendations also indicate the importance of regular CGM usage as an element of ongoing monitoring and retrospective clinical assessment of glycaemia. Also, the HCL systems are reported to facilitate glycaemic control and are therefore recommended by Diabetes Poland scientific association. Currently, there are a number of commercially-available HCL systems: Minimed780 G (Medtronic), CamAPS FX (CamDiab), Omnipod5 (Insulet), Tidepool Loop (Tidepool), Diabeloop DBLG1 (Roche), and t:slim X2 Control IQ (Tandem). This work focuses on MiniMed780G, which is used by the highest number of patients in our centre. In this system, in addition to modulating the basal insulin rate, small, automated boluses (autocorrections) to better control for high glucose excursions are utilised, so this system is called advanced hybrid close loop (AHCL). Its target glucose range can be set between 100, 110, and 120 mg/dl. In clinical trials, the use of MiniMed780G led to considerable improvements of glycemic control [6]. However, with the device being used by increasing numberss of patients switching to this system from previous devices, questions about the magnitude and sustainability of benefits arise. The aim of this study was to establish long-term clinical benefits and follow possible changes in diabetes management in AHCL users after a year of using the Medtronic MiniMed 780G system.

Material and methods

Study design

This was a retrospective observational study based on routinely collected data in a single, SWEET-referenced centre for paediatric diabetes care in Łódź, Poland.

Study population

We first reviewed our records to identify all children and young adults (5–25 years old) with established T1D, who initiated AHCL therapy using MiniMed780G in our Department between January 2021 and April 2022, and who had a 12-month record after the transition. Among those patients we applied the exclusion criteria listed below and presented in Figure 1:

- using CGM or insulin pump therapy < 1 month before transition to AHCL,

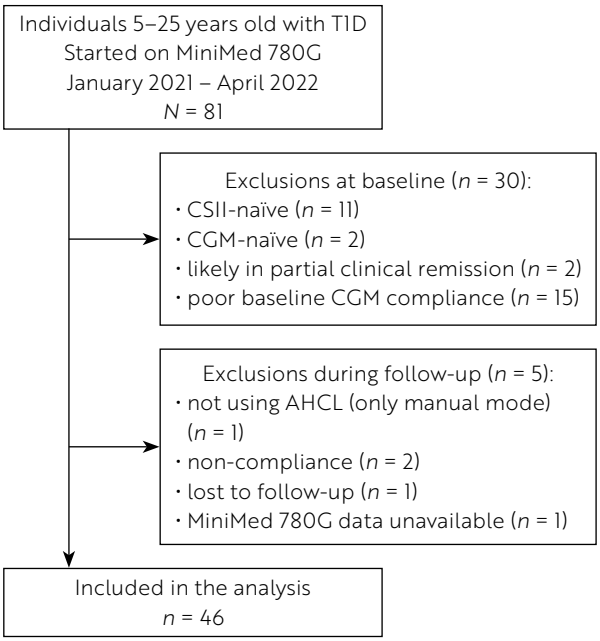

Fig. 1. Flowchart of retrospective chart review, with exclusions noted

AHCL – advanced hybrid closed-loop, CSII-naive – no previous insulin pump, CGM-naive – not using continuous glucose monitoring before transition, T1D – type 1 diabetes

- having a partial remission (< 3 months duration of T1D and daily insulin dose [DDI] < 0.3 UI/kg),
- poor prior CGM use define as < 70% data completeness for 2 weeks when the sensor was used the most,
- non-compliance (use of automode less than 50% of the time and lack of data available for comparison),
- using MiniMed 780G system in a non-intended way (e.g. without initiating AHCL function).

All such exclusions were noted and reported.

In the reported period, personal insulin pumps and CGM were partially reimbursed to both children and young adults with T1D. However, AHCL models such as MiniMed 780G were outside the reimbursement range. Thus, all MiniMed 780G pumps used by those included in the study were self-purchased by the users or their parents. Transitions to AHCL followed a standard procedure in our centre. First, each patient underwent inpatient training with a qualified educator concerning technical handling of the new pump and AHCL therapy rules, and online education with physicians concerning the principles of automode. After transition, each patient used the MiniMed 780G in a manual mode utilising only predictive low-glucose suspend (PLGS) assistance for about 5–7 days. Afterwards, the patients started the automode and continued to use it on a regular basis. Throughout this initiation process, on-demand online outpatient consultations were available to the users and their parents, as well as technical assistance.

