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Detection of Tooth Decay: Report of a Novel Invention

Mohammad Ali Roozegar[1], Zeinab Mohamadi[2], Amirreza Hashemian[1*]

[1]Department of Periodontology, Faculty of Dentistry, Ilam University of Medical Sciences, Ilam, Iran
[2]Department of Chemistry, Payam Noor University of medical Sciences, Ilam, Iran

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ABSTRACT

Tooth decay is a microbial infectious disease that caused to local damage of calcification tissues of tooth and common cause of tooth damage in youth. Therefore, prevention of this damage is necessary. One of the most important methods of prevention of tooth decay is opportune diagnosis of decay and reconstruction. The present study aimed to introduce a novel invention for early diagnosis of tooth decay and to compare result of experiment of this device with other common methods. This device will diagnose tooth decay without any chemicals and rays such as lasers or X-rays. It works by shining infrared light reflected on the surface of the tooth. It will be placed on the tooth and Transmitting infrared light will be reflected on the surface of the tooth and Infrared sensor receives light from the tooth surface. All lights are reflected, but if the tooth was rotten, then its color would be darker and the reflected light would be absorbed on the surface of the teeth. The rest of the light is reflected. By the difference between the amount of light reflected from the surface of decayed teeth and Healthy Teeth the device is able to detect decay and dental health. Infrared sensor is a type of optical transistors. When the light is shone on them, the light will be converted into an electric current. This electric current will be changed in different expressions. The microcontroller device will process these flows. The phase logic is used for data processing that substantially increases its accuracy. The invented device does not use chemicals to detect caries which is quite safe and affordable. Comparison the result of diagnosis of damaged tooth using this device with diagnoses of two independent dentists indicated more accuracy, efficiency and confidential ($p<0.01$). The invented device can be used as the primary method of dental caries.

Keywords: Invention, Tooth Decay, Toothbrush

INTRODUCTION

Dental caries and gingival diseases are among the most common chronic diseases in the world. Dental caries are a bacterial infection which cause localized dissolving and destruction of calcified tooth structure (1). Dental plaque is a gel like cluster of bacteria which stick to the tooth's surface. The plague's bacteria metabolize sugar and produce organic acid. This destroys the tooth's structure. Dental caries is a transmittable infectious disease which initiates with bacterial activity on the tooth's surface and advances within its structure. For tooth decay to occur, sugar has to be in reach of the bacteria in order to produce acid which is the mineral structure's destructive factor. Therefore tooth decay is actually the destruction of the tooth's mineral structure. One of the important methods of preventing damage caused dental caries is identifying them prior to this and restoring them. Using decay detection device dental caries detection can be carried out without the need for chemical substances or dangerous beam rays such as x-ray and lasers. The device works by emitting infra-red light on the tooth's surface and receiving its reflection. In the time of registering this invention the following methods and instruments are used for caries detection: dental

explorer and mirror, eye examination, fiber optics and trans-illumination (FOTI), x-ray radiography, measuring tooth electrical resistance (electrical caries measurement- ECM) and fluorescent laser.

MATERIALS AND METHODS

Explanation of electronic components' function
Capacitor: To store electrical charge. Function of capacitor in the circuit: when the circuit's voltage drops the capacitor discharges to make this drop in voltage (3).
Resistor: Reduces voltage and is shown with the "r" symbol and its unit is Ω.
At mega 32 microcontroller: The microcontroller is the brain of the device and works based on the program given to it. The process includes input from the sensors, processing through the program assigned to it and the output (information) displayed on a monitor (4, 5).
2x16 monitor: Displays the received data from the microcontroller as text (6).
Voltage regulators: In order for many of the components of the circuit to work a steady, non-alternating is needed, for example 5V. To achieve such a voltage a regulator is used (7).

Infra-red transmitter and receptor sensors: The build of infra-red diodes is not much different than other diodes. The infra-red receptor is usually used in unbiased. This diode increases current in reverse direction when it receives infra-red from its surroundings and when it isn't receiving infra-red the current is reduced in reverse direction. However this current is very low and has to be enhanced. The infra-red transmitter is biased directly (is connected to the main source) (Figure 2). However to prevent it from overloading, the running current should be controlled with a resistor which is placed in a series circuit with the transmitter (8, 9).

