Wireless micro-sensors: innovation and application in dentistry

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SUMMARY
Micro-sensors have a huge implication in clinical research and will greatly improve the level of evidence in dentistry.
The emergence of micro-sensors offer in the future the opportunity to deploy and implement many exciting application with scientific analysis.
With new features, smaller size and excellent reliability, these micro-sensors will change the way clinicians monitor adherence. While further testing of these micro-sensors is warranted, especially in real life settings, this idea can serve as a platform for future research in the field. In the future, it would be ideal if the micro-sensors had the capacity to send information to clinicians even if patients are not coming to the office.

Key words: telemedicine, wireless, micro-sensors, dentistry.

Telemedicine

Telemedicine has been defined as the use of telecommunication to provide diagnostic and therapeutic medical information and to facilitate healthcare services, saving patient and doctor alike having to travel across geographic, time, social, and cultural barriers. In other words, telemedicine is a novel way of healthcare service delivery, whereby the problem of distance is overcome and healthcare professionals use information and communication technologies to swop relevant information for disease or injury diagnosis, treatment, and prevention as well as for research and assessment, and for in-service education and training to the betterment of both individual and the community health.

Increasingly effective sensors, low-power integrated circuits, and wired or wireless high data-rate broadband communication services open up new fields of research along with prospects for an efficient and economical deployment of telemedicine technologies.

This paper therefore sets out to assess the technologies involved in telemedicine applications and to establish a relationship between telemedicine system analysis and design and efficient delivery services in a wide geographic area depending on bandwidth and user requirements.

Telemedicine applications allow medical professionals to obtain not only patient records, but also other vital symptoms and reference data. Depending on the needs and availability of communication's infrastructure, some of the transmission modes used include various integrated services digital network (ISDN), local area network (LAN), asynchronous transfer mode (ATM), digital subscriber line, satellite, microwave, digital wireless, and the Internet. With such a gamut of technology at its disposal, telemedicine had paved the way for a more cost-effective network.

Telemedicine can be divided into two modes of operations: first there is real-time mode (synchronous), where patient data are available at the remote terminal immediately after acquisition; second there is store-and-forward mode (asynchronous), which accesses data at a later date (1). In the store-and-forward mode, a digital image is taken, stored, and then forwarded to a medical specialist at another location for consultation, so avoiding the need for simultaneous communication in real time. Tele-radiology, where by radiographic images need to be transferred or dermatology, where visually skin lesions are examined, are both good examples of this kind of mode. Store-and-forward also includes the asynchronous transmission of clinical data, e.g. blood glucose levels and electrocardiogram (ECG) measurements, from one site (e.g., patient's home) to another (e.g., home, health agency, hospital, or clinic). In the real-time mode, both locations need appliances such as cameras or monitors to further the interaction. It can also use means as simple as a phone call, or as sophisticated as virtual reality robotic or tele-surgery. Patients and providers can thus communicate by using audio-visual and wireless or microwave signals. It is particularly useful for monitoring of long-term care patients or patients in their homes. Its applications can be in cardiology, neurology and gynaecology, to cite just three.

In whichever case, telemedicine unit basically consists of the following modules:

- bio-signal acquisition module through sensors and peripheral devices
- digital camera for image or video capturing
- processing unit: computers
- communication module: Global system for mobile communication (GSM), general packet radio services (GPRS), third generation (3G), satellite, plain old telephone system (POTS), modem, Internet, WAN, metropolitan area networks (MAN), personal area networks (PAN), etc.

