UPGRADED SCIENTIFIC ORHODONTIC SIMULATOR WITH TEMPERATURE CONTROL AND THERMOCHAMBER

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ABSTRACT

Introduction There are many orthodontic simulators known as Typodonts used since 1981. We use in daily practice electrodonts by Savaria-Dent Kft (Szombatheley, Hungary), a laboratory device, which simulates the orthodontic movements. The electrodonts were created by setting the teethes in a silicone mould filled with dual consistency wax. Every tooth is wrapped in coper coil and continuous electric current is injected, heating the wax generating orthodontic movement under the action of orthodontic wires. This device comes with a time regulator and the amperage is limited to 2 Amps. The electrodont must be under direct supervision of the user because the heat inducted by copper in the wax will over melt the wax resulting complete destruction of the electrodont and subsequent failure in obtaining the results of the treatment performed on electrodont. **Aim of the study** Primary goal of this study was to evolve an orthodontic simulator for scientific and didactic use. The system developed in this study has the added benefit of tooth of time and visual movement quantification, increasing students understanding and allowing the study of biomechanical principles and appliance design in order to obtain the replication of the case for head to head studies of different orthodontic wires from ultra-flexible to thermo activated ones. Secondary goal was to reduce the human intervention for reconfiguration of electrodonts due to loss of wax or complete damage by overheating. **Materials and methods.** We initiated a collaboration between Orthodontic Department and the Dental Materials Department University of Medicine and Pharmacy Craiova for a tool necessary to evaluate orthodontic treatment with fixed appliance systems for scientific and didactic means. We aimed to reduce the time lost in laboratory to readjust the electrodonts during othodontic treatment stages, also to reduce student failure when operating the electrodonts. **Results** In the laboratory, we upgraded the electrodont using a thermo chamber independent of ambient interferences, we placed in direct contact with the wax for each dental arch thermometer that measures directly the temperature and disconnect the influx of current in the device when the wax is overheating 25 degrees is the maximal reference. The active phase of orthodontic treatment is situated between 20 and 25 degrees Celsius. We assessed the upgraded electrodonts with the new configuration and the results were evaluated by Orthodontic Specialist and dental technician, without any evidence of melting wax and the treatment was continuous. **Conclusions** The electrodont is an incredible tool for didactic and scientific purposes, offering consistent and accountable results of simulated orthodontic treatment. The upgraded version is offering this experience without the delay caused by repairing, correcting the wax model, with the help of technicians and the danger of completely melting the wax if it is not supervised correctly.

Key words: Electrodont, Typodont, Orthodontic simulated treatment.

INTRODUCTION

Orthodontic treatment can be achieved using removable and fixed appliances in order to solve clinical cases of malocclusions [1,2,3]. Orthodontic activations in case of fixed appliances may develop biological changes in the oro-dental system [4] complex force systems [5] and. This complex system forces are placed in all three plans sagittal, vertical

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and transversal and if they are not controlled the result will be uncontrolled movement such as tipping, prolonging the treatment [6], root resorption, and enamel demineralization [7,8], even dental elements being move outside the bone [9]. During the treatment the orthodontist acquire intra oral images and correlates with radiological images the progress. Now with the new technologies like intra oral scans and the AI analysis treatment can be predicted and visualized in 3 D. The predictability of dental movements used by these systems are based on computational methods with numeric assumptions of biological elements. The Finite Element Method FEM and the Orthodontic Measurement and Simulation System [10-15]. This system has a limitation of less than 3 teeth movements prediction. In real life, the predicted treatment works for moderate cases of malocclusion with no complicated orthodontic movements and sometimes when we want to see the final result we receive a before and after printed model. If we are using Straight Wire method to treat orthodontic cases as clinicians we conduct a treatment in three-dimension transversal, vertical and horizontal. All of these three dimensions are applied by the wire to the teeth to a limited surface via brackets. In order to understand the movement and the anchorage, so much needed to perform the orthodontic treatment, we have to return ourselves the analogical models because the wire itself can be deformed by different factors anatomical or individual (vicious habits). The arch wire can be reshaped to create expansion or constriction [16,17], but we can come in presence of an underlying skeletal cause or dentoalveolar typology, such as asymmetric mechanics or asymmetric extractions [18] and we need to counteract in order to achieve the treatment goals. Coronal landmarks such as cusp tipping have been used in previous studies to measure dental units movements[19,20,21]. On electrodont we can ask technician to replicate the obstacles or the anatomy as we want. Typodonts have a long history of models going back to 1973, and with constant upgrades we have efficient typodonts and even electrodonts. Wax Typoodont [1-18,22-24] is an experimental and didactic tool that emulates the oral cavity with removable teeth with or without roots, bonded brackets to teeth, silicon that emulates tissue, synthetic periodontal ligament. It was designed for almost all oral specialities: periodontology, general dentistry, orthodontics, cariology, even surgery. The typodont is being recommended for didactical use due to his price and how easy is to stimulate students hand on.