Data collection

For this study, we collected data recorded during routine visits and available through the cloud CGM profiles shared with our centre. For the baseline (pre-transition) visit, we recorded the mode of previous insulin pump and CGM system use, daily dose of insulin, last available anthropometrics (body weight, height), as well as HbA_{1c} concentration. HbA_{1c} was measured in capillary blood with high-performance liquid chromatography in line with NGSP criteria. Raw CGM data were downloaded via dedicated platforms in .csv format, covering the 2 most complete weeks of data within the month preceding the visit. Follow-up CGM and pump data were acquired through CareLink software. For each MiniMed 780G user, we manually retrieved the date of automode start and identified dates corresponding to 3, 6, 9, and 12 months of automode use. For these dates, we retrieved raw data covering the preceding 30 days and singled out 14-day periods based on data completeness. Also, for each period an AGP report was generated and assessed for daily insulin dose and summary doses of basal, bolus, and autobolus. While follow-up outpatient consultations occurred approximately every 2–3 months, not all aligned perfectly with the dataset for CGM analysis. Thus, for each timepoint, we identified the closest (+/–30 days) visit and recorded body weight, height, and HbA_{1c} concentrations. However, some visits were performed remotely and resulted in missing data in body weight, height, and HbA_{1c}. In case of missing weight or height, they were extrapolated as a mean between last and next available visit. However, for HbA_{1c} no missing data imputation was performed.

Study environment

According to the Diabetes Poland scientific association from 2022 patients with T1D should strive for maintain HbA_{1c} level ≤ 6.5% (≤ 48 mmol/mol). The recommendations also highlighted the impact of CGM on HbA_{1c} as it may help in decreasing the HbA_{1c} level. The suggested CGM parameters are as follows: TBR < 54 mg/dl < 1%, TBR < 70 mg/dl < 4%, TIR > 70%, TAR < 180 mg/dl < 25%, and TAR > 250 mg/dl < 5%. The advised treatment method involves multiple daily injections (MDI) or continuous subcutaneous insulin infusion (CSII) with glycaemic control using a blood glucose meter or CGM. The continuous glucose monitoring systems might help in reducing time spent in hypoglycaemia and improve patients' quality of life [5].

Statistical analysis

Continuous characteristics were reported as means and standard deviations. Body weight and height were reported as raw values and used for group description only. Body mass index (BMI) was calculated according to the standard equation (body weight [kg]/body height [m] squared) and presented both as absolute values, as well as age- and sex-relative *z*-scores and percentiles based on contemporary Polish growth charts. For adults, BMI *z*-score was calculated by fixing age at 18 years (paediatric growth charts are at this point consistent with overweight/obesity thresholds for adults). Due to high variability in HbA_{1c} and DDI among the patients at baseline, we calculated adjusted HbA_{1c} index according to the equation: HbA_{1c} (%) + 4 × DDI (UI/kg). Included patients were also categorised using the ISPAD-advised cut-off for partial clinical

remission as ≤ 9%/> 9%, although c-peptide concentrations were not evaluated as part of routine diabetes management in Poland. Continuous glucose monitoring data were analysed with Glyculator 3.0 according to current guidelines [7]. Daytime was defined as the time between 6:00 AM and 0:00 AM, and missing data were not imputed.

Clinical variables and glucose variability (GV) indices were compared among 5 timepoints: before transition to 780G, 3, 6, 9, and 12 months after start of AHCL. This analysis was performed using repeated-measures ANOVA, with Tukey's HSD tests used for post-hoc comparisons. Importantly, due to missing data during follow-up, HbA_{1c} concentrations were compared only between baseline and 12-month timepoint (paired Student *t*-test).

In addition, we calculated standardised differences (Cohen's *d*) between the pre-transition period and 12-month timepoint and presented them with corresponding 95% confidence intervals (based on non-central t-distribution) to assess the relative magnitude of over-time changes.

To explore potential differences between age-groups, different pre-transition technology, and possible remission status or carryover, subgroup analyses were performed. Age was categorised into ≤ 8 years old, 9–12 years old, 13–17 years old, and ≥ 18 years old – for those groups, due to very few observations, only summary statistics of key clinical outcomes were given without formal hypothesis testing. Furthermore, we compared 2 broader categories (< 12 years old and ≥ 12 years old) – using Student's *t*-test for independent sample to assess baseline differences and changes up to each timepoint. Due to the exploratory nature of the analysis, no correction for multiple comparison was performed. Similarly, the same procedure was applied to subgroups based on pre-transition technology: those using and not using predictive low glucose suspend mode (PLGS+/–). Finally, the patients were classified based on baseline dose-adjusted HbA_{1c} as ≤ 9%/> 9%, and those groups were compared with repeated measures ANOVA in terms of TIR. Other variables were not assessed in those subgroups.