Wireless technologies

In a telemedicine environment, doctors and healthcare workers need to be mobile to carry out their respective duties, whether in a clinic or hospital. Therefore, the more ubiquitous and immediate the connectivity, the better their access, from a remote mobile terminal, to the central database of patients' clinical records. Light, smaller sized, and cheaper mobile devices with longer battery life, along with improved interfaces have also contributed to wireless technologies' effectiveness in telemedicine applications. Indeed, the 'mobile telemedicine' is the fastest changing aspect in telemedicine applications now that wireless technology is moving from third to fourth generation, with transmission rates of wireless techniques varying one from another. GSM offers 9.6 Kbps band-width and therefore restricts potential mobile telemedical services and the type, speed, and quantity of medical information to be transmitted. However, the advent of GPRS now promises data rates from 56 up to 114 Kbps and continuous connection to the Internet for mobile phone and computer users. Also, enhanced data rates for global evolution (EDGE) is a radio-based high-speed mobile data standard. It allows data transmission speeds of 384 Kbps when all eight time-slots are used. EDGE was initially developed for mobile network operators who failed to win access to the universal mobile telephone system (UMTS) spectrum. EDGE enables present GSM operators to provide data services at speeds near to those available on UMTS networks. With EDGE, the operators and service providers can offer more wireless data applications, including wireless multimedia, e-mail (Web-based),Web 'infotainment': above all, they provide video conferencing facilities that overcome GSM's limitations regarding telemedicine applications. The emergence of 3G mobile phone networks has increased a number of systems for transferring vital signs such as ECG and heart rate, offering a more effective to earlier mobile medical system using satellites to establish communications between remote sites and base hospitals. The 3G mobile phone is a digital mobile phone based on the International Telecommunication Union (ITU) IMT-2000 standard. In 3G communication networks, a CDMA system is used to provide a whole range of services via high band width and multimedia transmission capabilities. Since the 3G mobile phone adopts the CDMA system, noise and cut-off in communication is reduced, while high-speed data transmission is possible at the rate of 384 Kbpsat, outperforming 2G mobile phones. For example, Chu and Ganz (2) report use of 3G networks for simultaneous transmission of video, medical images, and ECG signals. They describe a portable tele-trauma system: this which assists healthcare centers by relaying simultaneous transmission of a patient's video, medical images, as well as the ECG signals required throughout the pre-hospital procedure. The system's performance is assessed over commercially available 3G wireless cellular data service and real network conditions. With the commercially available 3G wireless links, such a system can simultaneously transmit video, still ultrasound images, and vital signs. System designs with 3G links require particular attention when managing data so as to ensure smooth transmissions through low-speed and fluctuating 3G link as the actual throughput of such cellular links fluctuates. Also, different types of streams such as real time video, images, vital parameter, or other readings from medical sensors have different transmission requirements. Therefore, it is also necessary to coordinate, prioritize, and compress the different media streams to eliminate distortion of multimedia content in cellular networks which are also essential criteria in design issues of a telemedicine system using cellular networks. A collection of intelligent, physiological and wearable sensor nodes capable of sensing, processing, and communicating one or more vital signs can be seamlessly integrated into personal or body wireless networks (WPANs) for monitoring health. The most important features of a wearable health monitor are long battery life, lightness of weight, and smallness of size. If integrated into a tele-medical system, these systems can also alert medical personnel to life-threatening changes. In addition, patients can benefit from continuous long-term monitoring as a part of diagnostic procedure, whilst also being guaranteed the best treatment for chronic conditions or supervision following trauma or surgery. Long-term health monitoring can capture the diurnal and circadian variations in physiological signals. These variations, for example, are a very good indicator of recovery in cardiac patients after myocardial infarction (3). In addition, long-term monitoring can enhance adherence to treatment guidelines (e.g., regular cardiovascular exercise) or help monitor effects of drug therapy. Other patients can also benefit from these systems; for example, the monitors can be used during physical rehabilitation after hip or knee surgery, or rehabilitation after a stroke or brain trauma. The last few years have seen a significant increase in the number of various wearable health monitoring devices, ranging from simple pulse monitors, activity monitors, and portable Holter monitors (Holter Systems, 2007) to sophisticated and expensive implantable sensors. However, wider acceptance of the existing systems is still limited: traditionally, personal medical monitoring systems, such as Holter monitors, have been used only to collect data. Data processing and analysis are performed off-line, making such devices impractical for continual monitoring and early detection of medical disorders. Systems with multiple sensors for physical rehabilitation often contain clumsy wires which may cause discomfort and hinder movement as well as compromising the results measured (4). In addition, individual sensors often operate as stand-alone systems and often lack flexibility *vis-a-vis* third-party devices. Finally, the existing systems tend to be costly.

