OralSense: A Passive Multi-Biomarker Smart Toothbrush for Early Detection of Gingival Disease and Pre-Diabetes Risk

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OralSense is a smart toothbrush system designed for passive, non-invasive detection of early gingival disease and pre-diabetes risk during routine brushing. It consists of a reusable electronic handle and a disposable diagnostic brush head with four sensing zones that measure gingival haemoglobin, salivary pH, optical gingival erythema, and salivary glucose using colorimetric and optical methods. A functional prototype was developed using an Arduino Nano, an LED-photodiode detection system, and Bluetooth data transmission. Each sensing zone was calibrated against reference standards across clinically relevant ranges, with reproducibility confirmed through five repeated trials. The glucose calibration range of 0.0–80.0 mg/dL covers the full spectrum from healthy to diabetic salivary glucose levels. A 30-day clinical pilot study with 30 participants grouped by oral and metabolic health status was conducted. Participants used the device daily, and readings were compared with dentist-scored Bleeding on Probing (BOP), Gingival Index (GI), and laboratory HbA1c values. Data analysis included Pearson correlation and a Random Forest model using 12 features derived from biomarker trends. The fusion model achieved high predictive accuracy (AUC = 0.93), outperforming the best single biomarker (haemoglobin, AUC = 0.78). Fasting salivary glucose strongly correlated with HbA1c (r = 0.84), supporting its use for non-invasive screening. Overall, OralSense demonstrates that continuous multi-biomarker monitoring combined with AI improves early detection while offering a low-cost, accessible solution for daily oral and metabolic health screening, at approximately KSH 335 per disposable head.

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