All analyses were performed using Statistica 13.3, with a significance threshold for α set at 0.05.

Results

In the assessed period, 81 age-appropriate patients started MiniMed 780G therapy. Among those, we excluded 30 due to pre-defined criteria and 5 due to non-compliance or missing data (Fig. 1). As a result, our study group included 46 individuals with T1D [41 (89.1%) children, 25 (54.3%) girls]. Their mean age at baseline was 11.5 ±4.4 years, and the mean time of T1D duration was 4.4 ± 3.6 years (< 3 months for 2 children). Before transition, the mean HbA_{1c} concentration was 7.03 ±1.0% (*n* = 43) and DDI 0.8 ±0.7 UI/kg (< 0.3 UI/kg for 5 children). Detailed group characteristics are presented in Table 1.

Prior to the transition, most of the patients used Medtronic insulin pumps [MiniMed 640G – *n* = 28 (60.9%), MiniMed 754 (Veo) – *n* = 17 (36.9%)],

Table 1. Study group characteristics

Group characteristics	Mean ± SD
Age (years)	11.5 ±4.4
Weight	
[kg]	46.7 ±22.2
Percentile	65.3 ±26.9
z-score	0.6 ±1.0
Height	148.4 ±1.2
[cm]	61.7 ±27.9
Percentile	0.4 ±0.9
z-score	
BMI	
[kg/m^2]	20.0 ±4.9
Percentile	64.0 ±27.0
z-score	0.5 ±1.0
T1D duration (years)	4.4 ±3.6
DDI [UI/kg]	0.8 ±0.7
HbA_{1c} (%)*	7.0 ±1.0
TBR < 70 mg/dl (%)	4.3 ±4.6
TIR 70–180 mg/dl (%)	69.1 ±12.0
TITR 70–140 mg/dl (%)	45.3 ±14.2
TAR > 180 mg/dl (%)	26.6 ±13.0
	***n* (%)**
Sex	
Female	25 (54.3)
Male	21 (45.7)
Pre-transition insulin pump model	
Medtronic 640G (Medtronic)	28 (60.9)
Paradigm Veo (Medtronic)	17 (36.9)
Accu Check Spirit (Roche)	1 (2.2)
Pre-transition CGM system	
Guardian 3 (Medtronic)	34 (73.9)
FreeStyle Libre 1 (Abbott)	11 (23.9)
Dexcom G6 (Dexcom)	1 (2.2)

BMI z-score – body mass index z–score, CGM – continuous glucose monitoring, DDI – daily dose of insulin, SD – standard deviation, T1D – type 1 diabetes, TAR – time above range, TBR – time below range, TIR – time in range, TITR – time in tight range