Recent advances in integration and miniaturization of physical sensors, embedded microcontrollers, and radio interfaces on a single chip, wireless networking, and micro-manufacturing have given rise to a new generation of wireless sensor networks with many applications. Some physiological sensors for monitoring vital signs, environmental sensors (e.g., temperature, humidity, and light), and a location sensor can all be integrated into a wearable wireless body/personal area network (WWBAN) (5). When integrated in a broader tele-medical system with patients' medical records, the WWBAN promises a breakthrough in medical research through data mining of all gathered information, the abundance of collected physiological data allowing quantitative analysis of various conditions and patterns.

A LAN is used to connect digital devices such as personal computers and mainframe computers over a localized area such as a building or campus of a hospital, university, or factory. In hospitals they are often used to access a patient master index, to track medical records, appointment booking systems, and pathology test results. Distances are small, 1-2 kilometers at the most, allowing high data transmission rates. A wide area network (WAN) is a network which covers a greater geographic area than a LAN. In health applications, a typical WAN would connect the LANs from all the hospitals in a city or region. A wireless LAN or WLAN is a wireless local area network, linking two or more computers without using wires.

Thus, WLAN systems capable of transmitting at high speeds are currently being developed and installed worldwide. They possess various advantages ranging from installation flexibility and mobility to increased scalability. Such technology will ensure a faster and more precise response to hospital patients' needs, enabling the delivery of services to the point of care, even if the hospital staff are elsewhere.

Originally WLAN hardware was so expensive it was only used as an alternative to cabled LAN in places where cabling was difficult or impossible. Early development included industry-specific solutions and proprietary protocols, but in the late 1990s these were replaced by standards, primarily the various versions of IEEE 802.11 (Wi-Fi) and HomeRF (2 Mbit/s, intended for home use, unknown in the UK). An alternative ATM-like 5GHz standardized technology, high performance local area network (HIPERLAN), is yet to have market success, unlike the faster 54 Mbit/s 802.11a (5 GHz) and 802.11g (2.4GHz) standards.

Among the available protocols, Bluetooth is a low cost, low power, short-range radio technique introduced by Ericsson and others. Bluetooth was originally a replacement for physical cables. The goal of eliminating cables has led to the creation of the notion of PAN, a close range network surrounding a person carrying several heterogeneous devices equipped with wireless communication techniques. It has enabled mobile devices to communicate with computers within a 10 m distance, so improving patient monitoring and the response to emergencies in remote locations.

The merging of Internet and mobile computing is promoting development in handheld devices, wireless infrastructures, application programming languages, and protocols, all aimed at providing mobile Internet access. Among these is the wireless application protocol (WAP), a communication protocol and application environment for the deployment of the information resources, advanced telephone services, and Internet access from mobile devices. Thus WAP is a possible option for telemedicine applications. Hung et al. (2003) utilize WAP devices as mobile access terminals for general enquiries and patient-monitoring services. In this experiment, an authorized user, whether a doctor or the patient's relatives, can browse the patient's general data, monitor blood pressure, and the electrocardiogram in store-and-forward mode.

Given all the above technology options, it goes without saying that the mobile telemedicine is eminently worthy of further research and exploration due to potentially enormous data transmission capabilities of the next generation wireless networks.

Medical sensors

Sensor networks constitute an emerging field of telemedicine. Sensor networks consist of small sensing areas and typically reside the patient's home. In the latter case, they are called the patient's body area network (PAN). PAN helps monitor many facets of a patient's physical health via "conventional sensors" based on piezo-electrical material for pressure measurements to infrared sensors for body temperature estimation and opto-electronic sensors monitoring SpO2, heart rate, HRV, and blood pressure (6). In this research, Robert et al. confirm that the future of healthcare lies in using existing technology such as mobile medical sensors for communication in-health care along with prospective ideas for 4G wireless communications. Therefore, smart medical sensor design needs a special attention.

