The Use of Spectral Domain Optical Coherence Tomography in Orthodontics

ROXANA OTILIA ROMINU[1], MALINA POPA[1]*, COSMIN SINESCU[1], MEDA LAVINIA NEGRUTIU[1], DANIELA MARIA POP[1], LAURA CRISTINA RUSU[1], MIHAI ROMINU[1], FLORIN TOPALA[1], ADRIAN GH. PODOLEANU[2]

[1] "Victor Babes" University of Medicine and Pharmacy, Timisoara, 9 Revolutiei 1989 Blv., 300070, Timisoara, Romania

[2] University of Kent, Applied Optics Group, School of Physical Sciences, Canterbury, Kent, UK

Optical coherence tomography is a new noninvasive investigation method with various applications in dentistry and orthodontics respectively. The intra-oral OCT investigation opens a totally new perspective on the investigation of orthodontic bonding. Polymeric orthodontic brackets (Damon Clear) were bonded on the teeth of the upper arch of a patient following the manufacturer instructions with a light-curing orthodontic adhesive (Blugloo). After bonding the teeth were examined by spectral OCT in order to examine the interface formed by the enamel, orthodontic resin and the bracket. Several images were obtained. Intra-oral OCT is a method of great potential and real benefits in elaborating a prognosis on the clinical durability of bonded polymeric brackets.

Keywords: spectral optical coherence tomography, orthodontic bonding, orthodontic adhesives, polymeric brackets

Bonding brackets is routine procedure in today's fixed orthodontics. As the demand for tooth-colored brackets has dramatically risen over the last decades due to the increase in adult patients and the higher level of awareness, bonding of esthetic brackets is also being perfomed at a greater scale. Polymeric brackets have a slightly higher debonding rate than ceramic ones thus, investigating the bracket-tooth interface is a useful tool in assessing bonding quality.

The vaste majority of investigation methods available today are invasive and can only be performed *in vitro*, under conditions that simulate the oral environment. Not only do these methods lead to results that are different from those that would hypothetically be obtained *in vivo*, but also they imply the destruction of the samples which in turn makes them of no further use.

Optical cohence tomography (OCT) is an interferometric method working at a near-infrared wavelength that has been used as an investigation tool in industry, arts, ophtalmology and more recently in dentistry [1-6]. The main advantage of this method is its non-invasiveness, so the samples or restorations can be re-used for testing or inserted into the oral cavity if proven flawless.

Intra-oral OCT is of particular use in orthodontics as an *in vivo* investigation method since it can reveal the integrity of the adhesive at the bracket-enamel interface. This aspect cannot be evaluated otherwise intra-orally (by the naked eye).

Experimental part

Materials and Method

A fixed orthodontic was applied on the maxillary arch of a patient. Prior to bracket bonding the teeth were professionally cleaned with a rotary brush and fluoride free prophylactic paste. Then they were rinsed and thoroughly dried. Then the buccal surfaces were etched for 30 s with orthophosphoric acid (Etching Colution). Then, the acid was rinsed off and the enamel surfaces were dried for a minimum of 5 s. The enamel was checked upon seeking for a uniform, dull, frosty appearance as a proof for effective etching. Then, a thin layer of adhesive (Ortho Solo) was applied with a brush onto the etched enamel and thinned with a gentle stream of air. Following enamel conditioning, the brackets were bonded one by one. A small amount of resin was extruded from the syringe onto the bracket base. The bracket was then positioned correctly and then firmly pressed against the enamel surface.Excess resin was removed with a scaler. Light curing was performed using a light-curing lamp for 20 s for each tooth. For all teeth light-curing was performed within 1 minute starting from the extrusion of the adhesive onto the bracket base.

After the bonding procedure was completed, the patient was allowed to rinse and then the spectral OCT investigation was performed [7-13].

The manual probe allowed an investigation to be performed directly in the oral cavity up to the second premolar (normally the handpiece would allow acces for investigation up to the second permanent molars). The system operated at a wavelength of 850 nm. The scanning procedure implied a vertical axis in an occluso-cervical direction. The investigation instantly provided images of the entire interface for each considered tooth.

Each investigated interface was evaluated in approximately 10 s compared to the time domain working mode of the OCT system where the examination would have lasted significantly longer (70 s/sample or tooth).

Results and discussions

Following the OCT investigations several images were obtained. On these slices normal interfaces (with no material defects) could be spotted in most of the cases (eight out of ten). On the other two (on the premolars), material defects were identified along the occlusal margins of the interfaces. The defects were small but they created chains that easily could lead to fractures within the orthodontic adhesive and thus to bonding failure (fig.1, 2).

