Integral Ceramic Inlay Evaluation by Time Domain Optical Coherence Tomography

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Marginal adaptation of the integral ceramic inlays along with the ceramic integrity was investigated by a non invasive method, Optical Coherence Tomography working in Time Domain mode. Some of the samples presented a good close interface between the ceramic restorations and tooth structures. All the ceramic samples presented material defects. Optical Coherence Tomography proves its capability of a good and non invasive evaluation of the integral ceramic inlay.

Keywords: ceramic inlay, optical coherence tomography, marginal fit, material defect

In the last decades, the face of restorative dentistry have been changed dramatically. All-ceramic restorations became popular options to restore decayed teeth for both anterior and posterior regions. In the mid-1960s, McLean and Hughes introduced the ideea of reinforcing restorations by using ceramic oxides (e.g. alumina - Al2O3)[1]. Later, different oxides (e.g. spinell - MgAl2O4, zirconia - ZrO2) have been used to increase mechanical parameters of dental ceramics/all-ceramic frameworks [2].

In prosthodontics, the alternatives to conventional metal/ceramic techniques such as all-ceramic restorations were promoted especially from esthetic, periodontal and alergologic considerations. Durability is also considered to be important when this types of restorations are clinically evaluated [3-6] or tested in laboratory [7, 8]

Dental ceramics can be classified according to their crystalline phase and fabrication technique [9] (table 1).

All ceramic systems may be used to fabricate high-strength ceramic restorations, and some systems may use new ceramics (e.g. alumina, zirconia) for framework production only. These frameworks then must be veneered in a conventional manner, by hand, using ceramic powder (e.g. Vitadur Alpha1, Vita VM 71, VM 91) or pressed using prefabricated ingots (e.g. IPS e.max CAD-on technique2).

OCT represents a major advancement in imaging in dentistry due its ability to provide detailed characterization of the dental microstructures, enabling the dentist to make earlier and more accurate diagnosis of oral disease including decay and periodontal disease. The early detection of tooth decay facilitates the dentist to employ non- or minimally invasive techniques to treat or even reverse decay and periodontal disease, using topical or chemical means. Less invasive treatment enhances the patient experience and results in a higher level of professional service and patient care.

Experimental part

There have been three basic approaches to optical tomography since the early 1980s: diffraction tomography, diffuse optical tomography and optical coherence tomography (OCT). Optical techniques are of particular importance in the medical field, because these techniques promise to be safe and cheap and, in addition, offer a

	Fabrication technique	Crystalline phase
Metal-ceramics	Sintering	Leucite
	Heat-pressing on metal	Leucite, leucite & fluorapatite
All-ceramics	Sintering□Heat-pressing	Leucite
	Dry pressing and sintering	Leucite, lithium disilicate
	Slip-casting & glass infiltration	Alumina
		Alumina, spinel, alumina-zirconia (12Ce-TZP)
	Soft machining & glass-infiltration	Alumina, alumina-zirconia (12Ce-TZP)
	Soft machining & sintering	Alumina, zirconia (3Y-TZP)
	Soft machining, sintering & heat-pressing	Zirconia/fluorapatite-leucite glass-ceramic
	Hard machining	Sanidine, leucite
	Hard machining & heat treatment	Lithium disilicate

Table 1
CLASSIFICATION OF DENTAL CERAMICS

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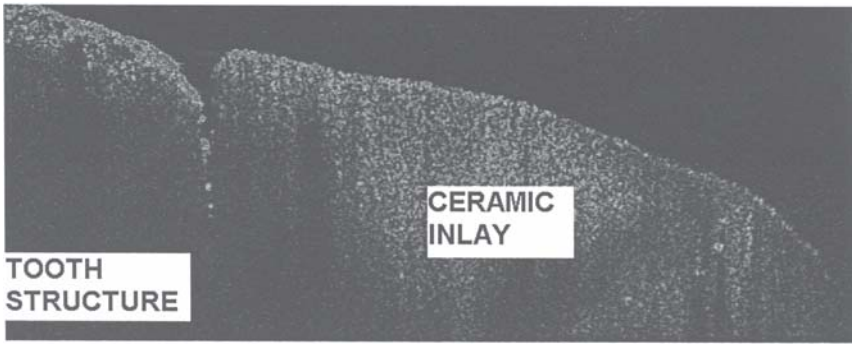