Applications

Micro-sensors for orthodontic oral appliances

The ability to monitor intra-oral appliance adherence amongst patients is still more challenging for orthodontists. Though the adherence monitors used in extra-oral appliances cannot be used in the oral environment, their general principles can be applied to oral devices. One of the first methods used to assess adherence of OA wear was the use of controlled release glass discs (7).
The controlled-release glass was composed of phosphates, borates and trace elements made into a disc and fitted onto the surface of an orthodontic appliance. The discs would dissolve when in saline solution indicating wear. Problems with this method included the discs detaching themselves from the appliance due to poor adhesion; surface grinding of the discs would lead to fragmentation and the discs would dissolve. More recently, AlignTechnology has incorporated a Blue Dot Indicator into the Invisalign Teen system, which uses the food dye, Erioglaucine disodium salt. The dye is encapsulated in the clear aligner and is released from the polymer in the presence of oral fluid (8).
Manufacturer reported that the embedded dye would dissolve when exposed to moisture and temperatures equal to or higher than body temperature, the clinician then being able to evaluate five potential colour changes (from dark to clear blue), providing a graphic representation of the wear-time. This system would allow patients to continually monitor and have instant feedback by checking the colour in the aligners themselves. It is thought that this feedback may be more effective in achieving adherence, especially in older patients (9).
However, Schott and Goz (10) found that the adherence could be easily falsified by patients since the dye would fade when stored in drinking water at 200° C, which is well below body temperature. The dye was also found to fade faster if the aligners were left in the mouth while drinking, stored in water, cleaned with tablets containing oxidizing agents or cleaned in a dishwasher. A large variation in fading was found among patients who strictly adhered to the prescribed wear-times. Due to the fact that the clinicians have to rate the colour change on a five-point scale, this involves inherent subjectivity and does not produce an objective wear-time of the OA. An objective adherence monitor, much like the ones used in headgear devices, would provide doctors with a more accurate picture of their patients adherence of removable OA wear. In 1990, Sahm et al. (11, 12) created a reed-switch, which was embedded into a bionator-functional appliance and activated by a magnet system bonded to the lingual of the mandibular first permanent molar. The main problems noted with this device was its bulkiness and patient discomfort. Bartsch et al. (13). used the microelectronic timing system developed by Sahm in their study. They found that the adherence rate of patients wearing the bionator was only 56.7%. Currently, there are several micro-sensors commercially available that can be integrated into removable OAs. Scientif-

ic Compliance (Atlanta, Ga) invented the SmartRetainer (14), which consists of a miniature microprocessor that can keep time, monitor temperature and store data for up to 40 years. The micro-sensor records the temperature once every 45 minutes. The data are read off by a USB-reader that transmits the data wirelessly through optic signals. This means that only clear appliance material can be used to embed the micro-sensor to allow transmission of the optic signal. A small short-term randomized clinical trial, funded by Scientific Compliance, was conducted using the Smart Retainers in 19 maxillary Hawley Retainer, worn by subjects 20 hours per day (15).

They reported that individuals made aware of their wear-time being monitored wore the device significantly more (mean 2.3 hours) per day than unaware patients. Subjects tended to reduce their wear (mean 0.2 hours) with each passing day. In addition, subjects reported to wear their appliances full time but were found to wear the appliances 12.4 hours less than the more honest patients in the study. Thus, this clinical trial shows a significant disparity between actual and prescribed retainer usage.

