Safety of a CGM-Informed Insulin Bolus Calculator Mobile Application for People with Type 1 and Type 2 Diabetes

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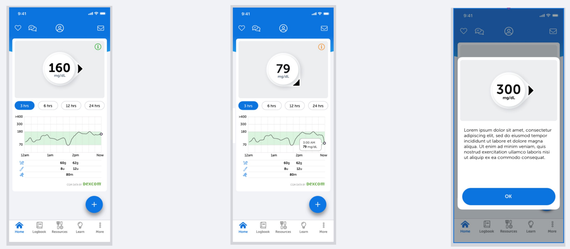
BACKGROUND AND AIMS

- People with diabetes on basal-bolus insulin regimens face challenges adjusting bolus doses
- There is some evidence from blood glucose monitoring (BGM) data that insulin bolus calculators may improve glycemic control and treatment satisfaction[1]
- Continuous glucose monitoring (CGM) systems can assist users with bolus dose optimization through the use of trend arrows
- The purpose of this study was to demonstrate the safety of a novel, CGM-informed insulin bolus calculator (IBC*, Welldoc, Inc., Columbia, Maryland, U.S.A.) that applies trend arrow adjustments to the bolus insulin dose recommendation
- The IBC was imbedded into Welldoc's BlueStar® mobile application
- This investigational software also provided real-time coaching on CGM data to assist users in improving their time in range (TIR)

METHODS

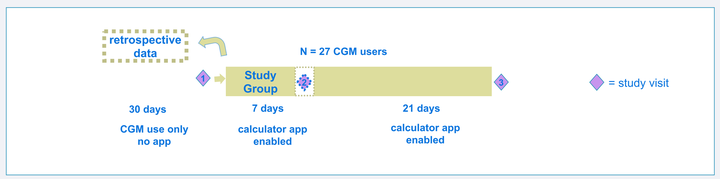
- Twenty-seven participants (T1 and T2 diabetes) using CGM (Dexcom, San Diego, California, U.S.A.) were enrolled in a 30-day prospective study where they were asked to use the mobile application to monitor their CGM data and calculate their insulin doses using the IBC
- CGM metrics during the prospective 30-day study period were compared to those from 30 days of baseline data
- The primary objective of this safety study was to demonstrate non-inferiority of the TIR during the study period as compared to that at baseline

Figure 1: Screenshots of the IBC mobile application



The home screen displays the real-time CGM value and trend arrow with an expandable view of historical data.

Figure 2: Study design



RESULTS

Figure 3: Demographic Data

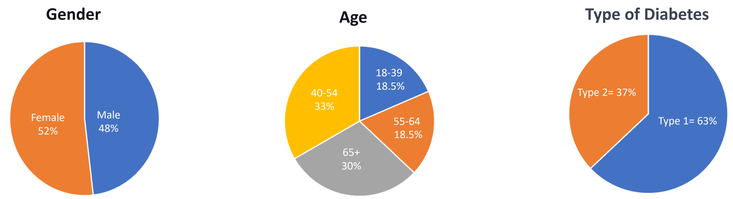


Table 1: Primary Safety Endpoints

ITT cohort - all participants who enrolled in the study; CC cohort - all participants who completed visit 3 and had CGM wear time of >=90%; PP cohort - all CC participants who used the calculator at least 30 times during the study period

Analysis [1] Population	Percentage (%) of Time in Range (between 70-180 mg/dL) Baseline	Post-Baseline (IBC)	Difference (IBC - Baseline)	P-value [2]
Primary Effectiveness Endpoint				
Per-Protocol (PP)				
n	19	19	19	
Mean (SE)	67.7 (2.8)	70.8 (3.8)	3.0 (2.4)	0.0006
95% CI for Mean	(61.9, 73.6)	(62.7, 78.8)	(-2.0, 8.0)	
Sensitivity Analyses				
Complete Cases (CC)				
n	24	24	24	
Mean (SE)	67.7 (2.4)	70.6 (3.2)	2.9 (1.9)	< 0.0001
95% CI for Mean	(62.8, 72.7)	(64.0, 77.2)	(-1.2, 6.9)	
Intention-to-Treat (ITT)				
n	27	27	27	
Mean (SE)	66.9 (2.4)	68.8 (3.4)	1.9 (1.8)	< 0.0001
95% CI for Mean	(61.8, 71.9)	(61.9, 75.7)	(-1.9, 5.7)	

P-value is from a one-tailed paired t-test, testing non-inferiority of the IBC app to baseline using a non-inferiority margin (NIM) of 6.2%

