

A Microsensor for Monitoring Removable-Appliance Wear

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Although the success of removable-appliance therapy is greatly dependent on patient compliance,¹⁻³ orthodontists do not always have suitable fixed alternatives.^{4,5} When removable or functional appliances must be prescribed, the only way to monitor their wear has been to rely on patient reports and treatment progress. This article describes the use of a more reliable indicator.

The TheraMon* sensor (Fig. 1) monitors the time an appliance is worn by recording changes in temperature. The temperature of the oral cavity, between 34°C and 35°C, counts toward wear time. This device is so small—only 13mm × 9mm × 4.5mm, including its polyurethane cover—that it can be integrated into virtually any appliance with a baseplate, including functional appliances, aligners, and upper removable retainers (Fig. 2). The sensor is protected both by the cover and by polymerization within the baseplate, ensuring that neither the oral environment nor cleaning of the appliance will affect the readings. While it is visible, it does not affect patient comfort.

Monitoring and Data Processing

The sensor documents the appliance's temperature at 15-minute intervals, thus providing 96

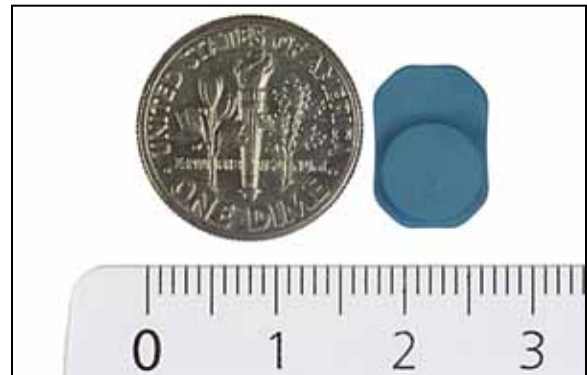


Fig. 1 Size of TheraMon sensor compared to dime (scale in millimeters).

data points per 24-hour period. It goes into “sleep” mode between measurements. The internal memory stores data for as long as 100 days (after which the oldest data is erased), meaning the patient should be seen at least every three months. In the office, wear data is transferred to a reading device by an embedded micro-transmitter that functions for as long as 24 months without recharging. The sensor cannot transmit data by itself and does not emit any frequency except when communicating

*Trademark of TheraMon, Binderberg 11, 4483 Hargelsberg, Austria; www.thera-mon.com.



Fig. 2 Removable orthodontic appliances with embedded TheraMon sensors.

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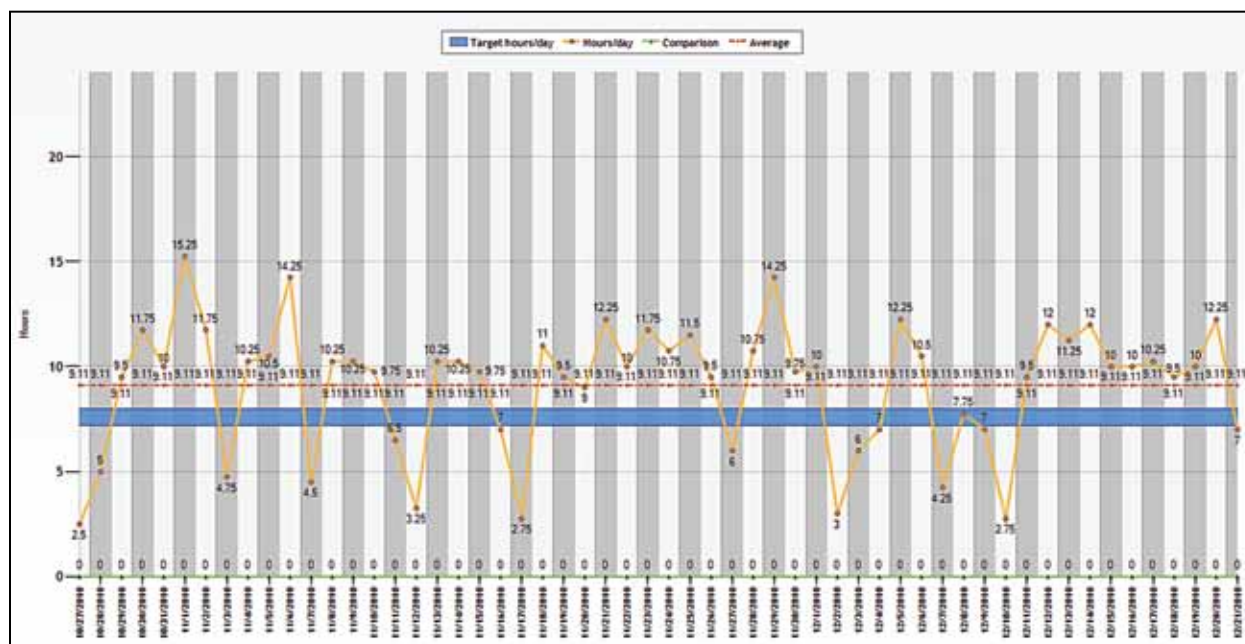


Fig. 3 Wear-time report produced by TheraMon reader and software (daily wear time indicated by red dots and yellow line, prescribed wear time by horizontal blue bar).

with the data reader.