The TheraMon sensor (Handelsagentur Gschladt, Hargelsberg, Austria) (16, 17) was developed at the same time as the Smart Retainer in Europe. It works by recording the oral environment's temperature at 15-minute intervals. Temperatures noted between 31.5°C and 38.5°C are recorded as wear-time. The company reports that sensitivity of the temperature module makes it very difficult for patients to dissimulate adherence as the software highlights any abnormal temperature fluctuations such as "suspicious" activity. The micro-sensors transmit data through a radiofrequency identification device (RFID) and do not emit any frequency except when communicating with the reader. *In vivo* testing of the micro-sensor was conducted by Schott and Goz (16) on 20 patients fitted with upper and lower active plates, functional appliances or retention devices. However, the paper only provides a case report of one patient wearing an upper appliance and provides no statistical analysis on the accuracy of the device. More recently, in October 2013, Schott et al. (18) published a study examining the adherence rate of 100 patients fitted with Hawley retainers or functional appliances during their orthodontic treatment's retention phase. While patients were instructed to wear the appliances a minimum of eight hours per day, it was found that during the first three months, 60% of patients wore the retainer for an average of less than 8 hours/day, that 25% wore it between 8-10 hours/day and that 15% wore it more than 10 hours/day. The median wear-time was 7.0 hours/day. While the report stated that adherence rates were influenced by age, sex and place of treatment, these differences were not statistically significant. However, patients receiving government funded statutory health insurance wore their appliances significantly more than patients with private insurance. This is the first study to examine the association between clinical and social parameters and to report objective wear-times of removable retainers using an incorporated micro-sensor.

In November 2013, Pauls et al. (19) used TheraMonmicrosensors in a 168-day trial where a control group of 14 patients fitted with removable appliances was informed about an adherence monitor embedded in their appliance. A study group of 18 patients was not told about the adherence monitor until after the first appointment. It was found that the subjective reports of adherence differed significantly from the objective measured adherence at the first appointment when the study group did not know they were being monitored. However, subsequent to being told of the monitoring device, there was no significant difference in reported usage compared to the recorded use during a later appointment. Thus, patients tend to overestimate their wear-times but become more realistic and honest once they know they are being monitored. In addition, no significant difference was found in the wear-time between the two groups. This suggests that adherence does not necessar-

ily increase when patients know they are being monitored.
The Thera Monmicrosensor has been used in several clinical studies (18-20), however the micro-sensors accuracy remains largely unresearched (21) attempted to assess the accuracy of the Smart Retainer compared to the Thera Monmicrosensor by *in vitro* testing using a programmable water bath. They reported that the Thera Monmicrosensor was more accurate, with the Smart Retainer overestimating wear-time by one hour. Pauls et al. cited this study to show that clinically sufficient accuracy of the Thera-Monmicrosensor has been investigated *in vitro*. However this study has several flaws including an unreported sample size, no statistical analysis and then programming the water bath at room temperature and oral temperature while ignoring the time it takes for the water bath to heat or cool. Pauls et al. (19) attempted to show accuracy of the TheraMonmicrosensor *in vivo* by having a postgraduate student wear a removable appliance with a micro-sensor for 2 weeks and record the time when the appliance was inserted and removed. It was found that there was a mean discrepancy of 7.92 minutes per day between the wear-time recorded by the micro-sensor and the log kept by the student. The level of evidence on the micro-sensor's accuracy is quite low since there was only one sample size and the trial was over a short time-period. In addition, no statistical analysis was provided.

Microsensors for oral appliances for obstructive sleep apnea (OSA)

