Optimization of mechanical properties in CQ and Lucirin-TPO resin composites

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INTRODUCTION: The polymerization kinetics of camphorquinone (CQ) and Lucirin-TPO-based (TPO) resin composites are notably different [1,2]. It has been shown that TPO-composites polymerize to higher conversion degrees (DC) with reduced irradiation times. However these results were obtained for specific formulations. It was necessary to investigate if resin composites of different viscosities would present the same trend, through the measurement of mechanical properties.

METHODS: Five experimental resin composites were prepared with BisGMA/TegDMA at molar ratios of 0/100, 20/80, 40/60, 80/20. One resin series used TPO and the other CQ. Initiators were introduced in equimolar quantities, at 0.0134g/mol. 75 wt% of micro and nano particles were added (65/10 wt%). Mechanical properties, namely the flexural modulus (E) and flexural strength (σ) were determined using the 3-point flexural bending test. 25*2*2mm bars of composites were prepared in Teflon moulds and irradiated using an AURA Light engine (Lumencor, USA) which provided an output appropriate to the absorption spectra of either initiator. TPO and CQ-composites were irradiated 5x for 3 or 20 s at 1000 mW/cm^2, respectively. Cured bars (n=3) were stored for a week at 37°C in 75/25 vol% EtOH/H_2O as an accelerated aging process.

RESULTS:

Table 1. Optimal Flexural modulus and strength values for TPO and CQ-composites. Standard deviations in parentheses.

Description B/T Ratio	E (GPa)	o (MPa)
TPO 1000–3 s 40/60	5.23 (0.03)	82.7 (7.2)
CQ 1000-20 s 20/80	4.29 (0.32)	58.5 (4.8)

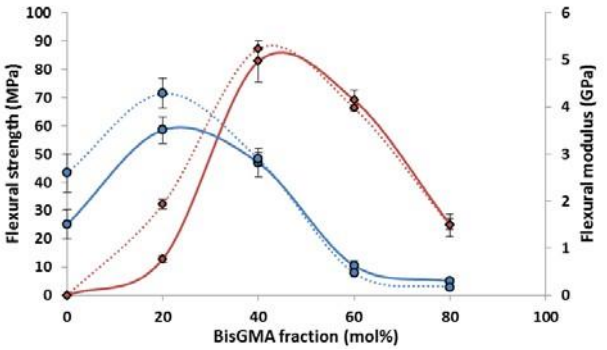

Figure 1: Flexural modulus (dotted line) and strength (thick line) for TPO (red) and CQ-composites (blue)

DISCUSSION & CONCLUSIONS: CQ and TPO-composites presented optimum mechanical properties at different BisGMA/TegDMA ratios (*Figure 1*). Polymerization with CQ-composites was improved with less viscous formulations in accordance with previous results [3]. In such systems, CQ-composites cure to higher levels due to higher polymerization rates and more balanced kinetics [4]. For both the flexural modulus and flexural strength, the highest values measured were obtained with 40/60 TPO-composites (*Table 1*), indicating an increased DC. This improvement was obtained in a more viscous medium, possibly allowing for optimal radical generation and mobility during the polymerization reaction [2].

TPO-based resin composites showed improved mechanical properties compared to CQ-composites for a specific resin base formulation. The two initiators seem to require different viscosities and hence polymerization would be expected to proceed on the basis of different mechanisms. TPO-composites displayed improved mechanical properties at ultra-short curing times of 3 s. These results tend to promote the use Lucirin-TPO as a replacement of Camphorquinone as initiation system in dental composites.

Analysis of fit CAD/CAM zirconia coping. A pilot investigation.

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INTRODUCTION: The clinical applications of CAD/CAM technologies involve achieving the quality control of adaptation prosthetic. Marginal fit and internal fit adjustment of fixed restorations are the key criteria for the quality prosthetic. The minimization of these gaps from 100 to 120 µm seems favorable for a marginal fit clinically acceptable[1]. 2D measurement analyses of fit are generally limited to a maximum of 350 measurement points and led sometime to poor evaluation. New methodologies based on 3D evaluation of prosthetics fit give meaningful information on assembly between prostheses and prepared teeth[2]. The aim of this pilot study is to compare measurement of the marginal and internal fits of Zirconia coping produced by three CAD/CAM systems.

METHODS: An ivoirine maxillary molar and an ivoirine maxillary premolar were prepared. Three impressions were made with silicon and then were poured in extra hard stone, giving suitable optical properties to be digitized. These masters cast were dividing in three CAD/CAM production group and 10 Zirconia copings per die were manufactured (Table 1). The virtual design proposed by CAD software was automatically accepted. The CAD/CAM software parameters were similar for the three groups and the copings were sintered as recommended by the manufacturer.

Table 1. Distribution groups.