** HbA_{1c} reported only for n = 43 individuals*

Table 2. Variability indices over the 12-month follow-up

Parameters	Pre-transition (mean ±SD)	3rd month (mean ±SD)	6th month (mean ±SD)	9th month (mean ±SD)	12th month (mean ±SD)	*p*-value
Clinical variables						
DDI [UI/kg]	0.8 ±0.7	0.8 ±0.2	0.8 ±0.2	0.8 ±0.3	0.8 ±0.3	0.9902
Basal insulin/DDI (%)	35.1 ±6.9	35.8 ±7.3	37.7 ±9.0	36.3 ±10.0	37.0 ±9.3	0.3159
Bolus/DDI (%)	66.1 ±7.4	63.6 ±7.5#, *	61.7 ±9.0	61.3 ±11.0#	63.7 ±10.0*	0.0228
Auto correction bolus/ bolus (%)	N/A	23.3 ±10.8#	22.7 ±12.0#, *	27.1 ±13.9*	28.9 ±16.6#, *	0.0002
HbA_{1c} (%)	7.0 ±1.0	6.8 ±0.8	6.8 ±0.9	6.8 ±0.6	7.2 ±1.2	0.8920 ^
Weight						
[kg]	46.7 ±22.2	48.9 ±22.4	50.1 ±22.4	51.1 ±13.9	51.9 ±22.3	N/A
Percentile	65.3 ±26.9	69.3 ±25.3	68.7 ±26.0	68.6 ±25.7	68.0 ±26.8	N/A
z-score	0.6 ±1.0	0.7 ±1.0	0.7 ±1.0	0.7 ±0.9	0.7 ±1.0	0.2500
Height						
[cm]	148.4 ±21.2	150.6 ±21.1$, #, *	152.1 ±21.1$, *	153.5 ±20.9$, #	154.3 ±20.4	N/A
Percentile	61.7 ±27.9	64.6 ±30.1	63.3 ±29.5	62.6 ±29.4	62.9 ±30.8	N/A
z-score	0.4 ±0.9	0.5 ±1.0	0.5 ±1.1	0.5 ±1.0	0.5 ±1.1	0.5843
BMI						
[kg/m^2]	20.0 ±4.9	20.4 ±4.9	20.5 ±4.9	20.5 ±4.6	20.7 ±4.8	N/A
Percentile	64.0 ±27.0	67.4 ±24.8	67.6 ±24.1	68.1 ±22.8	67.4 ±24.0	N/A
z-score	0.5 ±1.0	0.6 ±0.9	0.6 ±0.9	0.6 ±0.8	0.6 ±0.9	0.2213
Glycaemic variability indices						
Mean SG [mg/dl]	149.8 ±21.8	139.9 ±12.6$	138.9 ±12.3$	142.9 ±16.4$	142.3 ±14.3$	< 0.0001
SD SG [mg/dl]	54.1 ±11.4	47.9 ±8.0$	46.7 ±8.5$	49.4 ±8.8$	47.7 ±8.3$	< 0.0001
CV of SG (%)	36.1 ±5.5	34.1 ±4.2$	33.6 ±4.9$	34.5 ±4.4	33.5 ±4.6$	0.0010
Median SG [mg/dl]	141.3 ±21.2	130.9 ±12.5$	129.6 ±12.3$	133.3 ±16.1$	133.2 ±14.2$	< 0.0001
TBR < 54 mg/dl (%)	1.2 ±1.8	0.6 ±0.5$	0.7 ±0.8$	0.6 ±0.8$	0.4 ±0.5$	0.0003
TBR < 70 mg/dl (%)	4.3 ±4.6	2.9 ±1.8$	2.9 ±2.2$	3.1 ±2.7	2.5 ±1.8$	0.0020
TIR 70–180 mg/dl (%)	69.1 ±12.0	77.6 ±7.8$	78.0 ±7.3$	75.2 ±9.6$	76.9 ±8.5$	< 0.0001
TITR 70–140 mg/dl (%)	45.3 ±14.2	55.1 ±10.1$	55.3 ±9.9$	52.6 ±10.6$	53.3 ±10.4$	< 0.0001
TAR > 180 mg/dl (%)	26.6 ±13.0	19.5 ±8.4$	19.1 ±7.7$	21.6 ±10.4$	20.6 ±9.2$	< 0.0001
TAR > 250 mg/dl (%)	6.5 ±5.8	3.4 ±2.6$	2.9 ±2.4$	4.0 ±4.1$	3.6 ±3.1$	< 0.0001
LBGI	1.1 ±1.0	0.8 ±0.4	0.8 ±0.5	0.8 ±0.5	0.7 ±0.4$	0.0134
HBGI	5.4 ±2.7	3.9 ±1.5$	3.7 ±1.4$	4.2 ±1.6$	4.2 ±1.8$	< 0.0001
GMI (%)	6.9 ±0.5	6.7 ±0.3$	6.6 ±0.3$	6.7 ±0.4$	6.7 ±0.3$	< 0.0001
m100	183.4 ±43.2	153.5 ±27.1$	151.5 ±26.2$	161.0 ±33.4$	158.0 ±29.5$	< 0.0001
J-index	42.5 ±12.9	35.6 ±7.0$	34.8±6.8$	37.5±9.9$	36.5±7.9$	< 0.0001
MAGE	99.9 ±21.6	88.8 ±14.1$	86.4 ±16.1$	92.0 ±16.1$	88.8 ±16.4$	< 0.0001
GRADE	7.6 ±2.5	6.0 ±1.5$	5.9 ±1.4$	6.4 ±1.9$	6.2 ±1.7$	< 0.0001

AUC – area under the curve of sensor glucose, CV – coefficient variation, GMI – glucose management indicator, GRADE – glycaemic risk assessment diabetes equation, HbA_{1c} – glycated haemoglobin, HBGI – high blood glucose index, LBGI – low blood glucose index, MAGE – mean amplitude of glycaemic excursion, SD – standard deviation, SG – sensor glucose, SD SG – sensor glucose standard deviation, TAR – time above range, TBR – time below range, TIR – time in range, TITR – time in tight range

p-values were calculated with repeated measures ANOVA.