MATHERIALS AND METHODS

The electrodonts are created by setting the teethes with clinical roots in a silicone mould filled with dual consistency wax following the user protocol. Every root of tooth is wrapped in coper coil and continuous electric current is injected, heating the wax generating orthodontic movement under the action of orthodontic wires.

In our case, all electrodonts setup comprised full anatomic mandibular and maxilar teeth with orthodontic brackets with 0.022-inch slots (GC Axcess Roth), Two types of wax, first layer pink (Base plate wax; Regular; Kerr Corporation) and second layer sticky (Sticky wax; Kerr Corporation).

RESULTS AND DISCUSSIONS

We upgraded (Fig 1.) the existing setup made by Savaria-Dent Kft (Szombatheley, Hungary) with a controlled environment with Peltier effect for heating or cooling. Also, we

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added for each dental arch, embed in wax, thermo sensors to monitor the wax temperature, in order to keep the wax temperature stable between 20 to 25 degrees celsius during active phase [25]. When the wax temperature reached 25 degrees the thermo sensor shut down the current injection into electrodont and permitted for the controlled environment, thermos chamber to cool down the wax to 20 degrees Celsius. This process was repeated without intervention until the orthodontic wires used for orthodontic treatment transfer all information to electrodont dental units and perform levelling and alignment.

Figure 1. Scientific orthodontic simulator with temperature control and thermo controlled chamber OSIM No: A 2024 00105

From orthodontic point of view, the upgraded electrodont makes easier to control the orthodontic treatment. Simulated treatment in thermo chamber was significant faster them the orthodontic treatment performed in open laboratory conditions. Also, the rate of readjustments on the upgraded electrodonts by dental technician was almost inexistent.

Although the wax typodont, not the electrodont, is widely used both in teaching institutions and to study orthodontic biomechanics, its benefit of being simple to use must be balanced against its shortcomings.

First, the magnitude of tooth movements observed in wax typodonts and electrodonts can differ from the true movements that occur in vivo since the wax does not reflect the biological responses of periodontal and soft tissue structures. Second, differential rates of tooth movement are produced at different depths of the wax arch possible linked to bracket positioning and the thickness of glue used in the fabrication process of artificial teethes. Furthermore, it is common for the shape of the wax arch to deform during experiments especially when we have multiple cycles of heating and cooling. Although biological inaccuracies cannot be addressed in electrodont methodology, tooth movements produced in electrodonts are comparable to those occurring in vivo [26]. In attempts to ensure a uniform rate of tooth movement at different depths of the wax arch, other studies have attempted various modifications to the conventional typodont, such as using gelatine as a base material [26,27]. However, these modifications require a sophisticated hardware setup and/or special material. The system developed in this study has the added benefit of visual and time quantification of tooth movement, increasing students understanding and allowing the study of biomechanical principles and appliance design in order to

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obtain the replication of the case for head to head studies of different orthodontic wires from ultra-flexible to thermo activated ones.

Secondary goal was to reduce the human intervention for readjust the electrodonts due to loss of wax or complete damage by overheating. During simulated orthodontic sessions with students, almost all electrodonts started to show signs of degradations such as melted wax, fissure line between the layers of sticky and normal wax. Any gap in wax resulted by the uncontrolled melting, will create a false result of the simulated treatment because the dental units can travel faster, in the wax environment, and we will not be able to reproduce the scientific comparing between different arch wires made by different producers or materials using the same case on electrodont. Dental technician role in the best-case scenarios is to readjust the electrodont when the operator spots any sign of melting and in the worst-case scenario the electrodont was replaced with a new one and the experiment restarted. This shortcoming was frequently meet on the normal electrodont and by controlling the amperage in direct coordination with the thermo sensors and the controlled environment we managed to conduct levelling and aligning orthodontic stages without the technician intervention.

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