Nano Filler Composite Restorations Marginal Adaptation

Direct and indirect assessment

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Marginal adaptation at composite enamel interface was assessed through direct clinical method, three-dimensional scanning and optical microscopy respectively for three composite materials with Nano filler: Tetric EvoCeram® (Ivoclar Vivadent-), Premise™ (Kerr Corp.) and experimental material C20 ("Raluca Ripan" Chemistry Research Institute, Cluj-Napoca). Clinical evaluation of marginal adaptation highlights at 6 months and at 12 months a rate of 25-40% marginal defects, regardless the Nano composite material used. Characterisation of interface between Nano-composite material and dental tissue requires a complex multifactorial assessment.

Keywords: adaptation, nano composite, marginal defects

Composite materials have become the treatment choice for aesthetics direct restoration of anterior and posterior teeth, due to theirs biomechanical and aesthetic properties [1, 2]. On the other hand, there remain some inherent drawbacks for direct composite restorations: polymerization shrinkage [3-6], getting and preserving in time the correct contour and perfect marginal adaptations, especially in extensive or difficult to access cavities [2, 7, 8].

In order to improve the composite materials properties, including wear resistance, inorganic filler using nanoparticles appeared to be an alternative choice [9].

USPHS (United States Public Health Service) criteria, introduced more than 30 years ago, are the most commonly method for direct restorations clinical quality and acceptability of restorative materials assessment [10-12]. Due to improved mechanical properties of the new generation of composite materials, clinical criteria have become not enough to evaluate the rate and pattern of wear, the anatomical shape and marginal adaptation [13, 14]. Recent recommendations for conducting controlled trials, mentions the need to value the above mentioned parameters with indirect qualitative and quantitative methods. These methods include laser scanning and scanning electron microscopy [13].

The aim of this study was the assessment of marginal adaptation of Nano composite materials restorations through direct clinical method, three-dimensional scanning and optical microscopy respectively.

Experimental part

Three composite materials were compared: Tetric EvoCeram® (Ivoclar Vivadent), Premise™ (Kerr Corp.) and experimental material C20 (*Raluca Ripan* Chemistry Research Institute, Cluj-Napoca) (table I).

Study group consist of 11 patients, select to meet the criteria for inclusion (proper oral hygiene or improved after training, absence of periodontal disease and para functions,

Table1

DESCRIPTION OF NANO COMPOSITE MATERIALS

Material	Category	Composition
Premise™ (Kerr Corp)	universal Nano composite	**Organic matrix**: bisphenol-A-ethoxylate methacrylate, Triethyleneglycol dimethacrylate, initiators **Inorganic fillers**: (84% weight) particles pre polymerised 30-50 µm, barium glass 0.4 µm, 0.02 µm silica
Tetric EvoCeram® (Ivoclar-Vivadent)	optimized Nano ceramic	**Organic matrix**: dimethacrylates **Inorganic fillers:** (82-83% by weight): barium glass, yterbium trifluoride, mixed oxide, pre polymerized particles
C20 (ICCRR)	Nano composite	**Organic matrix**: Bis-GMA, TEGDMA **Inorganic filler:** (77.8% by weight): glass with strontium and zirconium oxide, colloidal silica, hydroxyapatite, zirconium oxide

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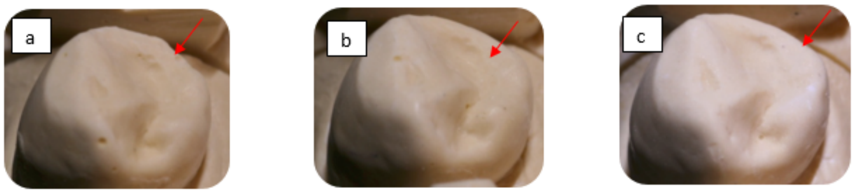

Fig. 1. Plaster models for 4.4 disto-occlusal restoration: initially (a), at 6 months (b) and at 1 year (c)

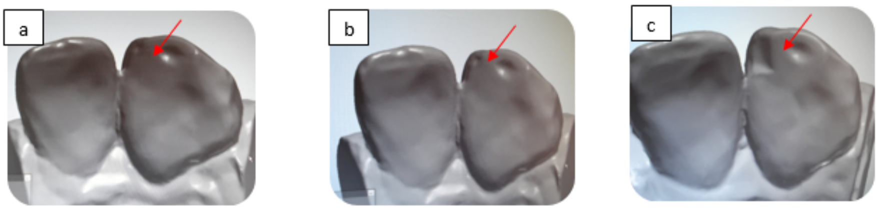

Fig. 2. Virtual models generated by three-dimensional laser scanning initially (a), at 6 months (b) and at 1 year (c)