N/A- not applicable

^ Due to missing HbA1c values across timepoints, p-value computed with paired t-test only for the difference between HbA1c pre-transition and after 12 months of follow-up (for N=42 individuals).

*Significant (p < 0.05) pair-wise comparisons in post-hoc tests between different timepoints: 3/6/9/12 months are marked with #, *, @.*

For continuous glucose monitoring metrics, the only significant (p < 0.05) pair-wise comparisons in post hoc tests were detected between baseline and 3/6/9/12 months – all marked with $.

and one individual (2.2%) used Accu Check Spirit (Roche). In terms of pre-transition CGM, 34 (73.4%) individuals used the Medtronic Guardian G3 system, 11 (23.9%) used FreeStyle Libre 1 (Abbott), and one (2.2%) used Dexcom G6 (Dexcom). Notably, all MiniMed 640G users utilised predictive low-glucose suspend function, but only some [*n* = 6 (35.3%)] used the low-glucose suspend option offered by the MiniMed 754. Twelve patients (26%) had no integration between insulin pump and CGM. The mean duration time between the onset of using MiniMed 780G and starting SmartGuard function was 14.6 ±12.4 days.

Over the year after transition, we noted significant improvements in the most of CGM-based glycaemic control parameters (Table 2 for exact means, Figure 2 for relative effect sizes). In particular, both time in target range 70–180 mg/dl (TIR) and time in tight range 70–140 mg/dl (TITR) improved (TIR – pre-transition: 69.1 ±12.0%, 3 m: 77.6 ±7.8%, 6 m: 78.0 ±7.3%, 9 m: 75.2 ±9.6 % and 12 m: 76.9 ±8.5%, $p < 0.0001$; TITR – pre-transition: 45.3 ±14.2%, 3 m: 55.1 ±10.1%, 6 m: 55.3 ±9.9%, 9 m: 52.6 ±10.6% and 12 m: 53.3 ±10.4%, $p < 0.0001$). The differences were significant both for 24-hour records as well as day and nighttime separately, but most notable improvements occurred in night glucose profiles. Time below target range 70 mg/dl (TBR < 70 mg/dl) decreased significantly for 24-hour records (from 4.3 ±4.6% at baseline to 2.5 ±1.8% at 12 m, $p = 0.0020$), but not for daytime hours (baseline: 4.0 ±4.6% vs. 12 m: 2.6 ±2.0%, $p = 0.0530$). Time in clinically significant hypoglycaemia (time below range 54 mg/dl, TBR

