Orthodontic Force sensing Device and In-Vitro Model for Validation

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Introduction

Patient compliance is a critical factor influencing the success of orthodontic treatments, especially among younger generations. In modern Orthodontics the fundamental challenge to obtaining objective information about the wear time is immense [1]. With the miniaturisation of electronic components, the revolution of oral wearables is close to a breakthrough. However, till now, there has been no comprehensive work to develop an oral wearable device for monitoring interarch elastics.

Materials and Methods

Collaboration with orthodontic professionals and continuous testing resulted in an evolution of the device's housing design, in which the minimized device design with maximized sensitivity and reliability was utilised. During the development process, special considerations were taken into account: device fixation mechanism to the braces and aligners, device sealing solution with sufficient force transferring, material of the housing and communication pin for read out.

The final prototype was achieved by modelling, producing, assembling, and testing each design iteration (see Fig. 1). For the detection of the presence of applied elastics, an FSR (Forse-sensing Resistor) sensor was employed. Measurements with different sizes of FSR sensors were conducted to acquire area dependency of the sensitivity.

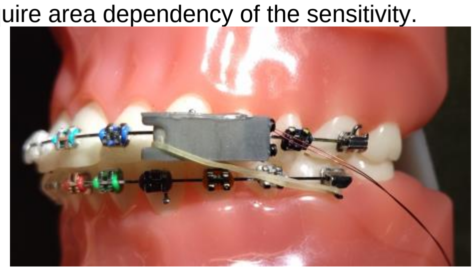

Fig. 1 The final sealed prototype with an FSR sensor inside, attached to fixed braces.

In cooperative work with the orthodontic office, a prototype for a clear aligner was created and tested. Connecting the FSR sensor to the main PCB (Printed Circuit Board), a special slip-fit design was carried out, where the PCB components are at a 90-degree angle.
Interarch elastics stress-strain measurements were performed to obtain the minimum force requirement for the device. Sufficient force transfer capabilities of various sealing solutions were examined and evaluated with the implemented FSR sensor.

The synergy between electrical and mechanical engineering has been demonstrated by building an in-vitro testing machine, representing the mouth (see Fig. 2). Jaw movement was simulated by deploying a parallel mechanical system, driven by a stepper motor. For the controlling of the temperature and the driving system, an STM32 development board was programmed and utilised.

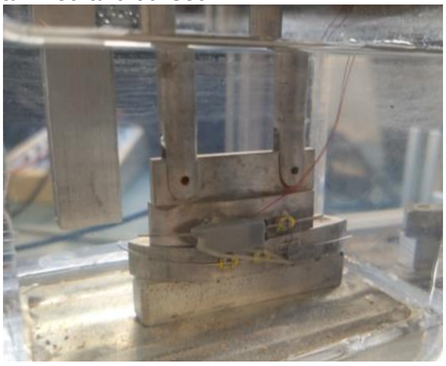

Fig. 2 In-vitro testing machine simulating the mouth with jaw movement.

Results and Discussion

Despite successful testing on a dummy, water damage occurred during subsequent testings in liquid.
In spite of that, after several tests and numerous small modifications on the prototype, a practical application of the device successfully demonstrated its capability to detect the presence of elastics. Accordingly, the distinct voltage levels corresponding to the on and off states of the elastic were achieved through the improved design and thus, validated the device's potential for real-world use.

References

[1] T. Schott, H. Meyer-Gutknecht, N. Mayer, J. Weber, and K. Weimer. A comparison between indirect and objective wear-time assessment of removable orthodontic appliances. European Journal of Orthodontics, 2016. [Epub ahead of print].

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