* *email: mali.popa@gmail.com*

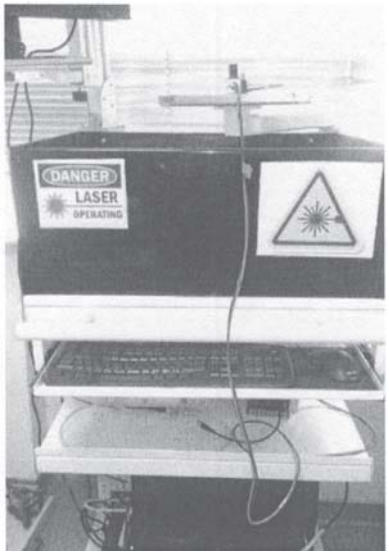

Fig.1. Spectral OCT: overall view

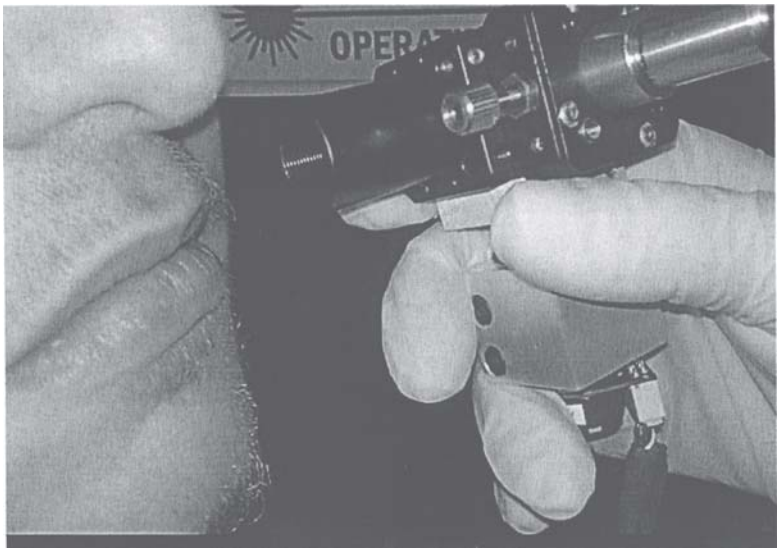

Fig. 2. The handpiece of the spectral OCT system

Conclusions

Working with spectral domain OCT increases the speed of the non-invasive investigation in orthodontics in comparison with time domain OCT. Although time domain OCT allows an investigation greater in depth than does spectral OCT, in orthodontic samples the width of the interfaces to be assessed is suitable for both methods.

References

1 B. T. AMAECHI, A. GH. PODOLEANU, S.M. HIGHAM, D. JACKSON, "Correlation of Quantitative Light Induced Fluorescence and OpticalCoherence Tomography Applied for Detection and Quantification of Early Dental Caries", Journal Biomedical Optics (2003).

2. B. T. AMAECHI, A.GH.PODOLEANU, G. KOMAROV, J. ROGERS, S. HIGHAM, D.JACKSON "Application of Optical Coherence Tomography for Imaging and Assessment of Early Dental Caries Lesions", Laser Physics, Special Issue No.2, Laser Methods in Medicine and Biology, Vol.13, No.5 703-710, May , (2003).

3.D. HUANG, E.A. SWANSON, C.P. LIN, J.S. SCHUMAN ET AL., "Optical Coherence Tomography", Science 1991 254:1178-1181, (2000).

4. A. GH. PODOLEANU, J.A. ROGERS, D.A.JACKSON, S. DUNNE, "Three Dimensional Images from retina and skin". Opt.Express, Vol.7, No.9, p.292-298.

5. BR. MASTERS, "Three-dimensional confocal microscopy of the human optic nerve in vivo," Opt. Express, 3, 356-359 (1998), http://epubs.osa.org/oearchive/source/6295.htm.

6. C.SINESCU, M.L. NEGRUTIU, C. TODEA, C. BALABUC, L. FILIP, R. ROMINU, A. BRADU, M. HUGHES, A. PODOLEANU, Quality assessment of dental treatments using en-face optical coherence tomography, Journal of Biomedical Optics, Vol. 13(5), (2008).

6. J.A. IZATT, M.R. HEE, G.M. OWEN, E.A. SWANSON AND J.G. FUJIMOTO, "Optical coherence microscopy in scattering media," Opt. Lett. 19, 590- 593 (1994).

8. C.C. ROSA, J. ROGERS AND A.GH. PODOLEANU, "Fast scanning transmissive delay line for optical coherence tomography," Opt. Lett. 30, 3263-3265 (2005).

9. A.GH. PODOLEANU, G.M. DOBRE, D.J. WEBB AND D.A.JACKSON, "Coherence imaging by use of a Newton rings sampling function", Optics Letters, 21(21), 1789 (1996).

10. PODOLEANU A. GH., ROGERS J.A., JACKSON D.A. AND DUNNE S., "Three dimensional OCT images from retina and skin" Opt. Express, Vol. 7, No. 9, p. 292-298, (2000) http://www.opticsexpress.org/framestocv7n9.htm.

11. F. I. FELDCHTEIN, G. V. GELIKONOV, V. M. GELIKONOV, R. R. IKSANOV, R. V. KURANOV, A. M. SERGEEV, In vivo OCT imaging of hard and soft tissue of the oral cavity, Optics Express 3(6), (1998).

12. B. W. COLSTON, JR., U. S. SATHYAM, L. B. DASILVA AND M. J. EVERETT, Dental OCT, Optic Express, 3(6):230-238 (1998).

13. B.T. AMAECHI, A. PODOLEANU, S.M. HIGHAM AND D.A. JACKSON, "Correlation of quantitative light-induced fluorescence and optical coherence tomography applied for detection and quantification of early dental caries," Journal of Biomedical Optics 8 (4), 642-647 (2003)

Manuscript received: 27.01.2012