NEW TECHNOLOGIES AND METHODS FOR QUANTITATIVE EVALUATION OF 3D ORTHODONTIC ACTIONS

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Introduction

Among the clinicians, the evaluation of orthodontic effective forces and moments is a challenging topic with regard to the predictability of the course of teeth movements, as well as the reduction of traumatic side effects [Lapatki, 2007, Badawi, 2009]. The cascade of complex biological processes leading to periodontal ligament (PDL) and alveolar bone remodelling is initiated and maintained by the mechanical activation of an orthodontic appliance that consists of therapeutic application of a force-moment system on each tooth. Trauma of dental and periodontal tissues and possibly pain during orthodontic treatment, are correlated with the magnitude of these loads: the application of high forces is one of the factors behind root resorption phenomenon and irreversible loss of dental hard tissue and attachment [Newmann, 1975, Brudvik, 1995]. Knowing the magnitude and direction of the applied mechanical actions, both on the tooth and on the entire dentition, is paramount for therapeutic success.

Methods

In order to remove the risk of tissue hyalinization, the magnitude of the orthodontic actions should be reduced from around 1.5 N, value commonly applied in clinical practice, to 0.3 N that is the magnitude of biological forces. Hence the need of a measuring system able to detect very low loads.

The measuring system is composed by customized load cells, one for each tooth, able to detect at the same time the 3D mechanical actions, three forces and three moments, exerted by wire-brackets complex on the tooth. The system contains a total of 14 load cells for each dental arch. The single load cell is equipped with 6 sensors (strain gauges) able to detect the strain due to each of the 6 mechanical actions to which the tooth is subjected. Furthermore, the load cell is designed so that each sensor acquires data independently. The measurements are done on a sectioned model of the malocclused mouth produced in 3D printer. The CAD for the 3D printer is realized thanks to a scan of the dental arch impression or from 3D software thanks to data coming from biomedical images such as CT. The data are sent to the PC through a DAQ acquisition module to which is connected the signal conditioning board.

Results

The sensorized load cell has been prototyped and calibrated; the first acquisitions have shown a correct correspondence between the loads applied and the output data. Subsequent measurements will be carried out on a complete malocclused mouth model equipped with wire and brackets.

Discussion

The attempts made over time in designing orthodontics measuring systems are responsible of several limitations that hamper their clinical application: they need a long time to fix and adjust the measuring system and to acquire the data, often the measurements are inaccurate, incomplete and dependent on each other, the systems are complex, and the orthodontic actions cannot be simultaneously determined. The special design of the load cell presented allows to independently detecting all the 3D mechanical actions. Furthermore, the measurements are acquired in real time and simultaneously from all sensors of all load cells: this makes the procedure not time-consuming and more accurate if compared to the systems at the state of the art [Friedrich, 1998, Fuck, 2005, Rues, 2011].

References

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