Group	CAD/CAM systems	Specimens numbers
C	Cerec InLab	20
Zm	Dental-wings + Wieland Zenotec mini	20
Zt	Dental-wings + Zenotec T1	20

The coping crown, the die, and the coping on die were digitized with a light structured industrial optical scanner (ATOS Scan, GOM: Measurement volume 150 x 110 x 110 mm^3, density of the cloud point: 275 points/mm^2). Special clamp was used to secure the coping on the die allowed to calibrate with tightening of 30 N.cm. The triple scan obtained was processed in GOM software (GOM Inspect SRV2, GOM). The repositioning of the three scans was performed with a best-fit algorithm. The gap measurement was processed, and a fit mapping as well as analyses of marginal and internal gaps in three-dimension was calculated (Fig. 1).

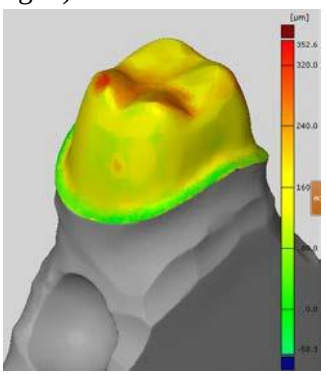

Fig. 1: 3D fit mapping.

RESULTS: The marginal and internal fit for each CAD/CAM systems were presented in Table 2. The mean number of measurement points was about 6819 points for molar and 4389 points for premolar.

Table 2. Comparison of median marginal, internal and occlusal fit measurements between three CAD-CAM systems.

CAD-CAM systems	Marginal gap*	Internal gap*	Occlusal gap*
C	54.3 ± 10.6 53.5	115.8 ± 28.4 118.4	143.8 ± 28.4 149.0
Zm	66.6 ± 31.4 71.2	100.0 ± 40.3 96.0	124.1 ± 20.2 129.8
Zt	61.1 ± 28.8 51.6	76.9 ± 16.0 77.6	127.4 +/- 18.0 123.0

*mean of discrepancy measurements ± SD (µm) - *median (µm)*

DISCUSSION & CONCLUSIONS: For the three CAD/CAM systems, the results were faithful to recommendations of keeping marginal gap less than 100 µm. The 3D investigation of marginal and internal fit provides a greater number measurement necessary to assess the adaptation of fixed prostheses.

Optimization of the bonding interface between glass ionomer cements and composite resins

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INTRODUCTION: The goal of this study is to evaluate the effects of various treatments of the surface of glass ionomer cements to optimize the adhesion with the resin-based composite.

METHODS: Conventional (Ionofil Molar AC, Ionofil Molar AC Quick, Fuji IX GP FAST) or resin-modified (Fuji II LC) glass ionomer cements were prepared according to manufacturer's recommendations. 7 minutes after mixing, the surface was either polished with 220-grit SiC paper or not, etched during 30s with phosphoric acid or not. Then, the surface was either left uncovered, or covered by a bonding agent (an etch&rinse adhesive - OptiBond FL, or a self-etch adhesive - OptiBond XTR, Kerr, USA). A resin-based composite (GrandioSo, VOCO, Germany) was then injected in a cylindrical teflon mold on top of the cement surface and light-cured. Bond strength was measured in a testing machine after 15 minutes and the data obtained were analysed with a two-way analysis of variance (ANOVA). Then, the fractured surfaces were examined to determine if the failure was adhesive or cohesive.

RESULTS: Figure 1 shows the general tendancy between the different glass ionomer cements.

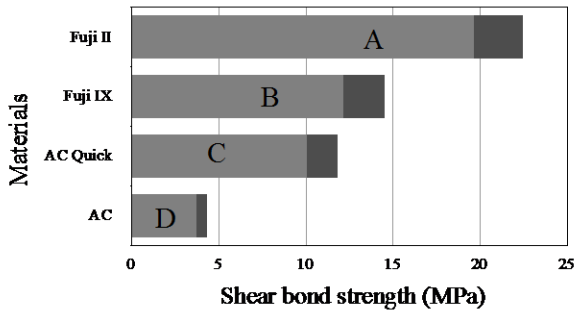

Fig. 1: Mean (light grey) and SD (dark grey) shear bond strength in MPa of resin composite to glass ionomer cements. Different letters represent significant differences ($p<0.05$).

Surface polishing had no significant influence on Fuji IX and AC QUICK ($p>0.05$) but led to a significant decrease of bond strength values on Fuji II ($p<0.05$). Surface etching with phosphoric acid had no significant influence on Fuji IX, Fuji II and AC QUICK ($p>0.05$) but led to a significant decrease of bond strength values on AC ($p<0.05$). Contrary to resin-modified glass ionomer cements, no adhesion was obtained for conventional glass ionomer cements without bonding agent. Regarding the impact of the type of bonding agent, significant differences were observed between Optibond XTR and Optibond FL ($p<0.05$), and the effect was specific to each type of cement. Hence, higher bond strength were obtained with Optibond FL for Fuji IX whereas Optibond XTR was more efficient on Fuji II.

DISCUSSION & CONCLUSIONS: Using a resin-modified glass ionomer cement improves the bond strength with a composite resin. This can be explained by the presence of similar chemical groups (metacrylates) in both materials. The best way to prepare the resin-modified glass ionomer surface is to avoid any pre-treatment (polishing and etching) and to use a self-etch adhesive. The respect of the oxygen inhibited layer present on the resin-modified glass ionomer cement surface seems to be determinant. Among the conventional glass ionomer cements, Fuji IX gives the best results. The present data highlights that it is better not to polish but well to etch its surface and to use an etch-rinse adhesive (OptiBond FL). It is important to notice that etching is not detrimental to fast-setting glass ionomer cements. However, it has a negative effect on slow setting ones, such as AC.