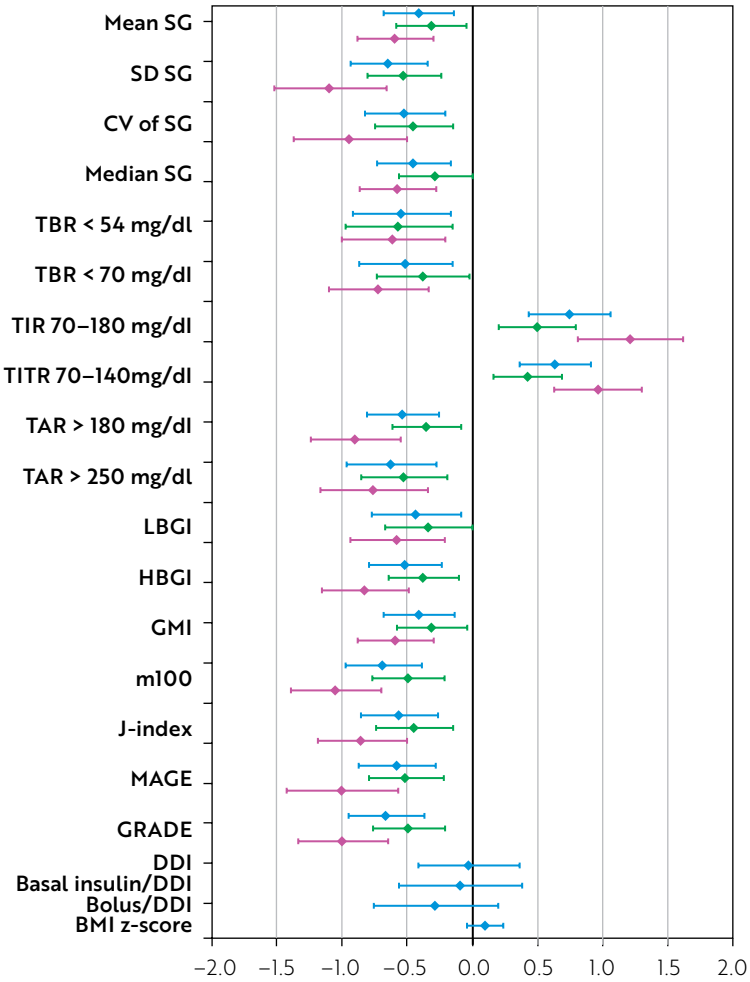

Fig. 2. Standardised differences in continuous glucose monitoring-derived glucose variability metrics between 2-week periods before transition to 780G and after 12 months using advanced hybrid closed-loop feature. Separate calculations were made for 24-hour records (blue), daytime records (green), and nighttime records (purple)

BMI z-score – body mass index z-score, CV of SG – coefficient of variation of sensor glucose, DDI – daily dose of insulin, GMI – glucose management indicator, GRADE – mean amplitude of glucose excursion, HBGI – high blood glucose index, LBGI – low blood glucose index, MAGE – mean amplitude of glucose excursion, SD – standard deviation of blood glucose, SG – sensor glucose, TAR – time above range, TBR – time below range, TIR – time in range, TITR – time in tight range

< 54 mg/dl) decreased consistently across all times of day (24-hour – baseline: 1.2 ±1.8%, 12 m: 0.4 ±0.5%, p = 0.0003; daytime – baseline: 1.0 ±1.7, 12 m: 0.5 ±0.5, p = 0.0168; nighttime – baseline: 1.7 ±3.0%, 12 m: 0.3 ±0.8, p = 0.0001). Glycaemic variability measured by coefficient of variation (CV) also decreased (24 hour – 36.1 ±5.5%, daytime – 36.0 ±5.7%, nighttime – 34.2 ±6.7% at baseline to 24 hours – 33.5 ±4.6%, daytime – 33.7 ±4.5%, nighttime – 28.4 ±5.5% at 12 m, 24-hour p = 0.0010, daytime p = 0.0041, nighttime p < 0.0001). Overall, almost all assessed glucose control metrics showed improvement between baseline and 12 m, with greatest relative improvements (effect size) seen in nighttime TIR, TITR, m100, and glucose SD (Supplementary Table 1). Importantly, those improvements were not accompanied by an increase in DDI (baseline: 0.8 ±0.7 UI/kg vs. 12 m: 0.8 ±0.3 UI/kg, p = 0.9902), BMI (baseline: 0.5 ±1.0 z-score vs. 12 m: 0.6 ±0.9 z-score, p = 0.2213), or body weight (baseline: 0.6 ±1.0 z-score vs. 12 m: 0.7 ±1.0 z-score, p = 0.2500). Between the initial post-transition period and final observation, the fraction of insulin administered as bolus decreased slightly, while the fraction of auto-correction boluses significantly increased. Based on available data, HbA_{1c} concentrations decreased in the observed period (significance not tested), with a non-significant increase after 12 months (n = 42, baseline: 7.0 ±1.0%, 12 m: 7.2 ±1.2%, p = 0.8920). Correlation coefficients between HbA_{1c} and GMI for each timepoint were as follows: for pre-transition 0.66 (n = 43, p < 0.0001), for 3 m 0.35 (n = 39, p = 0.0271), for 6 m 0.46 (n = 32, p = 0.0033), and for 12 m 0.25 (n = 45, p = 0.1036).

What is important, those younger than 12 years old (n = 28) presented distinct clinical profiles from those older at transition (n = 18). Groups differed at baseline in terms of multiple glycaemic control parameters, most importantly: mean SG (< 12: 144.7 ±18.8 vs. ≥ 12: 157.8 ±24.2, p = 0.0441), SD SG (< 12: 51.3 ±9.4 vs. ≥ 12: 58.3 ±13.1, p = 0.0401), TIR (< 12: 72.3 ±9.6 vs. ≥ 12: 64.0 ±13.9, p = 0.0207), TAR > 180 mg/dl (< 12: 23.4 ±10.7 vs. ≥ 12: 31.6 ±15.0, p = 0.0361), and TBR < 70 mg/dl (< 12: 4.3 ±5.5 vs. ≥ 12: 4.4 ±3.1, p = 0.9380); full data in Supplementary Table 3. In terms of follow-up, those > 12 years old gained weight significantly (+0.2 ±0.4, p = 0.0366 vs. baseline) and gained significantly more than younger patients (+0.0 ±0.3, p = 0.0365).

