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Micro sensors in orthopeadic appliances: For monitoring appliance Wear-Review

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***Abstract*---**Orthopaedic appliances are designed to transfer forces to facial skeleton as directly as possible. These appliances effectively influence bone growth and sutural changes which when given in growing age favourably alters the continuing facial growth pattern. The primary objective is to correct the skeletal imbalance; correction of the malocclusion is relatively secondary in importance. Yet the success of orthodontics mainly depends on the retention which aims to stabilize the treatment in optimal aesthetic and functional

positions. The aim of the present writing is to review the usage of micro sensors in the orthopaedic appliances in order to monitor their wear and thus finds a way to stabilize treatment results.

***Keywords*---**Micro sensors compliance, orthopaedic appliances, retention.

Introduction

Dentofacial orthopaedics is directed primarily towards the correction of facial skeletal deviations influencing or associated with malocclusions.[1] Orthopaedic appliances are designed to transfer forces to facial skeleton as directly as possible. These appliances effectively influences bone growth and sutural changes which when given in growing age favourably alters the continuing facial growth pattern.[2] With orthopedic appliance therapy, it is possible to treat the dental discrepancies as equally improves the facial profile by taking advantage of the growth potential of the children regardless of the kind of orthopedic appliances to be used. This depends on the understanding of every appliance, its working mechanism, the skeletal and dental condition of the patients to be treated and their retention of the treatment outcomes and their compliance.[3] There are both removable and fixed orthopaedic devices which can be used while the active phase of treatment and during first phase of retention.[4] Various types of orthopaedic appliances are used during treatment phase such as headgear, facemask and chin cup while in retention phase mainly used are removable Hawley, vaccum formed and fixed retainers. Ultimately success of the treatment is related to the patient's compliance which can't be appropriately assessed by an orthodontist, thus leading to failure of treatment strategy as well as its stability in post treatment phase. Compliance, in turn relies on the interest of patient regarding the treatment and maintenance of appointments and an appropriate retention plan customised to that particular patient. There are certain methods suggested for recognizing and improving compliance like direct questioning, tooth movement, and electronic timing devices like micro sensors. Micro sensors are the devices incorporated into the orthopaedic appliances which monitor the compliance. This is designed in such a manner that it would assess the oral environment and stores data in encrypted form, which is later used by the software in orthodontist's office to determine appliance wear frequency and duration. Within a few seconds information is downloaded, decrypted, further analysed for the trends and algorithms of wear. Thus an orthodontist will be able to properly assess the usage of the appliance and can decide the customised retention plan.

Removable orthodontic appliances

Removable orthodontic appliances have been widely used since the first half of the 20th century, when Andresen and Schwarz introduced a monoblock appliance and an active plate. As fixed orthodontic appliances are now in common use, standard removable appliances have their undeniable advantages.[5] Removable orthodontic appliances are easy to manufacture and use, show resistance to damage, and reduce the risk of caries development during orthodontic treatment.

Above all, they are inexpensive and are ideal for solving many orthodontic issues in early and interceptive treatment, i.e., in general treatment of children and adolescents .[6] The largest disadvantage related to using removable appliances is the difficulty in prediction and monitoring the patient's compliance during treatment, and also these appliances must be worn as recommended by the orthodontist to be effective.[6]

Retention and retainer

According to, Norman Kingsley,[7] the father of orthodontics, stated that' the success of orthodontia as a science and art as now lies in retainer'. However, orthodontists agree that retention is absolutely necessary for three principal reasons: (1) Gingival and periodontal tissues are affected by orthodontic tooth movement and require time for reorganization when the active appliances are removed.[8] (2) The teeth might be in an inherently unstable position after active treatment, so that soft-tissue pressures constantly produce a relapse tendency and (3) Changes produced by growth can alter the treatment result in growing patients.[9] Reorganization of the periodontal ligament occurs over 3 to 4 months after active appliance removal.[8] Reorganization of the collagenous and elastic fibres in the gingiva occurs more slowly.[10] The collagenous fibre networks in the gingiva complete their reorganization by 4 to 6 months after active appliance removal. The elastic supracrestal fibres remodel slowly and can still cause tooth movement 1 year after active appliance removal.[11] Various retention protocols are used in orthodontic practice. In spite of scant data available in scientific journals some authors have suggested that retention appliances should be placed immediately after the active appliances are removed,[11] worn full time except during meals for the first 3 to 4 months, and then worn part time for 1 or 2 years after active appliance removal. In day to day practice, most orthodontists develop their own retention protocol that is based their experience.[11]