Degradation of the hybrid layer: a review of strategies for prevention strategies

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INTRODUCTION: Because of its intrinsic moisture, bonding to dentin is less predictable than bonding to enamel: a small deviation in the protocol implementation of the adhesive may imply an accelerated loss of the restoration. Regardless of the adhesive type, the hybrid layer (the collagen network exposed by etching and embedded in adhesive resin) gives excellent immediate bond strength values. However, these latter decrease over time due to aging of the bonded joint, resulting in a loss of durability of the restoration. The aim of our purpose was to identify the various causes of hybrid layer deterioration and to describe current approaches that would slow this alteration.

METHODS: This literature review was conducted to discuss the recent reports concerning the aging of dentin/resin interface.

RESULTS: This research showed that there are three mechanisms responsible of the dentin/resin interface degradation: (1) the hydrolysis in the presence of water in the hybrid layer, (2) the incomplete infiltration of the adhesive in the demineralized dentin, and (3) the enzymatic degradation by MMPs and cysteine proteases.

Several strategies have been suggested to avoid or decelerate these processes: (1) the increase of the adhesive infiltration, of the monomers conversion rate and of the mechanical properties of the adhesive system, (2) the inhibition of collagenolytic activity of MMP and cathepsins by the use of various types of inhibitors : chlorhexidine, quaternary ammoniums salts, EDTA and tetracyclins, (3) the use of cross-linking agents, creating stable links between the collagen molecules and altering the catalytic domain of MMPs, (4) the ethanol-wet bonding for etch-and-rinse adhesive systems, consisting in replacing water from the extrafibrillar and intrafibrillar collagen spaces, with ethanol; and (5) the biomimetic remineralization of the collagen matrix with analogs of matrix proteins to replace water with apatites and fossilize endogenous proteases.

DISCUSSION & CONCLUSIONS: Several approaches to prevent the hybrid layer degradation were described. Some are clinically applicable; others need to be more developed for a future clinical application.

In vitro evaluation of HGF and HGK attachment and proliferation on prostheses materials: a pilot study

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INTRODUCTION: Biocompatibility and soft tissue attachment promotion are crucial properties for dental prostheses, particularly for transgingival implant components [1]. Many studies observed the biocompatibility of titanium and yttrium zirconia but there is a lack of data about other materials, as lithium-disilicate ceramics [2,3]. Moreover *in vitro* studies with cells cultures often encounter difficulties related to quantification of cells attachment and spreading on materials samples.

This *in vitro* study evaluates the attachment, the proliferation and the spreading of human gingival fibroblasts and keratinocytes on various supports characteristic of dental prostheses using PTFE inserts.

METHODS:

Primary cultures of Human Gingival Fibroblasts (HGF) and Human Gingival Keratinocytes (HGK) were established using the explant technique.

PTFE, yttrium zirconia, titanium and lithium-disilicate discs (1mm thick, 13.5mm diameter) were fabricated. Specific cylindrical PTFE inserts were manufactured to ensure an efficient seal around discs and growth of cells only on one face (*Fig. 1*).

The PTFE inserts were fixed on the different discs and distributed in 24-well plates culture. Cells were seeded at a concentration of 1.10^4 for HGF and 5.10^3 for HGK cells in 1 ml of culture medium. For each cellular type, three incubation time points were tested (24h, 48h and 72h).

After the different incubation times, the PTFE inserts were removed from the discs. The number of cells on the substrates was determined from microscopic fluorescent images (10X objective magnification). A quantitative analysis was carried out on 6 randomly photographed regions by counting DAPI-stained nuclei. To evaluate the percentage of the disc surface, which was covered by cells, actin staining was also performed.

A qualitative analysis of cellular morphology on discs was conducted by classical SEM methods.

RESULTS: The presence of cells in the bottom of culture wells after the disc-PTFE system removal was checked by phase contrast microscopy. No cells loss was observed from the discs, and colonisation on one face was confirmed with the 2 cell types.

The preliminary results indicated a better proliferation and spreading of the HGF on titanium discs than on yttrium zirconia and lithium-disilicate discs (Table 1).

For HGK, the proliferation appeared slower than for the HGF: the number of cells seeded should be increased up to 1.10^4.

DISCUSSION AND CONCLUSION: The PTFE insert system was proven to be a reliable method to ensure cells retention and to quantify *in situ* the soft tissue attachment and growth on discs of various materials. It avoids counting inaccuracies due to the loss of cells from the discs, and takes into account the shape of the cells.

This model will be used to study the influence of various materials and surface characteristics on biocompatibility properties and soft tissue attachment.

