Journal of Diabetes Science and Technology
2022, Vol. 16(1) 252–253

DOI: 10.1177/19322968211029627
journals.sagepub.com/home/dst
SAGE

Real-Time Continuous Glucose Monitoring Benefits Glycemic Control in Adolescents and Young Adults With Type 1 Diabetes Irrespective of Insulin Delivery Modality: Subanalysis of the MILLENNIAL Study

Ik Hur Teoh, MD[1], Joshi Prabhu, RN[1], Womba Mubita, RN[1], Shazli Azmi, MD, PhD[1,2], Andrea Urwin, RN[1], Ian Doughty, MD[3], Lalantha Leelarathna, MD, PhD[1,2], and Hood Thabit, MD, PhD[1,2]

Keywords
type 1 diabetes, real-time glucose monitoring, glucose sensors, adolescents, young adults, insulin pump, multiple daily injections

Real-time continuous glucose monitoring (RT-CGM) is associated with improved glycemic control. However, the benefit was found to be attenuated in adolescents and young adults, and predominantly involved insulin pump therapy (CSII) users. The MILLENNIAL study was an 8-week randomized controlled trial that compared glucose monitoring methods (Dexcom G6 RT-CGM vs self-monitored blood glucose [SMBG]) in adolescents and young adults with T1D who used either multiple daily injections (MDIs) or CSII for insulin delivery.[1] Overall, RT-CGM use led to significantly increased time-in-range (TIR) and decreased HbA1c compared with SMBG. Here, we compare the glycemic outcomes of MDI and CSII participants in the MILLENNIAL study. This is a post hoc analysis, and the number of participants includes the entire population of individuals in the study.

Changes in HbA1c, TIR (70-180 mg/dl), time above and below range, mean glucose, and glycemic variability (coefficient of variation) during RT-CGM were compared with SMBG separately for CSII and MDI users. Comparisons were analyzed using independent sample 2-sided *t* tests for parametric variables. Values of $P < .05$ were considered statistically significant.

Mean baseline characteristics in CSII and MDI group were comparable: HbA1c: 76 versus 80 mmol/mol, $P = .45$; age: 21.2 versus 21.2 years, $P = .96$; body mass index: 25.9 versus 25.4 kg/m^2, $P = .78$. Overall results are shown in Table 1. Real-time continuous glucose monitoring use led to comparable and significant increases in TIR, as well as reduction in both time-above-range and mean sensor glucose in MDI and CSII users ($P < .05$ for all). Clinically significant reduction of HbA1c was observed in MDI and CSII users during RT-CGM. The MILLENNIAL study showed no significant change in time-below-range and glycemic variability with RT-CGM, with no significant difference between CSII and MDI users. Sensor usage adherence rates were high and comparable (CSII: 82.8%, MDI: 86.2%; $P = .43$).

Adolescents and young adults face multiple psychosocial challenges which may contribute to suboptimal diabetes self-management and control.[2] Real-time continuous glucose monitoring can potentially provide a valuable self-management tool during this challenging phase. Despite less flexibility in adjusting insulin delivery compared with CSII, MDI users can still benefit from the comprehensive information that RT-CGM provides when adjusting insulin doses during meals and physical activities. Alerts for hyperglycemia and for existing or impending hypoglycemia likely contribute to improved glycemic outcomes for RT-CGM users to the extent that they prompt appropriate interventions.

[1]Diabetes, Endocrine and Metabolism Centre, Manchester Royal Infirmary, Manchester, UK
[2]Division of Diabetes, Endocrinology and Gastroenterology, Faculty of Biology, Medicine and Health, The University of Manchester, Manchester, UK
[3]Royal Manchester Children's Hospital, Manchester Royal Infirmary, Manchester, UK

Corresponding Author:
Hood Thabit, MD, PhD, Diabetes, Endocrine and Metabolism Centre, Manchester Royal Infirmary, Manchester M13 9WL, UK.
Email: hood.thabit@mft.nhs.uk

Table 1. Changes in Glycemic Outcomes for Overall, CSII, and MDI Group.