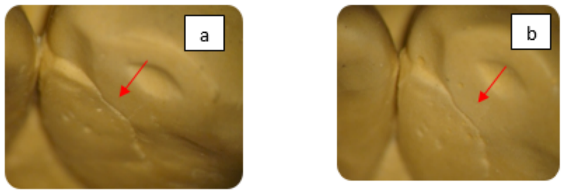

Fig. 3. Optical microscopy image of the mesial-occlusal restoration at 26.6x magnification highlighting marginal faults at 6 months (a) and 1 year (b)

presence of at least two coronary lesions with lack of substance or of inadequate fillings that needed replacement) and for returning to the control assessment. Patients were informed and consented to participate in the study. The average age of patients, 7 women and 4 men, was 25 years.

A total of 28 restorations were made (average fillings of 2.54/patient): 12-Premise restorations, 11-Tetric EvoCeram restorations and 5-C20 restorations. Materials were randomly distributed to classes, and each patient receive at least two fillings made of different materials.

Cavity preparation, filling and finishing were performed by the same operator, following the principles of adhesive design [15, 16].

Adhesion to tooth substrate was carried out by means of total each technique (Optibond SoloPlus ™, Kerr Corp.) following the manufacturer's instructions.

The filling material was applied by means of horizontally layered technique, in layers up to 2 mm thickness [17]. Each layer was polymerised in continuous mode for 20 s, for enamel shades, and 40 sec., for dentin shades, employing the halogen lamp Translux Energy (Heraeus Kulzer,) which has a light intensity of 900 mW/cm².

Once restoring teeth morphology, final shaping was done with fine and extra fine diamond burs (ex: 859-531886, 859-531884, 368-532814/DFS Diamon®, Riedenburg, Germany). Finishing was obtained using gums with particles of aluminium oxide and diamond particles.

Evaluation of restorations

All restorations were available for assessment after 1 week, at 6 and 12 months.

Restorations evaluation was carried out at selected time interval using photographs and plaster models (type IV GC Fujirock® GC) after extensive or segmental dental impressions with a silicone type impression material (Prestige light® / Vannini and Elite HD®/ Zhermack) (fig. 1).

Three-dimensional laser scanning was perform with D scanner 640 (3 Shape, Denmark) and software Dental Designer 2008 of the same company was used. Scanning resolution was between 110,000 and 130,000 points per tooth surface (fig. 2).

After scanning, virtual models were examined by three-dimensional rotation, in particular in marginal areas, to observe the quality of adaptation. In zones where marginal imperfections were detected, it was used 2D Cross Section function of Dental Designer software to investigate the marginal defects using a mesial-distal and then a vestibular-oral section plane

Optical microscopy was performed using a dental microscope (OPMI Pico, Carl Zeiss Surgical GmbH, Oberkochen, Germany) at 2.8x magnifications. Areas that had marginal defects were investigated further at magnifications up to 26.6x (fig. 3.).

Restorations were evaluated directly by inspection and palpation at 1 day, 6 months and 12 months intervals by two assessors, using magnifying glasses, dental mirror and probe. To assess marginal adaptation modified USPHS criteria were used [10-12], using the following scores:

A. Margins continuous along the edge of the restoration. Not cling to the touch probe;

B. Along the edge of the restoration an indentation is evidenced and the probe penetrates;

C. Exposed dentine or base.

Results are expressed as a percentage, for each of the three methods of investigation (clinical, three-dimensional scanning, optical microscopy) in agreement with the small number of patients (11) and fillings (28) included in this study.

Results and discussions

The results of direct clinical evaluation of restorations marginal adaptation, for the three composites tested, were presented in table 2.

None fillings it was qualified C, during the study.

Three-dimensional scan evaluation show off marginal defects only for four restorations (14.3% of total), at 6 months and 1 year assessment. Marginal adaptation was evaluated only in occlusal restorations areas because scanning technique make use of mobile abutments, technical elements that compromise proximal areas.

Optical microscopy at 26.6x magnification revealed marginal defects for restorations in every stage of evaluation (Table III). The scores were A for perfect edges or B for edge defects observed microscopically.

When evaluating after 1 day, 83.3% of restorations with Premises, 81.8% of those with Tetric EvoCeram and 80% of those with C20 revealed perfect edges (A rating). After six months, the ideal margins percentage decreased to 50% for Premises, 45.4% for Tetric EvoCeram and 60% for C20. The results were maintained unchanged at one year evaluation.