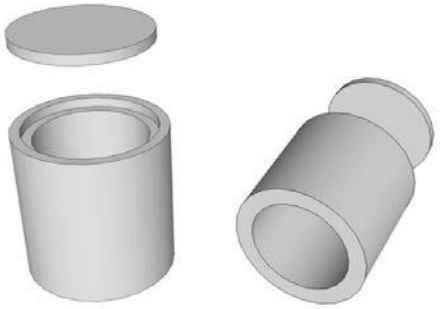

Fig. 1: PTFE insert system and disk

The input of Lucirin-TPO in light-curing resin cements for ceramic bonding

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INTRODUCTION: Light-curable resin-cements can be used to bond ceramics indirect restorations. However, the increase of ceramic thickness results in a decrease in light transmittance, which potentially impedes the resin cement adequate polymerization[1]. The objective of this study was therefore to determine the limits of such systems and establish some clinical guidelines. The quality of polymerization was evaluated by the measurement of degree of conversion (DC), and the relative impact of the following parameters was investigated: composition of resin cement (monomer ratio and photoinitiator), ceramic type, shade and thickness.

METHODS: Ceramic tablets of 10mm diameter were produced by CAD/CAM with LAVA Zirkonium (3M-ESPE, St Paul, MN, USA) and LAVA Ultimate (3M-ESPE, St Paul, MN, USA) (2 shades). Each substrate was prepared in 3 different thicknesses, 1, 2 and 4 mm. For the resin-cements, the control chosen is Rely X Veneer (3M-ESPE, St Paul, MN, USA), which was compared to four experimental resins: two proportions of conventional monomers TEGMA and BisGMA 50/50 and 30/70 wt%, either with camphorquinone or Lucirin-TPO as a photoinitiator. Samples (n=3) were prepared in a Teflon mold either uncovered or covered by the ceramic filters and were light-cured during 40 s using BluephaseG2 (Ivoclar-Vivadent, Schaan, Liechtenstein) used in « high power » mode (1200mW.cm^{-2}). Those samples are conserved dry and protected from light during one week, before being analysed by Raman spectroscopy to determine the DC on the upper surface of the sample.

RESULTS: The type of resin, the shade and the thickness influence the DC. The highest DC is reached with the 50/50 BisGMA and TEGDMA. The highest DC without ceramic filter are obtained with the resin including Lucirin-TPO, in agreement with Leprince et al[2]. For ceramic thicknesses of 1 mm, only a few differences are observed as compared to uncovered resin cements. On the contrary, for thicknesses of 2 mm or more, DC drops, especially for experimental resin with Lucirin-TPO.

Tables 1. The DC (%) for 5 different resins polymerized with the lamp Bluephase through Ultimate.

	Ultimate opaque				Ultimate A3			
	0mm	1mm	2mm	4mm	0mm	1mm	2mm	4mm
CQ 50/50	67	69	66	53	68	70	68	59
CQ 30/70	59	61	58	46	59	61	59	50
Lu-TPO 50/50	75	74	67	37	75	75	70	54
Lu-TPO 30/70	67	66	60	22	68	67	63	42
RelyX Veneer	57	57	56	48	57	54	54	51

Tables 2. The DC (%) for 5 different resins polymerized with the lamp Bluephase through Zirconia.

	Zircone uncouloured				Zircone A3			
	0mm	1mm	2mm	4mm	0mm	1mm	2mm	4mm
CQ 50/50	66	68	66	63	68	70	63	34
CQ 30/70	59	60	58	52	59	59	53	30
Lu-TPO 50/50	75	73	71	63	75	55	3,9	0
Lu-TPO 30/70	66	65	63	53	68	44	1,9	0
RelyX Veneer	57	54	53	51	57	56	54	42

DISCUSSION & CONCLUSIONS: This study confirms a decrease in DC with increased ceramic thickness. However, this effect is lower than what is reported in the literature. The resin cement with Lucirin-TPO and 50/50 wt% TEGMA/BisGMA has good clinical potential until 2mm thickness ceramic. This resin cement could be even used to bond Ultimate A3 restorations until 4mm of thickness. A combination of two photoinitiators could be beneficial to obtain a better curing in depth.

Evaluation of various procedures for intraoral fixed prosthetic restoration repair

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INTRODUCTION: Because of their excellent clinical performances, ceramics fused to metal and full ceramic crowns are routinely used in fixed prosthodontics. Unfortunately, ceramic veneer fractures can occur. They can either be restricted to the porcelain body or expose the metal or zirconia crown infrastructure[1,2,3]. Hence, the objective of the present work was to determine the most appropriate resin-composite bonding procedure to metal, ceramic and zirconia substrates for fixed prosthetic restoration repair.

METHODS: Rectangular specimens (20 x 10 x 2mm) of feldspathic ceramics, zirconia and noble metal alloy were fabricated (n=10). The substrates were subjected to various surface conditionings: sandblasting, hydrol cleaning (Hydrol) and fluorhydric acid (HF) etching when applicable. Resin composite cylinders (GrandioSo, VOCO, Germany) were bonded either with Superbond (SB-Sun Medical, Japan), Cimara (CI-VOCO, Germany), an Experimental universal adhesive (EUA-VOCO, Germany), Ceramic repair (CER-Ivoclar-Vivadent, France) or Clearfil repair (CLR-Kuraray, Japan). Bonded specimens were stored in 37°C distilled water for one week, and subjected to shear force in a universal testing machine (crosshead speed=0.75mm/min). Stress at failure was calculated (MPa). Data were analysed by two-way ANOVA and Tukey's test (p=0.05).