Compliance

Retention further depends upon the compliance of the appliance. And the difficulty arises in assessing the compliance with the discrepancy between reports stated by the patients and the clinical examination.[6] Since the last century, a fully objective assessment of the compliance of orthodontic patients treated with different types of removable appliances was considered virtually impossible that has affected not only clinical procedures but also the reliability of various studies related to this type of therapy, thereby affecting the treatment strategy recommendations based on this studies.[6] Sometimes the clinical examination confirms the patient's usage but in other patients, it is unclear whether the patient or the retainer was at fault for the observed relapse. In addition to this problem of retention related to the compliance, patients are responsible for regulating their behaviour to follow the prescribed regimen of retention.[11] Moreover , the assessment of optimal pressure by the appliance during the wear time is very difficult.[12] A great number of internal and external factors that potentially influence compliance. These include personal mentality and self-esteem of the patient and the doctor; optimal doctor-patient relationship; clear explanation of the purpose, risks, and costs of the therapy to the patient and his/her parents; maintenance of the regular control and recall appointments; and

type of appliance used.[13-15] Recent evidence [16-18]suggests that subjective assessments of compliance, such as reports by patients, parents, or doctors, are usually not reliable. In order to overcome these limitations, various methods and devices have been introduced in the past decades in an attempt to objectively evaluate the level of patient compliance. [18-21,22] However, the increased cost, increased size, and complicated use together with reduced reliability and inadequate accuracy in measurements have inhibited the widespread use of these methods and devices for research or clinical purposes. The even more recently developed electronic micro sensors, such as the Smart Retainer and the TheraMon, [23]seem quite promising since they are easy to use and because they have been proved reliable and accurate enough to measure wear time of removable orthodontic appliances.[23] The TheraMon chip offers more advantageous as a result of its smaller size and its increased accuracy and reliability. [24] Both of these microsensors can be embedded into the main construction material of the appliance and identify temperature changes (eg, from "room temperature" to "mouth temperature"), which are then transformed to wear time information.

TheraMon

Prototypes of the TheraMon sensor were provided by the developer (Handelsagentur Gschladt, Hargelsberg, Austria). It is praised for the miniature size, measures about (12 x 8 x 2 mm^3), accuracy and reliability.[25] According to the studies by Schott and Göz, TheraMon software ensures more precise control and recording of patient's cooperation, providing data on the duration of everyday appliance utilization, with 15-minute accuracy. TheraMon calculates the actual wear time by measuring temperature every 15 minutes and then transforms this information into wear time when the temperature ranges between two specific values. The vast majority of intraoral temperature values observed in an individual under normal conditions range between 28^0C to38^0C.[26-29] The chip was placed at the posterior region of the mouth, buccally or palatally, which presents less variation in intraoral temperature when the chip is exposed to influential factors (eg, environmental temperature or consumption of hot or cold food/drinks).[29] In cases in which an appliance consisted of two parts, one for each jaw, it was always placed in the maxillary part. The sensor's software is resistant to any attempt of patient's manipulation and it could be read on all Windows operating systems because of the compatible soft-ware. The read data could be printed out as wear-time graphs.[31]

Smart Microsensor

Scientific Compliance (Atlanta, Ga) has invented, and produced the Smart Retainer environmental micro sensor which can be easily incorporated into various types of removable orthodontic appliances. The principle technology of this environmental micro sensor lies over the recent reductions in electronic component sizes and power requirements.[11] The Smart Retainer environmental micro sensor automatically monitors the oral environment around it at preset intervals, and stores the data in an encrypted form. This information is later used by software in the orthodontist's office to determine retainer wear frequency and duration. As soon as the retainer placed on the proprietary USB-powered Smart