Fig. 1. B scan of the integral ceramic inlay sample on vestibular area with open interface with the tooth structure. The ceramic inlay seems to presents only small impacted aeric material defects

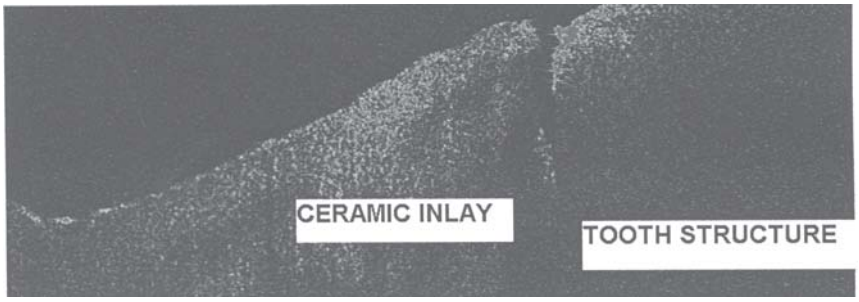

Fig. 2. B scan of the integral ceramic inlay sample on oral area with open interface with the tooth structure. The ceramic inlay seems to presents only small impacted aeric material defects

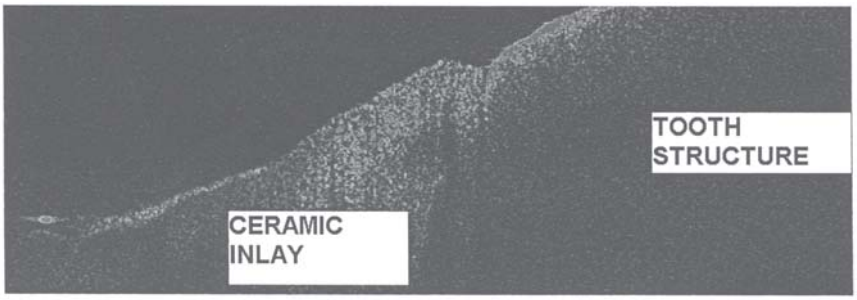

Fig. 3. B scan of the integral ceramic inlay sample on oral area with closed interface with the tooth structure. The ceramic inlay seems to presents only small impacted aeric material defects

therapeutic potential. Advances in OCT technology, on the optimal use of galvanometer scanners for lateral scanning in OCT [10-12], have made it possible to apply OCT in a wide variety of applications, but medical applications are still dominating. Specific advantages of OCT are its high depth and transversal resolution, the fact, that its depth resolution is decoupled from transverse resolution, high probing depth in scattering media, contact-free and non-invasive operation, and the possibility to create various function dependent image contrasting methods.

10 Integral ceramic inlay made from e.MAX (Ivoclar) were used in this study. All the samples were bonded in the designed dental cavities performed previously in the dental crowns.

The experimental configuration of the optical coherence tomography device, including optical choppers [14], was a Time Domain system, working at 1300 nm combined with a confocal channel that was working at 970 nm.

The samples were investigated by C scan and B scan approach. The scans were performed along the proximal axis of the samples.

Results and discussions

All the dental literature and research show that there is a diagnostic void for a device that can detect early, later or hidden decay with a high confidence level and provide an easy to read image. This system should provide real-time qualitative and quantitative information of the oral tissue to aid in performing diagnostics for early detection and evaluation of the oral microstructures. The unique characteristics of OCT meet the needs of a safe and advanced technology based system to provide the diagnostic means for dentistry to move towards the medical model [15].

7 from the 10 samples present open interfaces between the ceramic inlays and tooth structure. All the ceramic restorations presented aeric inclusions. The positioning of those materials defects is very important, 36% from them being in a stress active zones of the prosthetic restorations and could initiate fractures of the inlays.

Conclusions

There are several advantages of OCT compared with conventional dental imaging. This new imaging technology is safe, versatile, inexpensive and readily adapted to a clinical dental environment. OCT images exhibit microstructural detail that cannot be obtained with current imaging modalities. Using this new technology, visual recordings of internal aspects and marginal adaptation of porcelain restorations can be visualized.

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