RESULTS:

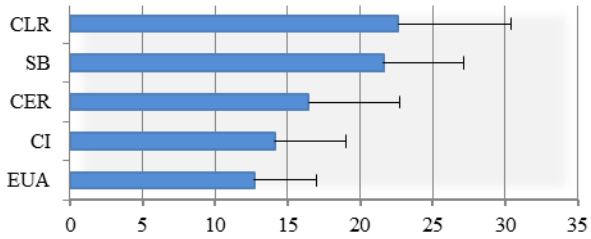

Figure 1. Shear bond strengths (MPa) on metal comparing the different bonding systems tested, all pretreatments combined.

Treatment	CI	SB	EUA	CER	CLR
Hydrol	13.4 (5.0)	22.8 (5.5)	9.5 (2.9)	13.2 (4.2)	19.9 (4.9)
Sandblasting	14.9 (4.9)	20.4 (5.6)	15.9 (2.9)	19.7 (6.4)	25.4 (9.4)

Table 1. Shear bond strengths on metal (Mean (SD) - MPa) comparing the surface conditioning for each bonding system

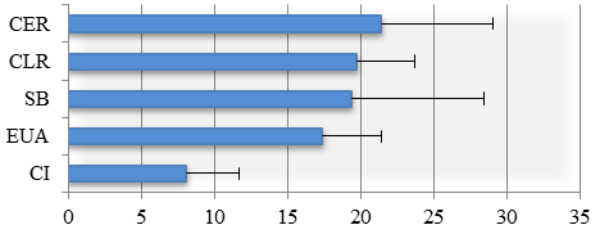

Figure 2. Shear bond strengths on zirconia. (MPa) comparing the different bonding systems tested, all pretreatments combined

Treatment	CI	SB	EUA	CER	CLR
Hydrol	5.7 (2.4)	21.0 (5.8)	17.5 (3.9)	17.4 (4.8)	20.5 (4.0)
HF	7.9 (2.4)	10.9 (4.8)	15.6 (2.7)	17.9 (5.0)	18.3 (2.6)
Sandblasting	11.4 (3.5)	26.2 (8.6)	19.1 (4.7)	29.0 (6.9)	20.4 (4.9)

Table 2. Shear bond strengths on zirconia (Mean (SD) - MPa) comparing the surface conditioning for each bonding system

Treatment	CI	SB	EUA	CER	CLR
Hydrol	3.7 (0.9)	17.8 (4.6)	2.3 (2.0)	7.48 (4.3)	31.2 (5.8)
HF	18.6 (5.3)	29.2 (8.0)	11.5 (2.8)	*	*
Sandblasting	18.8 (6.8)	22.4 (9.3)	13.8 (4.0)	23.6 (5.3)	*

**ongoing*

Table 3. Shear bond strengths on ceramics (Mean (SD) - MPa) comparing the surface conditioning for each bonding system

DISCUSSION & CONCLUSIONS:

The substrate, the bonding system and the surface treatment influence the bond strength results. For all substrates combined, the highest bond strengths were achieved with the Superbond and the Clearfil Repair. Sandblasting the metal, the zirconia and the ceramic significantly increased the bond strength values. Using HF acid etching on the zirconia is not advisable. However it was shown to increase the bond strength values on feldspathic ceramics.

Y-TZP and in-mouth low thermal degradation: a pilot prospective clinical study

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INTRODUCTION: Yttria-tetragonal-zirconia-polycrystal (Y-TZP) has been used as framework in dental prostheses for more than 10 years. Unfortunately, clinical reports about zirconia-based crowns and fixed partial dentures (FPDs) have indicated high rates of short-term failures, which are related to cohesive fracture of the veneering ceramic (chipping). The chipping problem has nowadays led to the introduction of monolithic zirconia restorations, but these restorations have not proven yet their long-term clinical efficacy. Indeed, the absence of a veneering ceramic layer as a barrier for water penetration could promote Y-TZP low thermal degradation (LTD), particularly in the occlusal surface, which is more subjected to wear processes. Moreover, specific properties of translucent Y-TZP used for monolithic restorations are suspected to influence its metastable behavior. Finally, in vitro evaluation of Y-TZP LTD processes is often far from realities. The objective of this work is to elaborate a protocol to study in-mouth aging and LTD of monolithic zirconia restorations.

METHODS: 4 posterior monolithic Y-TZP restorations (3 cemented crowns on natural molars, 1 screw-retained crown on implant), with natural antagonistic teeth, were placed in 4 patients. Restorations were manufactured using the CAD/CAM system Lava Plus (3M ESPE, Seefeld, Germany). Before Lava Plus crowns manufacturing, 4 occlusal contact points (1 mm^2) were adjusted in the mouth on a Lava Ultimate composite restoration, which was used as a model for the final crown. The Lava Plus zirconia was tried-in, eventually corrected, and then partly glazed: half of occlusal contact points and a palatal zone were left unglazed. Wear and Y-TZP microstructure in vitro evaluation of the occlusal, buccal and palatal zones were performed at baseline using SEM analysis 3D laser surface analysis (0.01 micron accuracy) and Raman spectroscopy (analysis of 5 areas per by contact point). Moreover, a clinical evaluation following standardized criteria was performed after restoration placement. Restorations will be removed after 6 months and then every year up to 5 years for in vitro evaluation and comparison with baseline data. To make the cemented crowns deposit easier, specific buccal and palatal grips were realized. The Lava Ultimate restoration will be used as a temporary crown during restoration in vitro evaluation.