Oral appliances (OA) used for the treatment of OSA, such as mandibular advancement devices (MADs), present similar issues of patient adherence as orthodontic appliances. Lowe et al. (22) published the first report using a micro-sensor embedded in an OA for sleep apnea in 2000. They produced an adherence monitor using a ceramic thick-film hybrid with a memory system to monitor wear-time based on temperatures above 310° C. The OA were tested over a two-week time span in eight patients with OSA. The agreement index between the subjects' adherence monitor and log records was 0.99. However, Lowe et al. (22) reported several problems with the monitors such as the damaging effect of saliva, heat intolerance of the electronic components and energy consumption over a long period of trial time. Tjin et al. (23) described the use of fibre-optic sensors to monitor the force and temperature of OAs worn by patients suffering from sleep apnea. Using Fibre Bragg gratings manufactured or as above from photosensitive fibres, the sensors can monitor temperature changes of 0.10° C and detect forces of 0.5N. The main advantage of these sensors is their small size (1 cm long by 3 mm wide and 0.375 mm thick) and immunity to electromagnetic interference. However, no detailed study of the sensors accuracy has been published. Inoko et al. (24) examined the cytotoxic effect of a "temperature data logger" (Thermochroni Button, Dallas, Texas) through *in vitro* testing, using a three-dimensional human dermal model kit was derived from human normal keratinocytes and fibroblasts. Due to the fact that the sensor is covered with stainless steel alloys, the investigators were concerned that the sensor may corrode in the oral environment and that the corroded material would be in direct contact with periodontal tissues. The results indicated that the sensor immersed in the human dermal tissue kit for 10 days had a minimal cytotoxic effect, since the cell viability of the extracted fluid was 96.92%. The study concluded that the sensors were not influenced by oral moisture and could be an effective and safe method for measuring OA adherence. In the second part the Inoko et al. (24) study, six patients with OSA were fitted with an OA with the Thermochron sensor attached to the buccal surface and were instructed to wear the appliance for one month. They reported that all participants wore the appliances every day, except one who wore it only 20% of the time. The average time used ranged from 5.4 to 7.5 hours per day. No statistical analyses were performed to evaluate the results. The sensor used was quite large with a diameter of 17.4 mm, a thickness of 5.9 mm and a weight of 3.3g. The use of this large sensor in everyday clinical practice maybe cause difficulty for some patients. The results of an abstract, testing the same thermo-sensitive microsensor (ThermochroniButton) embedded in an oral elastic mandibular advancement device in seven patients with OSA, found that the devices were worn approximately 90% of days in the trial for an average of about 6.2 hours per day. The study concluded that adherence to MADs could be objectively assessed with temperature microsensors. The first trial using TheraMonmicrosensors (Hargelsberg, Austria) as an adherence monitor in OAs was a three-month prospective clinical trial followed 51 consecutive patients previously diagnosed with sleep-disordered breathing (SDB). The micro-sensors were embedded in the upper right side of a custom-made titratable MAD. The results showed that the regular OA user rate was 82% with an average objective OA use of 6.7±1.3 hours per day. There was no significant difference between the computed objective data from the micro-sensors and self-reported log of OA adherence. The study proposed was able to calculate the mean disease alleviation as a measure of therapeutic OA effectiveness, where effectiveness entails both efficacy and adherence, the mean disease alleviation can be calculated as the surface area on a graph by multiplying the adjusted adherence rate (objective OA usage divide by total sleep time) and the therapeutic efficacy (AHI at baseline minus AHI with OA applied). It was established that OA therapy has an average disease alleviation of 51.1%, comparable to the 50% adjusted CPAP effectiveness (25). The values of the average disease alleviation of CPAP are therefore similar to OA therapy, where OA has a high adherence rate with suboptimal efficacy, and CPAP therapy has higher efficacy but decreased adherence. Still, the proposed mean disease alleviation calculation needs to further study to understand if it truly correlates with clinical outcomes. The same study reported no adverse effects, including oral burns, lesions or detachment of the micro-sensor, on the part of the participants. Only one sensor was ruled out due to technical problems. While this study has several limitations, including relatively small sample size, short follow up period and no control group, it does provide an excellent basis for creating clinical guidelines using proven research by means of objective thermo-sensitive micro-sensors. AIR AID SLEEP (AIR AID GmbH & Co KG, Frankfurt, Germany) micro-sensors were adapted from the TheraMon micro-sensors to be used more specifically for the demands of dental sleep medicine. While the micro-sensor's program is based on the software used by TheraMon, there are several differences between the sensors. TheraMon software requires a lab technician to activate the micro-sensors before giving the sensors to the clinician/orthodontist. The AIR AIDSLEEP software combines the software, allowing the clinician to decide when to activate the sensor. One of the most important objectives in this sensor's development was to compare (26) adherence measurement with CPAP. Therefore, the frequency of temperature recording was shortened to an interval of 5 minutes compared to the 15-minute interval used by TheraMon. The AIR AID SLEEP stores data for only 33 days of wearing time, significantly shorter than the 100 days of data stored on the TheraMon. This is a significant disadvantage for patients who have to return for appointments once a month to have the device read-out by the clinician. DentiTrac is a new micro-sensor developed by BRAEBON Medical Corporation (Kanata,Ontario). The micro-sensor is currently undergoing beta testing. The DentiTrac is a thermo-sensitive micro-recorder that records temperatures between 33.5-39.20° C. DentiTrac records temperature at a sampling interval of five minutes, similar to the AIR AIDSLEEP micro-sensors. Reading the data off from the sensors is done via infrared and takes one minute to load the data regardless of the time from the previous reading. DentiTrac has a base reading station for both the clinician and the patient. This allows patients to monitor their own adherence and upload their data remotely. Similar to the TheraMon and AIR AID SLEEP micro-sensors, the DentiTrac has anti-deception/ Detection device. However, the software is more sophisticated than the others, in that the micro-sensors will only record when in the mouth. They will not record any wear-time while in a water bath according to the manufacturer. TheraMon and AIR AID SLEEP will only alert to suspicious activity when the sensors are in a water bath but will still record this time as wear-time. The DentiTrac has a storage capacity of 180 days, longer than the TheraMon and AIR AID SLEEP but less than the Smart Retainer. The main factor differentiating this sensor from the others available is that it records head movement and head positioning by means of a three-axis accelerometer. This information is useful in the investigating OAs for OSA since clinicians and researchers need to be sure that the appliance is being worn when the patient is asleep, as indicated by a supine head position. The recording of head movement also allows clinicians and researchers to better understand how the person sleeps even when the head and body position correlations have not been assessed.