Direct and indirect restorations marginal adaptation has a particular interest in dental practice [13]. Polymerization shrinkage stress of composite material will affect the adhesive interface to the walls and edges of the cavity and

Table 2
DIRECT CLINICAL EVALUATION OF MARGINAL ADAPTATION

Marginal adaptation (clinical evaluation)	1 day		6 months		12 months	
	A	B	A	B	A	B
Premise (n=12)	12	-	9	3	8	4
Tetric EvoCeram (n=11)	11	-	8	3	7	4
C20 (n=5)	5	-	4	1	3	2

Table 3
EVALUATION OF MARGINAL ADAPTATION USING OPTICAL MICROSCOPY

Marginal adaptation (optical microscopy)	1 day		6 months		12 months	
	A	B	A	B	A	B
Premise (n=12)	10	2	6	6	6	6
Tetric EvoCeram (n=11)	9	2	5	6	5	6
C20 (n=5)	4	1	3	2	3	2

can generate composite cohesive fractures [2, 18]. Marginal defects can be created by the quality of restorative material, the adhesive system used, patient particular factors and the rigorous implementation of restorative protocol [13, 18, 19].

The clinical criteria for the direct assessment of marginal adaptation are valuable but insufficient to describe discriminative marginal defect type: over or infra contoured edges, marginal opening, marginal tooth fracture, or fracture of fillings marginal [2]. Marginal defects typically occur in an average interval of time after the restorations was applied and the type of defect may indicate the susceptibility to failure of the filling. For this reason, microscopy represent a more objective evaluation method. [2, 13].

Clinical evaluation in this study was carried out by inspection with magnifiers and probing, with a standard dental probe, being awarded the ideal score A only for perfect edges, unlike other studies [2, 20] that score ideal the fillings showing fractures of marginal excess of restorative material, were the probe cleaves only in one direction but does not penetrate. This could explain the higher number of B scores after six months and one year (20% C20, 25% Premises and 27.2% for TetricEvo Ceram). There were no substantial differences between the 3 composites, which advocates for the technical origin of the problem for these defects [18, 20].

Three-dimensional laser scanning has entered in recent years in the dental field in particular through the CAD/CAM techniques for prosthetic restorations [21, 22], but it was recommended also for the quantitative measurement of occlusal contacts [23, 24]. The method was employed in fundamental studies, to highlight qualitative wear rate of plaster replica of direct and indirect restorations [13, 18, 24] with an accuracy up to 10 μm.

In this context, we considered the using of laser scanning for detecting and examining marginal restorations faults in the study. Safety considerations in patient's evaluation, time consumption and cost of all enrolment procedures have led to fewer patients and restorations than ADA requirements; results and conclusions are therefore limited to the study group [18].

Virtual models of plaster replicas of the restorations were carried out at the maximum resolution permitted by the CAD/CAM scanning system used in this study. This particular technique obtain virtual models with glossy surfaces and sharp angles, milder than those of gypsum. Despite thorough visual analysis, in all three virtual 2D plans and sections, very few marginal defects could be identified. Otherwise defects being masked by fine marginal gloss and smoothness virtual model. Important differences between the percentage of marginal defects clinically diagnosed (37.7% at one year) and 3D scanning diagnosed (1.4% a year) advocate the inability of this method to investigate the marginal adaptation; it remains useful in evaluating quantitative wear on occlusal surfaces [13, 18, 25].

Optical microscopy has allowed the identification of more marginal defects, sometimes even existing at initial assessment.

The observed marginal defects varying in size, from a slight demarcation between restoration and enamel, barely perceptible, to marginal fractures of excess material from the pits, fissures and crests. Ideal edges percentage, evaluated at first, was between 80 and 83.3%, with no significant differences between Nano composites used. After six months, the percentage of visible marginal defects increased considerably to over 50% of gypsum lines examined. The result did not changed at the end of the evaluation; the defect present the same amplitude but with rounded edges, probably by grinding mechanism [13, 14, 18].

Conclusions

Given the limitations of this study, due to the low number of cases, the following conclusions can be draw:

- clinical evaluation of marginal adaptation highlights at 6 months and at 12 months a rate of 25-40% marginal defects (score B), regardless the Nano composite material used. The remaining restorations presents an ideal marginal adaptation;
- three-dimensional laser scanning system CAD/CAM does not allow accurate detection of marginal defects;
- optical microscopy allows visualization of a greater number of marginal imperfections than clinical evaluation, sometimes still in the initial evaluation;
- most failures are due to marginal art work, as a result of fracturing excess Nano composite material applied over the enamel adjacent to restoration;
- the study will continue to establish long-term functional outcomes of marginal adaptation related with marginal secondary caries or other reasons of restorations failure.

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