RESULTS: The protocol required high accuracy clinical procedures, notably in terms of occlusal points adjustments. Besides classical clinical evaluation, it allowed a precise evaluation of zirconia surface and microstructure, as of glazing surface. Preliminary results showing a baseline evaluation of a molar crown are presented in fig. 1, 2, 3 and 4. No monoclinic phase was detected in analysed areas.

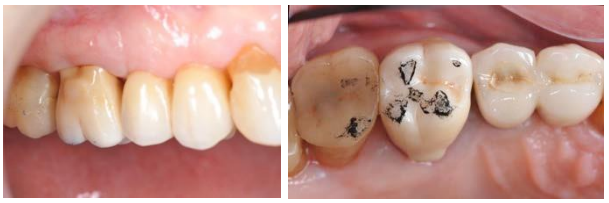

Fig. 1: tooth #16 :clinical views of Lava Plus zirconia crown.

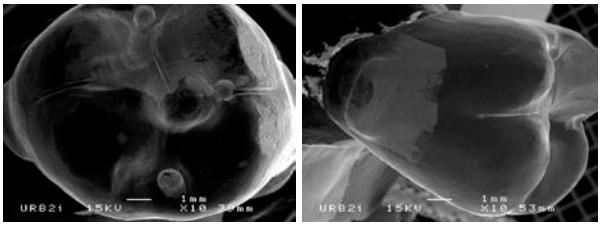

Fig. 2: SEM analysis: occlusal and palatal views. Note unglazed areas.

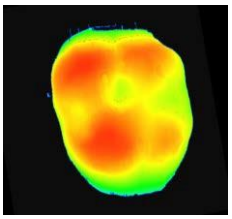

Fig. 3: 3D laser Surface analysis.

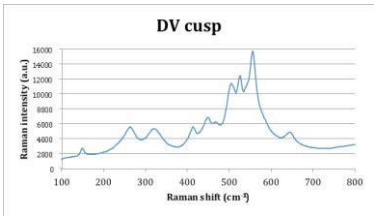

Fig.4 : Raman Spectroscopy analysis of the occlusal point on the disto-buccal cusp.

DISCUSSION & CONCLUSIONS: The combination of in vitro and clinical analysis can provide an accurate evaluation of zirconia microstructure aging and wear, as of glaze aging and of its influence on a potential t-m transformation. This protocol seems very promising to study in-mouth behavior of zirconia monolithic restorations.

In vitro comparison of the mechanical properties of new machinables materials: Enamic®, Suprinity® and Celtra Duo®

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INTRODUCTION : Recently, new machinables materials have emerged, such as a new "class" of composites (named "Hybrids") or new glass-ceramics (lithium-silicate and zirconia reinforced glass-ceramics). The objective of this preliminary work was to image the structure, study the basic mechanical properties of these new dental materials and compare them to dental hard tissues properties (enamel and dentin).

METHODS : SEM images were obtained ; for each material, one image helped in understanding the structure and one image showed the surface appearance after applying the surface treatment for adhesion recommended by the manufacturer. Three basic mechanical properties of Enamic (Vita), Suprinity (Vita) and CeltraDuo (Dentsply/Degudent) were evaluated.. Elastic modulus and flexural strength were evaluated using three point bending tests and surface hardness using Vickers microindentation. Specimens of each material were obtained by cutting Cerec blocks using a diamond disc in a precision cutting machine. Flexural strength was measured according to ISO 6872, modified to accomodate bar sizes that could be sectioned from commercially available blocks.

RESULTS: Flexural strength (MPa) was 139,04 (13,19) for Enamic, 236,8 (59,35) for Suprinity and 215,9 (61,86) for CeltraDuo. Modulus of elasticity (MPa) was 28 577,4 (4178,53) for Enamic, 53 148,9 (2991,53) for Suprinity, 70319,9 (5883,34) for CeltraDuo.

DISCUSSION & CONCLUSIONS : Enamic presented a modulus of elasticity intermediate between that of enamel (70 – 80 GPa) and that of dentin (20 GPa).

CeltraDuo and Suprinity presented a modulus of elasticity closer to that of enamel. The flexural strength and modulus of elasticity values we measured for Suprinity were different from those reported by the manufacturers.