Reader, a wireless communication link is established within a few seconds. All information recorded is automatically downloaded, decrypted, further analysed by using proprietary algorithms for trends and use patterns, and presented to the user in easy-to understand charts. This enables the orthodontist to discuss regarding the actual retainer usage versus prescribed retainer usage with the patient and the parent and make patient specific recommendations about future retention.[11] The Smart Retainer environmental microsensor comprises a miniature microprocessor and other ultra small electronics for keeping time, environmental monitoring, and data storage, all permanently and compactly sealed into a device smaller than a dime. A built-in clock circuit, resonating at a frequency of32,768 Hz plus or minus 20 millionths Hz over temperatures ranging from –40F to 185F, provides time of day, correcting for 28-, 29-, 30- and 31-day months, and periodically signals the microprocessor to collect, analyze, and store a measurement of some environmental condition. The 8-bit microprocessor runs at 20 MHz and has a built-in 10-bit analog-to-digital converter.[11] Light levels can be monitored with a high-sensitivity photodiode and a separate low-sensitivity diode. An additional piezoelectric crystal is sensitive to environmental vibrations. Environmental conditions can be monitored at up to 12-bit resolution. The electrically erasable and programmable read-only memory will store 131,072 bits of data for up to 40 years; the lifetime of a Smart Retainer environmental microsensor is estimated at 18 months under typical usage, but actual lifetimes will vary with usage.[11] Incorporating a temperature sensitive microsensors into removable appliances by polymerization has avoided such problems of retention and improved the compliance and hence preventing relapse.[12] The use of microsensors for monitoring wear was not a source of conflict between orthodontists and patients, but a documented measurable that provided additional value for both persons. Most patients maintained their compliance without significant change throughout the retention phase. Constant compliance possibly resulted if the patients were already familiar with active removable devices (eg, functional appliances) before they had.

Advantages

Main advantages of microsensors are that the electronic wear-time documentation can be done ,compliance times of orthodontic patients became a comprehensible measurement for the first time.[12] It even helps the Orthodontists to record the wear times for the whole retention phase at any time and assess their effect on retention-phase efficiency. The retention protocol can be altered if necessary, the patient can be encouraged, and therapy plans can be adapted in good time.[30]

Disadvantage

Being so sophisticated and most acceptable , It fails to determine how regularly a patient wore the retainer during the retention phase from the established mean monthly daily wear times. This information could only be obtained by analysing the measured daily wear times, which documented the variability in behaviour of the participants.[30]

Comparision of TheraMon with Smart micor sensor

TheraMon sensor's temperature measuring program takes the small fluctuations in temperature into account that may be expected to occur in a patient's oral cavity. When temperature fluctuations in the oral cavity registered as "unnatural" by the sensor program, "suspicion of manipulation" appeared in the wear-time graph whereas the smart retainer employs optical signals, hence required precise positioning of the appliance in the readout station. This might not be possible with a sensor laterally incorporated in the appliance. Another limitation caused by the optical signal transmission was that only colourless orthodontic appliances were readable, so that Smart Retainers cannot be incorporated into colored appliances.[31] Owing to the sensors' miniaturization, which was successful in both, and the incorporation of the smaller TheraMon sensors will not cause any loss of wearing comfort with the most frequently used orthodontic appliances, such as expansion plates, activators, and retention appliances. The slightly larger Smart Retainer ® may affect wearing comfort. Furthermore, its slightly larger dimensions and round shape may also limit incorporation of the sensor into the lateral section of orthodontic appliances, or even prevent its use in some appliances.[31] On relative comparision in the aspects cost effectiveness, the TheraMon sensors are most affordable for wide range of usage than the Smart microsensors.[22] Finally, comparative studies conducted by Scott and Goz, concluded that both microelectronic sensors fulfilled the basic requirements for use as objective wear-time sensors in orthodontic appliances in clinical trials and routine orthodontic practice. Having the smaller size, the TheraMon system offers greater versatility than the Smart micro sensor Retainer and also permits the accurate documentation and analysis of wear times down to the minute.[31]

Conclusion

Orthopaedic appliances are the work horses of dentofacial orthopaedics in the skeletal and dental malocclusions which can be principally done, using certain removable and fixed appliances whose wear determines the treatment outcomes and treatment stability of orthodontics. This final outcome of retention purely depends on compliance which varies with what a patient reports and the clinical examination. Hence here comes the role of microprocessors which objectively assess the wear time of appliance and thus enables the orthodontist to plan a, case specific appliance wear protocol which can be recorded and documented . It also can be used to discuss the wear patterns and behaviour with the patient comfortably. In this context the the TheraMon and Smart microsensor Retainer are the first, to meet the basic requirements for objective measurements of wear times in the daily practice of orthodontic treatment. However, it could generate the possibility of negative and positive changes in the patient-doctor relationship due to the objective documentation of patient compliance. In conflict situations, objective wear-time data may make discussions about treatment measures, wearing habits, biological conditions and treatment outcome much more objective, that would benefit both the practitioner and patient in a similar way.

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