In terms of pre-transition technology, at baseline, patients using PLGS (PLGS+) were similar to non-users (PLGS–) in the following metrics: CV (PLGS+: 35.58 ±3.74, PLGS–: 36.92 ±7.57, p = 0.4292), TBR < 54 mg/dl (PLGS+: 1.04 ±1.21, PLGS–: 1.36 ±2.54, p = 0.5728), TBR < 70 mg/dl (PLGS+: 3.70 ±2.97, PLGS–: 5.24 ±6.43, p = 0.2789), TIR (PLGS+: 66.70 ±11.27, PLGS–: 72.74 ±12.58, p = 0.0973), TITR (PLGS+: 42.42 ±13.14, PLGS–: 49.80 ±15.03, p = 0.0857), TAR > 180 mg/dl (PLGS+: 29.59 ±12.79, PLGS–: 22.02 ±12.37, p = 0.0536), and TAR > 250 mg/dl (PLGS+: 7.12 ±5.67, PLGS–: 5.60 ±6.04, p = 0.3917). After transition, both subgroups improved similarly (Supplementary Table 2).

There was no significant difference in 24-hour TIR across all timepoints between those who underwent transition at ≤ 9% and > 9% adjusted HbA_{1c} (76.86 ±1.59 vs. 74.88 ±11.29, p = 0.3940); the dynamics of change between the 2 groups were also comparable (p = 0.9315).

There were no episodes of severe hypoglycaemia or diabetic ketoacidosis during the observational period.

Discussion

The transition to MiniMed 780G therapy in 46 individuals with T1D yielded significant improvements in glycaemic control parameters over a one-year period. Notably, there were marked enhancements in time spent within target glucose ranges, with reductions in both hypoglycaemic and hyperglycaemic events. These improvements were evident across all time periods but most pronounced during nighttime. Overall, following transition the patients improved in most of therapeutic targets advised by 2022 guidelines [5]. Our observations concerning CGM metrics are in line with the first available reports on MiniMed 780G real-world performance, although the improvements observed in our study were more moderate (TIR70 – 180 mg increase 7.8% vs. 12.1%). However, in both groups end-observation TIR70–180 mg/dl were similar (76.9 vs. 75.5%), and the smaller benefit likely resulted from better baseline T1D control in our group. Similarly, TBR < 54 levels from the manual mode statistically decreased compared to the endpoint of observation after 6 months [8]. Other real-world studies have shown similar improvements with respect to, for example, GMI [9, 10]. In most published articles, indicators of metabolic control in children and young adults improved. There was a statistically significant increase in TIR to 75–80% as well as a decrease in TAR and TBR. There was often a drop in glycated haemoglobin below 7% [1]. In a study comparing more than 3000 subjects under 15 years of age, 75.3% of users achieved a GMI of less than 7.0%, 69.6% of

users achieved a TIR of more than 70%, and 71.7% of users achieved a TBR of less than 4.0%. However, only 47% achieved all these 3 goals at the same time [11].

Due to the anabolic effect of insulin and the altered influence of lifestyle and food on insulin doses administered in the ACHL system, there was a worry that AHCL use might result in an increase in the patients' weight and daily insulin dose. Importantly, in our study presented benefits were not diminished by significant changes in BMI or insulin dose. Overall, the whole cohort did not gain excessive weight or increased their insulin dose relative to body weight. However, a few observations from subgroup analysis must be mentioned. Despite not reaching statistical significance, DDI decreased in children < 12 years old shortly after transition, and in older individuals it increased. This might be related to different lifestyles of those patients, different approaches to using the 780G algorithm, or likely physiological puberty-related changes in insulin sensitivity in adolescents. However, by 12 months of observation, both groups were similar in terms of DDI (~0.8 UI/kg). What is more, we observed a significant increase in body weight *z*-score in older patients, contrasted with no increase in younger ones. This observation was accompanied by a non-significant increase in BMI for older individuals, reaching +0.2 *z*-score by 12 months of follow-up – a larger group would be needed for adequate power to test this difference. This effect, if true, might be related to puberty. Overall, our findings remain consistent with those made by others in similar populations. For example, Seget *et al.* reported at one-year follow-up that the BMI of children and adolescents with T1D treated with the AHCL system remained stable [12]. However, their study included much younger children, so vigilance in teenagers should still be advised.

Finally, our study revealed no significant differences in outcomes between patients with different baseline dose-adjusted HbA_{1c} levels or those utilising PLGS technology prior to transition, although a sufficiently powered study would be needed to definitely resolve this issue.