Change in glycemic outcome measures[a]	Overall (n = 30)	CSII (n = 16)	MDI (n = 14)	Between-group difference[b]	*P* value
HbA1c, mmol/mol	−5.9 ± 8.0	−5.9 ± 7.7	−5.9 ± 8.5	−0.005	.999
Time-in-range, %	11.1 ± 10.9	11.2 ± 11.0	11.0 ± 11.3	0.196	.962
Time-above-range, %	−11.9 ± 12.1	−12.1 ± 11.9	−11.7 ± 12.7	−0.393	.931
Mean sensor glucose, mg/dl	−32.3 ± 32.7	−34.3± 27.8	−29.9 ± 38.4	−4.48	.715
Time-below-range, %	0.9 ± 2.1	1.0 ± 1.7	0.8 ± 2.4	0.2	.799
Glycemic variability (coefficient of variation), %	3.0 ± 5.2	2.2 ± 4.5	3.8 ± 6.0	−1.6	.410

Data are mean ± SD.
Abbreviations: CSII, insulin pump therapy; MDI, multiple daily injection; SMBG, self-monitored blood glucose; CGM, continuous glucose monitoring.
[a]Change in glycemic outcome measure = $Outcome_{CGM} - Outcome_{Control}$. A positive value indicates a higher measurement during CGM (intervention) compared with SMBG (control).
[b]Between-group difference = $Outcome_{CSII} - Outcome_{MDI}$. A positive value indicates a higher measurement in the CSII group compared with the MDI group.

Previous findings showed low sensor usage adherence in this age group.[3] In contrast, sensor use was high for both MDI and CSII users in our study. Dexcom G6 is calibration-optional[4] and linkable to a smartphone, reducing device burden. Real-time continuous glucose monitoring use in this study was associated with higher glucose monitoring satisfaction scores. Recent studies suggested that RT-CGM use may be cost-effective[5] and provides superior glycemic control when compared with starting CSII.[6] Thus, offering RT-CGM is potentially more efficacious and cost-effective to improve glycemic control. Limitations of our subanalysis were the relatively short duration and small sample size. Larger and longer clinical trials are still needed to assess long-term efficacy and adherence.

In conclusion, we have shown that use of RT-CGM in adolescents and young adults on MDIs achieved comparable glycemic outcomes to CSII. Equitable access to RT-CGM irrespective of insulin delivery modality should be considered.

Abbreviations

RT-CGM, real-time continuous glucose monitoring; CSII, insulin pump therapy; SMBG, self-monitored blood glucose; MDI, multiple daily injections; TIR, time-in-range.

Acknowledgment

Study volunteers and support by the staff at Manchester Diabetes Centre and Royal Manchester Children's Hospital.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: H.T. received research support from Dexcom Inc and speaker fees from Lilly. LL reports having received speaker honoraria from Animas, Abbott, Insulet, Medtronic, Novo Nordisk, Roche and Sanofi; having served on advisory panels for Animas, Abbott, Novo Nordisk, Dexcom, Medtronic, Sanofi and Roche; and having received research support from Novo Nordisk.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was funded by Dexcom Inc.

ORCID iDs

Lalantha Leelarathna https://orcid.org/0000-0001-9602-1962
Hood Thabit https://orcid.org/0000-0001-6076-6997

References

1. Thabit H, Prabhu JN, Mubita W, et al. Use of factory-calibrated real-time continuous glucose monitoring improves time in target and HbA1c in a multiethnic cohort of adolescents and young adults with type 1 diabetes: the MILLENNIALS study. *Diabetes Care*. 2020;43(10):2537-2543. doi:10.2337/dc20-0736.
2. Verschueren M, Oris L, Claes L, Moons P, Weets I, Luyckx K. Identity formation in adolescents and emerging adults with type 1 diabetes. *Psychol Health Med*. 2020;25(5):519-529. doi:10.1080/13548506.2019.1653482.
3. Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group. Effectiveness of continuous glucose monitoring in a clinical care environment: evidence from the Juvenile Diabetes Research Foundation continuous glucose monitoring (JDRF-CGM) trial. *Diabetes Care*. 2010;33(1):17-22. doi:10.2337/dc09-1502.
4. Wadwa RP, Laffel LM, Shah VN, Garg SK. Accuracy of a factory-calibrated, real-time continuous glucose monitoring system during 10 days of use in youth and adults with diabetes. *Diabetes Technol Ther*. 2018;20(6):395-402. doi:10.1089/dia.2018.0150.
5. Roze S, Isitt J, Smith-Palmer J, Javanbakht M, Lynch P. Long-term cost-effectiveness of Dexcom G6 real-time continuous glucose monitoring versus self-monitoring of blood glucose in patients with type 1 diabetes in the U.K. *Diabetes Care*. 2020;43(10):2411-2417. doi:10.2337/dc19-2213.
6. DeSalvo DJ, Miller KM, Hermann JM, et al. Continuous glucose monitoring and glycemic control among youth with type 1 diabetes: international comparison from the T1D Exchange and DPV Initiative. *Pediatr Diabetes*. 2018;19(7):1271-1275. doi:10.1111/pedi.12711.