A Radio Frequency Identification (RFID) Enabled Fixed Prosthesis and its Applications in Clinical Dentistry

RFID-enabled dental prostheses can facilitate the use of relatively non-invasive procedures, while providing significant additional benefits as well. This article describes the insertion of High frequency (13.56 MHz) RFID devices in dental fixed prostheses. A high frequency (13.56 MHz) system using sheet-typeRFID-tags is inserted in the bilateral lower first molar buccal area for direct identification through the cheeks without saliva contamination. Simulations and experiments both indicate that both the area occupied by the antenna and the number of coil turns influence the density of the electromagnetic field. Experimental results show that, as the tag's area increases, the tag's detecting distance is increased to more than 1 cm throughout the agarose, consisting of about 98% water to mimic the physiology of a human cheek. We also successfully downloaded data from the tag including the prostheses design date, installing dentist identifier , and the materials used. Such a mechanism can protect patient privacy, while providing benefits for medical therapy as well as facilitating forensic identification. Further studies to minimize the antenna dimensions and improve its directional propagation are still needed for future applications (27).

Application of Magnetic Microwires in Titanium Implants – Conception of Intelligent Sensoric Implant

The idea of an intelligent sensoric implant which enables to wireless scan parameters from the human body comes from analysis of studies describing reasons of implants rejection or loosening. Inflammations and incorrect bio-mechanical loading are a frequent cause for surgery, the implant needing to be removed or replaced. The present study shows a concept of intelligent dental implant, where magnetic micro-wires are placed and fixed into titanium dental implant to obtain parameters from implant, tissue, or implant tissue interaction. A part of the study shows preparation of magnetic micro-wires, measurement of physical quantities using bistable magnetic micro-wires and the drawing up of the functional model of the sensor and experiments. Our results show the potential of magnetic micro-wires in implants for the scanning of selected physiological or physical parameters. However, to confirm that the concept of an intelligent sensoric implant is valid further research needs to be carried out in the field of manufacture, of magnetic wire preparation and of the scanning process (28).

Conclusion

These micro-sensors have a huge implication in clinical research and will greatly improve the level of evidence in dentistry.
The emergence of micro-sensors offer in the future the opportunity to deploy and implement many exciting application with scientific analysis. With new features, smaller size and excellent reliability, these micro-sensors will change the way clinicians monitor adherence. While further testing of these micro-sensors is warranted, especially in real life settings, this idea can serve as a platform for future research in the field. In the future, it would be ideal if the micro-sensors had the capacity to send information to clinicians even if patients are not coming to the office.

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