Building technic:
1. Use an infra-red sensor with a switching speed of 20 kh
2. Use LCD display because of its high quality
3. Use an at mega 32 microcontroller due to an auto-programming memory with four 8pin ports, input output, with 8MHz internal crystal and 8 analogue to digital convertor canals.
4. Use 2.2 and 100 ohm resistors to prevent sensor overloads

This invention was registered under the number 66880 at the date 9/10/2010 by the Patents and Industrial Property Organization.

RESULTS

To show the efficacy of the device at hand, the caries detected by this device were compared with the detection of the same caries by two independent dentists (table 1). The figures are based on the percentage of decay in all the teeth.

Discussion:
Methods of dental caries detection:

A. **Old Methods**:
1. Examining using the eye and observing changes in the structure and color of the tooth
2. Precise palpation using an explorer
3. Radiography
4. Trans-illumination

B. New Methods
1. Laser induced fluorescent (DIAGNODENT)
2. DIFOTI
3. Quantitative Light Fluorescent (QLF[1])
4. Electrical conductivity

1 QLF: Determines the actual amount of tooth structure loss. Determines the lesion's rate of advance over time and also whether it is active or not

Dental Explorer:
The most traditional instrument for caries detection is the dental explorer. Research has proven that this instrument can transfer bacteria from the grooves of one tooth to another. Using an explorer in comparison to only examining the tooth with only observation does not increase the ability to detect caries. This instrument can't determine the size of lesions in enamel or dentine. If not used cautiously, the dental explorer can cause damage to the tooth's surface and create cavities in places where they did not exist prior to examination with the explorer.

Palpation:
In caries detection it is defined as the gentle and cautious use of an explorer on the tooth's surface to determine the smoothness and or roughness of the lesion.

Examination Using the Eye:
Special magnifying glasses have been designed to examine small pits and fissures on the tooth's surface which help the dentist see in a wider and bigger field. It has been proven that this instrument is not much different in detecting caries compared to the naked eye.

Fiber Optics and Trans-Illumination (FOTI):
Using this device a special light is passed through the tooth. This light has the ability to make caries visible to the naked eye for the dentist to see. Dentinal caries are better detected using this device compared to dental mirrors and explorers.

Radiography:
Radiography is an integrated part of the diagnostic process in dentistry. However it is not without its flaws and has ionizing radiations which could have unwanted side effects. When interpreting radiographs its limitations have to be taken into consideration and other methods should be used as adjunctive. Radiographs are two dimensional pictures of three dimensional objects. It is possible to mistake anatomical structures for flaws in tooth structure. The lesions depth may be shown less than it is.

Electrical conductivity measurement (ECM):
This device measures the resistance against the flow of electrical current in teeth. This value differs in teeth with different depths of decay. Each certain depth of decay passes a certain amount of electricity. According to the amount of electrical current which passes the depth of decay can be calculated. This device has medium sensitivity and low specificity compared to other methods in caries detection. The device compares the flow of electrical current in teeth with normal enamel, which is conductive with decayed teeth.

Laser Induced Fluorescent:
Diagnodent emits a visible red laser light at the tooth which creates a reflection. This reflection is different in normal teeth compared to decayed ones. The device's receptors receive the reflected light and interpret it. Diagnodent uses the laser fluorescent technology to detect and measure products of bacterial metabolism in teeth. The more lesions advance, the more reliable the results are. One of the problems with this device is that colorants and calculus are considered as tooth structure and are calculated (10).

Benefits of the invented device:

1. The device has been designed in small dimensions, the size of a normal tooth brush.
2. It displays information as text
3. It shows the exact amount of decay
4. The components used to make the device are available in open market
5. The device is cost effective and can be mass produced
6. No chemical substances are used to diagnose decay
7. Infra-red is used which has no side effects

In comparison to similar inventions it is cost effective in a way that individuals in society can purchase and use them personally, whereas other inventions are only for use for dentists in dental clinics. No harmful beam rays are used in this device such as x-ray which endangers human health and also the device's accuracy is considerably high as it uses fuzzy logic in processing data (Figure 3).