Table3: Subgroup Analysis

Parameter Subgroup	Baseline Mean (SE)	Post-Baseline (IBC) Mean (SE)	Difference (IBC - Baseline) Mean (SE)	95% CI of Mean Difference
Percentage of Time in Range (70-180 mg/dL)				
Type of Diabetes				
Type 1 (n = 17)	62.75 (3.35)	62.44 (4.42)	-0.31 (2.48)	(-5.57, 4.95)
Type 2 (n = 10)	73.87 (2.03)	79.60 (2.89)	5.73 (2.35)	(0.42, 11.04)
Number of IBC Usage				
< 30 times (n = 7)	62.39 (5.19)	61.34 (7.32)	-1.05 (2.99)	(-8.36, 6.26)
30-60 times (n = 2)	68.99 (10.05)	83.48 (8.87)	14.49 (1.18)	(-0.45, 29.43)
> 60 times (n = 18)	68.38 (2.96)	70.06 (3.90)	1.69 (2.32)	(-3.20, 6.58)

Note that time in range improved for the type 2 diabetes subgroup. This improvement may be related to the number of IBC usages during the study period.

Table 2: Secondary Efficacy Endpoints

Parameter [1]	Intention-to-Treat (ITT) Baseline	Intention-to-Treat (ITT) Post-Baseline (IBC)	Complete Cases (CC) Baseline	Complete Cases (CC) Post-Baseline (IBC)	Per-Protocol (PP) Baseline	Per-Protocol (PP) Post-Baseline (IBC)
Percentage of Time with High Glucose (> 180 mg/dL)						
n	27	27	24	24	19	19
Mean (SD)	32.15 (12.66)	30.41 (17.49)	31.25 (11.64)	28.55 (15.60)	31.26 (12.01)	28.32 (16.53)
Median	29.81	24.56	29.22	24.37	29.81	24.19
SE	2.44	3.37	2.38	3.18	2.76	3.79
Min, Max	9.8, 59.9	6.1, 73.1	9.8, 50.5	6.1, 69.5	9.8, 50.5	6.1, 69.5
Percentage of Time with Very High Glucose (> 250 mg/dL)						
n	27	27	24	24	19	19
Mean (SD)	5.85 (5.11)	6.27 (7.47)	5.83 (5.38)	5.75 (7.57)	6.28 (5.90)	6.13 (8.31)
Median	4.68	3.21	4.41	2.77	4.68	2.66
SE	0.98	1.44	1.10	1.55	1.35	1.91
Min, Max	0.4, 20.6	0.0, 34.1	0.4, 20.6	0.0, 34.1	0.4, 20.6	0.0, 34.1
Percentage of Time with Low Glucose (< 70 mg/dL)						
n	27	27	24	24	19	19
Mean (SD)	0.98 (1.07)	0.79 (0.81)	1.03 (1.11)	0.87 (0.83)	1.00 (1.09)	0.91 (0.87)
Median	0.82	0.54	0.83	0.57	0.82	0.57
SE	0.21	0.16	0.23	0.17	0.25	0.20
Min, Max	0.0, 4.1	0.0, 3.4	0.0, 4.1	0.0, 3.4	0.0, 4.1	0.0, 3.4
Percentage of Time with Very Low Glucose (< 54 mg/dL)						
n	27	27	24	24	19	19
Mean (SD)	0.18 (0.28)	0.12 (0.19)	0.20 (0.29)	0.13 (0.20)	0.16 (0.25)	0.11 (0.19)
Median	0.08	0.04	0.08	0.04	0.08	0.05
SE	0.05	0.04	0.06	0.04	0.06	0.04
Min, Max	0.0, 1.0	0.0, 0.7	0.0, 1.0	0.0, 0.7	0.0, 1.0	0.0, 0.7

Overall, there were no significant changes in time high, time very high, time low, and time very low.

CONCLUSIONS

- The data of this study showed that the use of a novel CGM-guided insulin bolus calculator with trend arrow dose adjustment within the BlueStar mobile application* was safe and provided individuals with real-time coaching on their CGM data
- Further analysis should be conducted to understand how the software application supports diabetes self-management behaviors
- Future research may help us understand the differences between behaviors of users with type 1 and type 2 diabetes

REFERENCE

[1]Schmidt S, Nørgaard K. Bolus calculators. J Diabetes Sci Technol. 2014 Sep;8(5):1035-41. doi: 10.1177/1932296814532906. Epub 2014 May 19.

*The insulin bolus calculator (IBC) is an investigational device not yet cleared by the U.S. Food and Drug Administration

16th International Conference on Advanced Technologies & Treatments for Diabetes (ATTD)
February 22 – 25, 2023
Berlin and Online

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