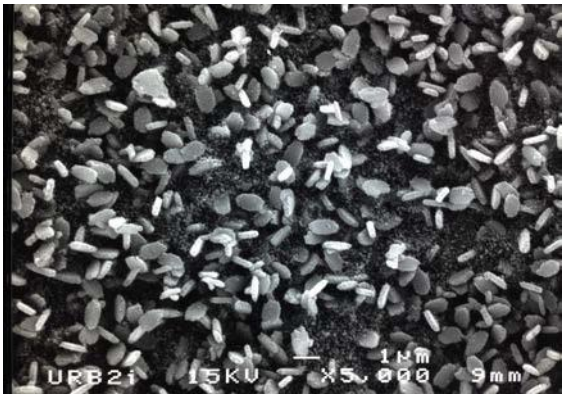

Fig 1 : SEM image of the structure of Celtra Duo

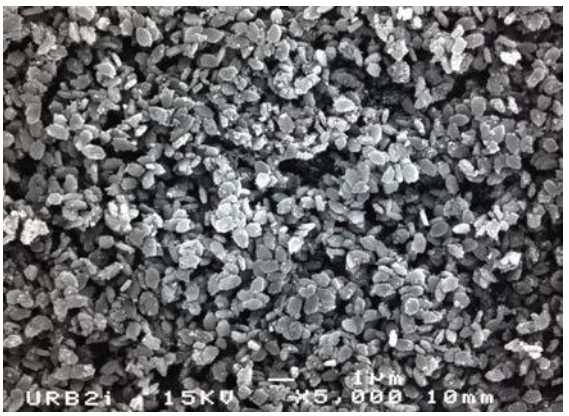

Fig 2 : SEM image of the structure of Suprinity

Restorative dentistry 3D model for finite element analysis.

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INTRODUCTION: The aim of this study was to describe sequential software processing of X-ray micro-computer tomography images (µ-XCT) for three dimensions finite element analysis model (3D-FEM) of a restored tooth. This model must be the exact replica of the molar used all along different stages of this study. Finally, this model was used in 3D-FEM to be validated.

METHODS: The scanning of a first mandibular molar was performed by a µ-XCT (1076, Skyscan, Belgique). 276 horizontals layers of the inner structure of the tooth were selected to create model, including the region of interest Segmentation and meshing were obtained with AMIRA software (AMIRA® 5.4.0, Mercury Computer System® TGS®). Then, a 3D solid computer-assisted design model was performed (Figure 1) and tooth cavity was achieved with second Rapidform software (Rapid form XOR®, 3D Systems® Geomagic Solutions®). Finally, to demonstrate efficiency of this model, this was imported back in Abaqus software (Abaqus® Dassault Systèmes® Simulia Corp®) and initiate FEM processing. The case of a class II restoration was analysed to evaluate the loadings (Figure 2). The outputs of von MISES stresses, elastic deformations and displacements were then evaluated.

RESULTS: Results of our study gave a 3D model processed without generating error in the FEM package used. Furthermore, the tooth selected clearly determined the shape and the geometrical dimensions of the model tooth. Finally, stress concentrations were found at the surface where the load was applied in the vicinity of the tooth-restoration interface.

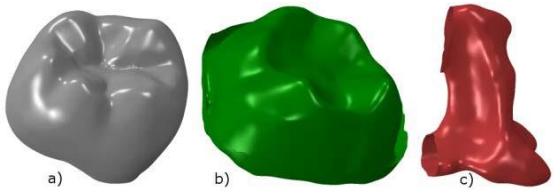

Fig. 1 : a) Surfaces geometry of enamel, b) dentin, c) pulp.

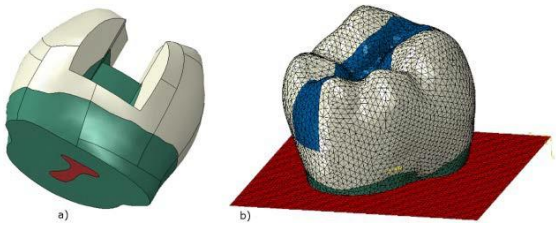

Fig. 2 : a) Volumetric tooth model, b) its volumetric mesh.

DISCUSSION AND CONCLUSIONS: In the present study, sequential software processing of µ-XCT dental images to optimize 3D-FEM analysis was performed. Further investigations are in progress to evaluate various cavity designs, modes of loading and new technology associates µ-XCT data and FEM.

ACKNOWLEDGMENTS: We gratefully acknowledge the Romeo computer centre of Reims-Champagne-Ardenne (https://romeo.univ-reims.fr/).

Kinetics of ultra-fast light-curing dental composites

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INTRODUCTION: The irradiation parameters commonly provided for commercial dental composites are to be associated with the curing kinetics of Camphorquinone-based materials. They require long irradiation time and the gold standard is 20 s. Regarding the output, modern light-curing units (LCU) display irradiances of about 1000 mW/cm^2. It has been shown that Lucirin-TPO (TPO) allows for shorter irradiation times with higher conversion degrees (DC) [1] and reduced monomer elution [2]. However the kinetics of polymerization for very short irradiation times (0.5 and 1 s) have not yet been investigated to this date.

METHODS: Two experimental resin composites were prepared using a 70/30 wt% BisGMA/TegDMA resin base, filled at 75 wt% with micro and nano particles (65/10 wt%). One resin composite used TPO and the other CQ. Both were introduced in equimolar quantities, at 0.0134 g/mol.

