HbA1c Estimation from a Long-Term Continuous Glucose Monitoring System: Comparison of Different Time Windows

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Introduction

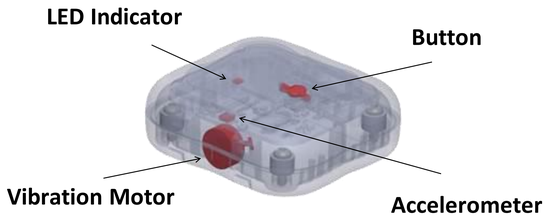
A new, long-term implantable continuous glucose monitoring (CGM) system (Eversense®) consisting of a fluorescence-based glucose sensor, wearable smart transmitter, and smartphone app has been developed. The PRECISE clinical study was performed to investigate the CGM system's performance over a 180-day period. The post-hoc analysis presented here evaluates different time windows for estimating HbA1c from the continuous glucose measurements.

Implantable CGM System

Sensor | Smart Transmitter | Mobile App

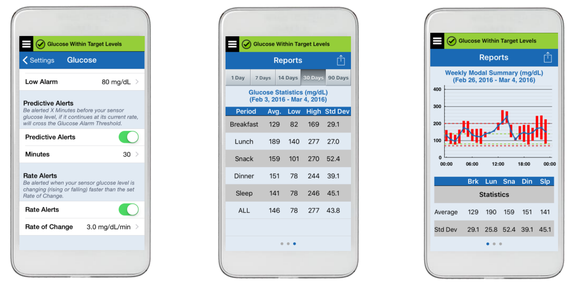
The Eversense CGM system utilizes a long-term implantable glucose Sensor powered by an external, wearable Smart Transmitter through a wireless inductive link. The Sensor is fluorescence-based and developed for subcutaneous implantation in the upper arm. The Smart Transmitter wirelessly communicates with the mobile App to display real-time glucose readings, trends, and alerts.

Wearable Smart Transmitter



- Transmits information for graphical display on smartphone via a secure, encrypted Bluetooth LE link
- Attached via replaceable adhesive patch
- Remotely powers Sensor via Near Field Communication (NFC)
- Provides discreet on-body alerts through the vibration motor
- Single button: powering and pairing
- Maximum charging time of 15 minutes

Smartphone App



- The App (iOS and Android) enables viewing of the real-time glucose readings, trends, and history through a touch interface
- Customizable alert settings with notifications
- Reports of daily glycemic variations that can be shared or exported

Clinical Study Overview and Results

Study Design

Population	• 71 adults
Insertion Site	• 2 Sensors were inserted bilaterally in the upper arm
Baseline Demographics	• Age 20 to 68 years • 42 (59.2%) males and 29 females • 66 (93.0%) T1DM and 5 T2DM • HbA1c 5.1 to 10.6% • BMI 19.5 to 41.1 kg/m^2
Calibration	• 2 SMBG per day for daily calibration
Study Duration	• 180 days

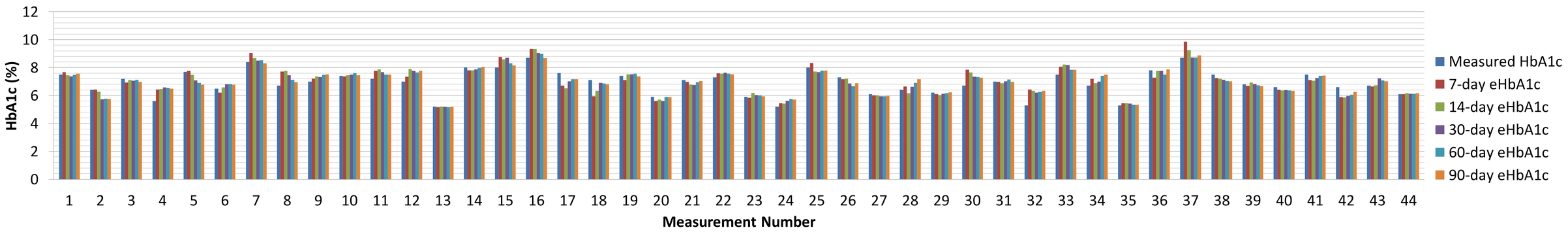
Methods

- During the investigation, HbA1c was measured at the screening, Day 90, and end of study visits.
- HbA1c of each subject measured in-clinic at the Day 90 and end of study visits were compared to an estimated HbA1c from average CGM glucose ($AG_{mg/dL}$) over the past 7, 14, 30, 60, and 90 days using a linear relationship:

$$eHbA1c\ (\%) = (AG_{mg/dL} + 46.7)/28.7^{[1]}.$$

- Forty-four (44) HbA1c measurements from 33 subjects with CGM glucose available for at least 80% of time in all time windows were included in this analysis.

Results



	Measured HbA1c	7-day eHbA1c	14-day eHbA1c	30-day eHbA1c	60-day eHbA1c	90-day eHbA1c	Linear Regression Slope	P-value
Mean (SD) [%]	6.93 (0.89)	7.03 (1.04)	7.03 (0.97)	7.01 (0.91)	7.01 (0.87)	7.00 (0.85)	--	--
Mean Absolute Deviation (%)	--	0.39	0.36	0.34	0.32	0.30	-0.0010	0.0141
Mean Absolute Relative Deviation (%)	--	5.63	5.31	5.05	4.75	4.53	-0.0122	0.0100
Pearson's Correlation Coefficient	--	0.87	0.87	0.89	0.90	0.89	0.0003	ns
Percent within ±10% from Measured HbA1c	--	82%	82%	89%	89%	84%	0.0375	ns
Percent within ±20% from Measured HbA1c	--	98%	100%	100%	100%	100%	0.0158	ns

Conclusion

Continuous glucose measurements from a long-term CGM system (Eversense) can be used to estimate HbA1c levels with acceptable accuracy. The estimation error decreases as the time window used for estimation increases from 7 to 90 days.

[1]David M. Nathan et.al., Translating the A1C Assay Into Estimated Average Glucose Values, *Diabetes Care* 31:1473–1478, 2008

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