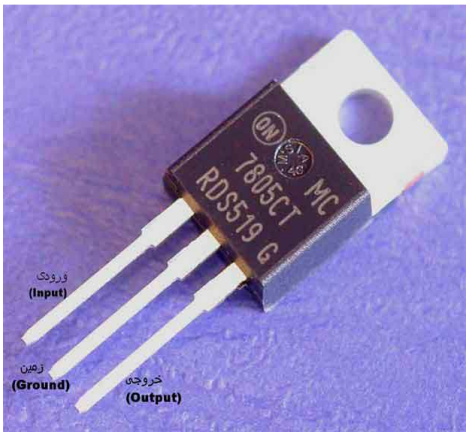

Figure 1: Voltage Regulator 7805

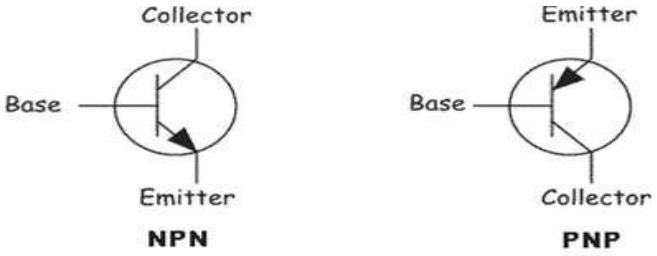

Figure 2: Infra-red transmitter and receptor sensors

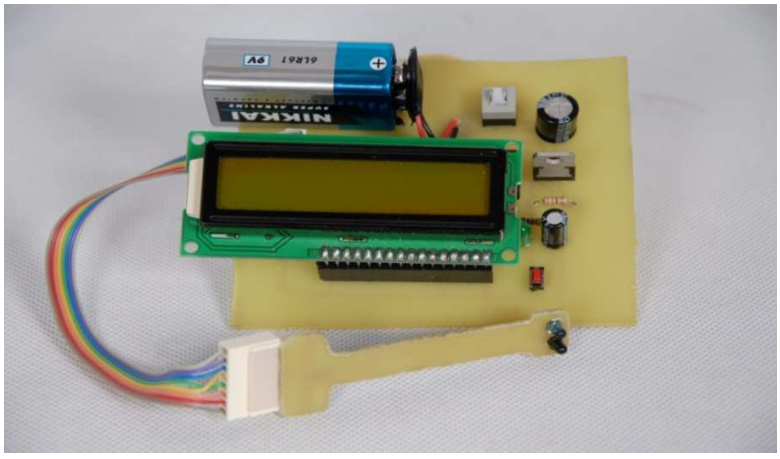

Figure 3: Decay detections Device (The present invention)

Table 1: Comparison between the percentages of decay of teeth based on the device and the opinion of independent dentists

Second dentist	First dentist	Device	Number of the tooth being examined
20	30	25	1
25	20	38	2
70	50	45	3
45	60	43	4
50	60	76	5
0	0	0	6
70	80	49	7
5	10	37	8
55	20	48	9
0	30	0	10
0	0	0	11
10	10	23	12
0	5	0	13
70	80	42	14
0	5	47	15
17	25	39	16
0	25	0	17
90	80	53	18
100	100	57	19
95	90	41	20
36.1	39	33.15	Mean

How to use the device:

The device works by emitting infra-red and receiving its reflection. To work the device a 5 volt battery is needed. Batteries in the circuit of this device are used in a way to have the highest efficiency. After the battery has been put in its place the device will turn on, then the device should be held in a perpendicular position to the tooth's surface. The position of the device in regards to the tooth and the distance of the sensors from the surface of the tooth affect the accuracy of the device so they should be calibrated carefully to get the optimum accuracy of the device. When the device is in an adequate position to the tooth surface the button to diagnose dental decay should be pressed. The device will start to emit infra-red beams (infra-red emitting sensor) towards the surface of the tooth, after the button has been pressed. Then the reflected infra-red is received by the device's infra-red receiving sensors. Then the device analyzes the amount of infra-red sent and received from the tooth's surface through its microcontroller which is the device's brain. Considering that normal healthy teeth are uniformly white (depends on the quality of teeth, in some teeth the color is uniform but not white) the transmitted beams are completely reflected. But if the tooth is decayed the color of the tooth is darker than its normal state therefore some of the transmitted light is absorbed and the rest is reflected. Based on the difference of reflection between the surface of the normal tooth and the decayed tooth the device is able to diagnose between decayed and healthy teeth. The infra-red receiving sensors are the light transistor type. When light reflects on them, they produce electrical current. This electrical current varies in different reflections, and the microcontroller interprets these currents. The fuzzy theory is used to process the data, which increases the device's accuracy considerably. The sensors transfer data to the microcontroller and the microcontroller processes the data based on its programming and reference information and the transfers the final data to the monitor. The transferred data from the microcontroller is displayed as text on the monitor as percentage of decay so the dentist or operator is informed of the amount of decay.

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