Therefore, Diabetes Poland scientific association highly recommends treatment with hybrid closed loop (HCL) and underlines that this solution might be the most effective in patients with poor glycaemic control [13]. This study showed that the HCL system may be used by patients regardless of their previous technological experience.

To increase the validity of our study, its protocol utilised a detailed analysis of CGM data in line with the current consensus [14, 15] and performed with validated tools [16]. We extended the set of assessed glycaemic variability indices to also include TITR 70–140 mg/dl, which is currently being debated as a secondary glycaemic target. The outcomes observed in our study might be used in the ongoing discussion concerning the optimal target for this metric, e.g. 50–55%. The data were also collected in a systematic way from continuous cloud records, which limited the risk of missing data or biases due to short-term device or sensor malfunctions. Moreover, our observation covered a relatively long period (12 m), which hopefully allowed us to detect sustained benefits and avoid bias related to a new tool and increased clinical surveillance. In fact, in some cases observation exceeded 12 months as data collection timepoints were scheduled in relation to the start of AHCL mode in Minimed780G, not the change of device itself. In addition, the setting of our study was real-world but also supported by routine procedures applied in our centre, which is a member of the Sweet registry. Thus, our results are likely to be replicated in other centres utilising similar practices – both Polish and European. Finally, our study group presented relatively good T1D control at baseline (TIR70–180 mg/dl ~69%) and still showed statistically and clinically meaningful improvement, encouraging the wide use of AHCL technology.

On the other hand, several limitations must be kept in mind when evaluating our results. Most importantly, we noted a discrepancy between response of CGM-based metrics to transition – and HbA_{1c} concentrations. While CGM metrics universally improved over the 12-month follow-up, HbA_{1c} concentrations remained similar between baseline and 12-month timepoint, and this difference could not be attributed solely to missing data for HbA_{1c}. There are several possible explanations. First, CGM-based outcomes were calculated based on 2 weeks' worth of data, as advised by consensus and used in clinical practice. However, it is known that short-term CGM traces are not a good representation of 90-day records and might be poor proxies for HbA_{1c}. Moreover, even in the best scenario the relationship between mean SG and HbA_{1c} is likely to be affected by multiple biological individual-specific factors such as red cell turnover, glycation rate etc. This results in higher between-individual variability of HbA_{1c} concentrations, which was also seen in our study, thus limiting statistical power of comparisons.

Secondly, this was a retrospective real-world study, so the usual risks of selection bias are likely: the pumps being self-purchased could have resulted in overly optimistic outcomes related to higher motivation, better socioeconomic background of users (or their parents). Still, such a design should provide good insight into clinical practice. Importantly, despite a wide age range inclusion criterion, only 2 patients were 18 years old or older before SmartGuard initiation. This strengthens the importance of the study for the paediatric population; however, for estimating the exact effect of AHCL therapy in young and older adults, further studies should be held. What is more, the study population is small, and further studies on bigger groups should be conducted. Moreover, we did not include detailed data on comorbidities. Clinically, the whole cohort was a good representation of the overall population with T1D, so the most common comorbidities (Hashimoto and celiac disease) were present, but the exact effects of transition in those subgroups could not be evaluated. Finally, a considerable number of patients were excluded from our study based on insufficient quality of pre-transition CGM data. The most frequent cause was a relatively long period of CGM abstinence preceding transition, because we did not want to use older CGM data on T1D control as baseline. In most cases, the missing data periods were the result of sensor malfunctioning some time before transition or patient preference (some patients used CGM in 2–3-week periods with breaks between). Still, the excluded patients could present a group that was clinically distinct from the included one, and their benefits from transition could be different.

Several practical advises derive from this study:

- transition into the HCL system is rapid and benefits are quickly visible,
- transition does not require much educational effort,
- the risk of excess body mass increase is low especially among the rapidly growing paediatric population,
- the benefits obtained during HCL system usage seems to be long-term – CGM parameters remained stable since transition until the 12-m timepoint (Table 2).

Conclusions

A prolonged 12-month-long observation in a routine care setting demonstrates that for young CGM and pump users with T1D, a switch to AHCL offers sustained benefits in multiple GV indices. The greatest relative changes were observed for nighttime TIR.

Disclosures

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2. The authors would like to acknowledge Zofia Lesiak (medical student) who assisted in part of data collection.
3. BM declares receiving speaker's or consultant honoraria from Abbott, Air Liquide Santé Int., Dexcom/Proglikemia, Medtronic, Ypsomed, Synoptis/Neuca, AstraZeneca.
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4. Conflicts of interest: None.

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