A novel platform to measure orthodontic actions

Orthodontics is the medical specialty, where there exists the strongest link between biomechanics and treatment outcome: the application of mechanical tools and instruments to achieve tooth movement and thus correct malocclusions. However, for many clinicians this link is still a “black box” and they base their treatment on commonly prescribed and practiced techniques without a substantial understanding of the quantity of force being exerted. The interest toward understanding orthodontic tooth movement comes from the necessity to improve the orthodontic treatment strategies in terms of early diagnosis, reduction in risk of tissue trauma and reduction of pain.

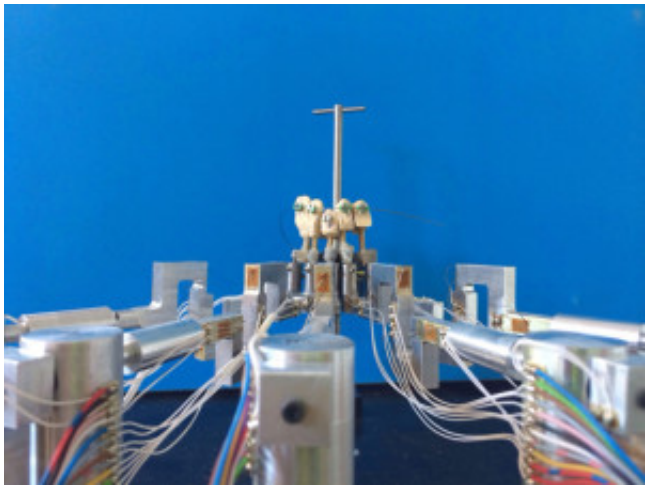

Fig. 1. Five force sensors interfaced with tooth models on which wire and brackets appliance is mounted.

Therefore, quantifying the orthodontic's effective loads (read in terms of forces that generate a translational motion, or moments, that generate a rotational motion) is a challenging topic in terms of predicting the course of tooth movement and reducing traumatic side effects.

To this aim, we've developed a customized measuring platform for detecting the orthodontic's force-moment actions. The measuring platform is meant to fill gaps in similar devices at the State of the Art: analysis of a single tooth at a time, long acquisition timing and encumbrance of the system, lack of a real human mouth model that allows analyzing complex cases of dental crowding, and lack of a measuring instrument suitable for all kind of orthodontic appliances.

The system presented within this study consists of force sensors (load cells) to which the tooth models interface with. The malocclused mouth model is obtained first from X-ray computed tomography or impression/scanning techniques from which 3D printer or plaster casted mouths are deduced (Fig. 1).

As a pilot analysis, we've used four types of superelastic metal alloys (based on Nickel and Titanium, NiTi) ligations (wire and bracket appliances) and two types of invisible aligners, in testing and anylizing a malocclusion with a high maxillary canine, and the effects on the axial rotation of a maxillary central incisor with and without a divot in the invisible aligners (Fig. 2a, 2b). Usually, invisible aligners have a less control of the rotation action. To better correct this actions movement, the invisible aligner has been provided with a divot (a kind of depressed area punched on the mask surface) (Fig. 2c) in correspondence with the tooth to be treated.

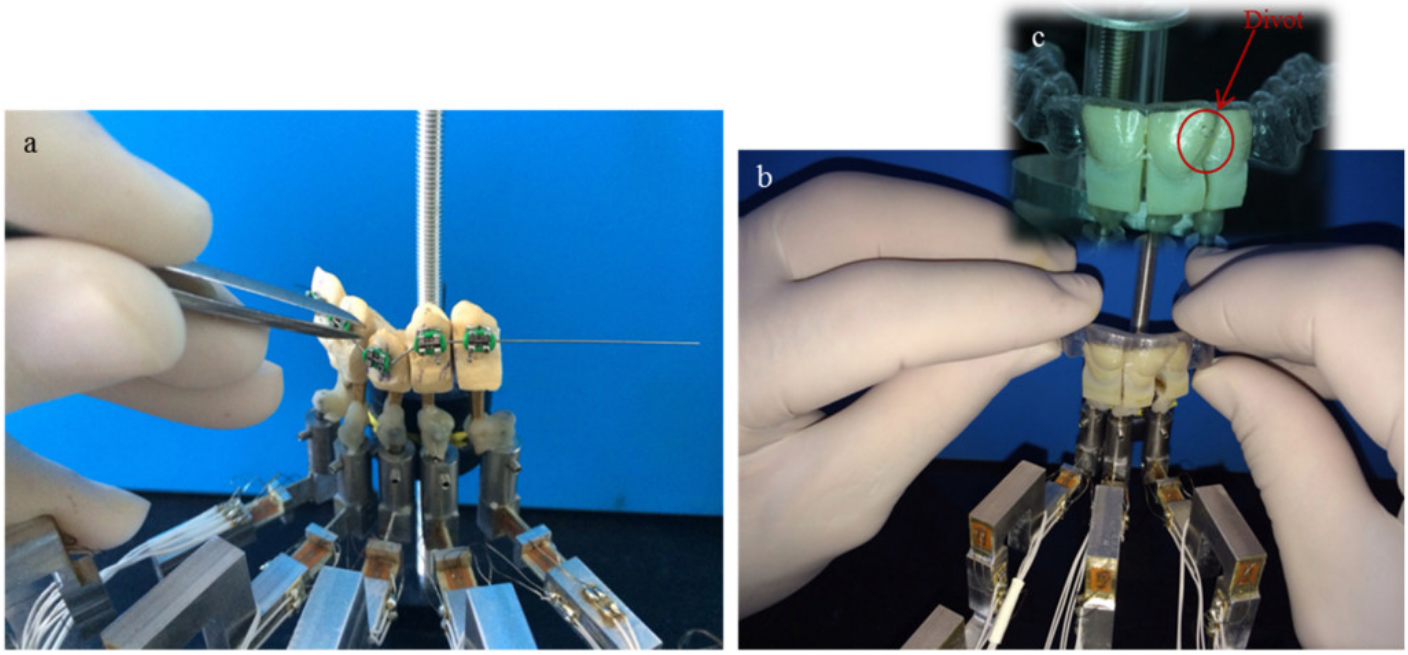

Fig. 2. (a) Superelasic arch wire engagement. (b) Invisible aligner engagement. (c) Divot on invisible aligner.

The first case study allowed us to choose, among a series of superelastic wires, the 0.012" NiTi (smallest cross section) low friction wire (partially engaged into the bracket) as the safer orthodontic technique both in terms of magnitude of loads exerted and low transmitted forces to neighboring teeth. Within the second case analysis, in addition to assessing the use of divot (the rotation action on right central incisor increased by 58% than the case without divot), deficiencies in invisible aligner fabrication are found. On the basis of these promising results, other clinical cases will be analyzed to corroborate the potency of this system, with the final aim to introduce it as a training platform for clinicians or to develop innovative orthodontic appliances able to exert lower treatment forces. Early diagnosis, prediction of disease behavior and evolution and treatment outcomes are the clinical objectives obtained with shorter times and lower costs by using this innovative platform. It will have a strong impact not only in the clinical environment, but also in the public’s interest and for the individual. The novel treatment solutions will enhance the customer

satisfaction and empower the individual in terms of removing the risk of trauma and relieving pain. It will increase the quality of life enabling a safer and more personalized care.

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Publication

Novel universal system for 3-dimensional orthodontic force-moment measurements and its clinical use.
Mencattelli M, Donati E, Cultrone M, Stefanini C
Am J Orthod Dentofacial Orthop. 2015 Jul