Figure 3 shows TheraMon readings between Oct. 27 and Dec. 21, 2010, for a 10-year-old male patient being treated with a Fränkel III appliance. The software calculates the average wear time over the chosen reporting period and compares it to the prescribed wear (in this case, eight hours a day). Although the patient recorded a mean daily wear time of 9.28 hours, his compliance was only mediocre because the wear times varied between 2.5 and 15.25 hours per day. At the high point, on Nov. 1-2 (Fig. 4A), the appliance was worn between midnight and 8 a.m. and reinserted at 11 a.m. for another 1.5 hours. It was used for another half-hour around 2 p.m., inserted again at 7 p.m., and left in place until 6:30 the following morning (Fig. 4B).

The sensitivity of the temperature module makes it extremely difficult to fake compliance, since the temperature of an appliance being worn correctly will move slightly up and down, even during sleep. To alert the practice to “suspicious” wear time, the software can highlight any abnormal lack of temperature fluctuation in the oral cavity, with slightly suspicious time periods indicated in yellow and strongly suspicious periods in red. We attempted to simulate wear time in our clinic by various means, placing appliances in a whirlpool, near a lamp or heater, and in a trouser pocket. Only a programmed thermostatic water bath was able to approximate normal wear closely enough to fool the software,⁶ and it seems highly unlikely that a patient would go to such extreme measures.

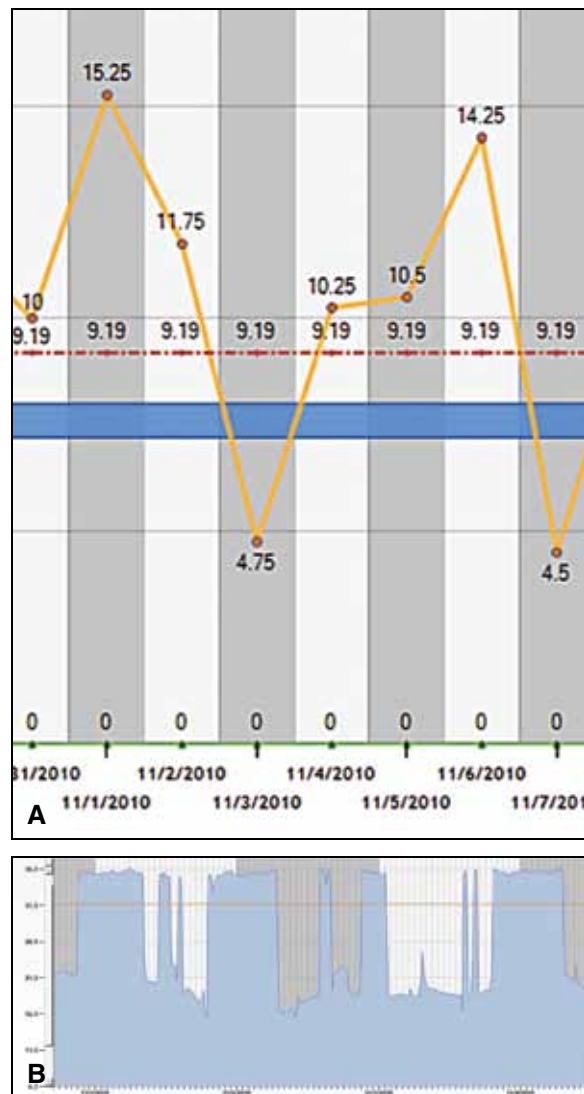


Fig. 4 A. Detail of wear-time report shown in Figure 3. **B.** Analysis of wear timeline, showing appliance temperature over time (light and dark backgrounds indicate 24-hour periods starting at midnight).

Conclusion

The TheraMon sensor allows easy monitoring of removable-appliance wear, with no special technical training of the practitioner or staff. The frequency of measurement ensures that credible evidence can be shared with the patient and parent, allowing the orthodontist to modify the treatment plan, if necessary, before too much time has been wasted. This type of motivational tool certainly fits the “concept of patients’ ownership of their own treatment and partnership with the doctor in achieving optimum results”⁷

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