The kinetics of polymerization were analysed with FT-NIR spectroscopy. Conversion was monitored based on the variations of intensity of the peak located at 6164 cm^{-1} associated to the vinyl -CH_2 groups (n=3). The evolution of polymerization stress was monitored using the Bioman platform (n=3).

Several irradiation protocols were used: 0.5, 1, 3, 9, 20 or 40 s at 1000 mW/cm^2 for TPO-based composite and 20 or 40 s at 1000 mW/cm^2 for CQ-based composites. The LCU (AURA Light engine, Lumencor, USA) provided an output appropriate to the absorption spectra of either initiator.

Statistical analysis was carried out using the JMP 10 software.

RESULTS:

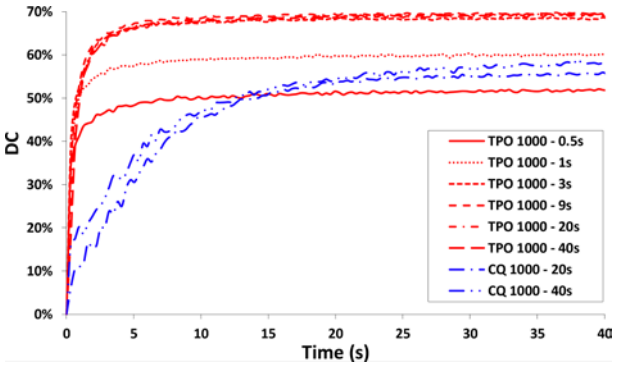

Fig. 1: Evolution of conversion with time for TPO (red) and CQ-based composites (blue)

Table 1. DC and polymerization stress values for TPO and CQ-composites. Standard deviations in parentheses. Same superscript connect similar values (α=0.05)

	DC (%)	Stress (MPa)
TPO		
1000 – 0.5s	54^{D} (2)	3.2^{C} (0.2)
1000 – 1s	63^{B} (2)	3.7^{C} (0.2)
1000 – 3s	70^{A} (1)	4.3^{B} (0.2)
1000 – 9s	69^{A} (1)	$4.6^{A,B}$ (0.1)
1000 – 20s	70^{A} (1)	$4.6^{A,B}$ (0.3)
1000 – 40s	69^{A} (1)	4.9^{A} (0.1)
CQ		
1000 – 20s	57^{C} (1)	3.5^{C} (0.2)
1000 – 40s	$60^{B,C}$ (1)	3.5^{C} (0.2)

DISCUSSION & CONCLUSIONS: TPO-composites reached similar or higher DC for irradiation times of 1 s or more compared to CQ-composites. Polymerization was more efficient for the former and the added stress at longer irradiation times could be attributed to thermal effects from the LCU.

Hence TPO-based composites irradiated for 1 s cure faster, to higher DCs while displaying similar stress values compared to composites using CQ.

Template-assisted cathodic electrodeposition of calcium phosphates nanowires

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INTRODUCTION:
Calcium phosphates (CaP) nanowires are expected to improve biological and mechanical properties in bone tissue engineering and the intrinsic properties of three-dimensional composites structures because of their restricted size and high specific surface area. The aim of this work was to synthesize calcium phosphates nanowires with high aspect ratio by cathodic electrodeposition in polycarbonate membranes, and to compare the effect of constant or pulsating potential electroplating mode.

METHODS: The experimental setup used for electrodeposition consists of a three-electrode cell: auxiliary electrode (platinum wire), reference electrode (Ag/AgCl) and working electrode (gold covered nuclear track-etched polycarbonate membrane Whateman® as template). The thickness and pore diameter of the membrane quoted by the supplier were 20 µm and 200 nm respectively. A Radiometer PGZ301 Potentiostat was controlled by Voltamaster4 software. The electrolytic aqueous bath is composed of 0.042 Mol $Ca(NO_3)_2$, $4H_2O$ and 0.025 Mol $NH_4(H_2PO_4)$ [1]. 9 % vol H_2O_2 was added to prevent hydrogen bubble formation and to favour a better deposition [2]. The pH was adjusted at 6.0 by sodium hydroxide (NaOH) addition and a forced convection was set up by using a peristaltic pump. Electrodeposition was performed at 75°C by applying a stable potential E = -1.6 V during 5 min or by applying a pulsed potential composed by a time deposition t_{ON} during which a potential is applied, followed by an OFF-time. t_{ON} = 1 min at a potential E = -1.6 V and t_{OFF} = 2 min at E= 0 V, this during 5 cycles. The nanowires were collected by dissolving the membranes by dichloromethane, and analysed by X-Ray diffraction (XRD), scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX).

RESULTS: X-ray measurements reveal the formation of OCP (octacalcium phosphate - ICDD : 79-423) and/or HAP (hydroxyapatite - ICDD : 9-432). The XRD patterns of the deposits clearly indicate that the pulsed mode favours a better cristallinity of the CaP deposited.

The SEM micrographs show many nanowires with average length 4.90 µm and diameter 740 nm for deposition in potentiostatic mode (Fig 1a) and average length 7.5 µm and diameter 370 nm for pulsed mode (Fig 1b). From the EDX analysis, the Ca/P molar ratios of the deposits were 1.66.

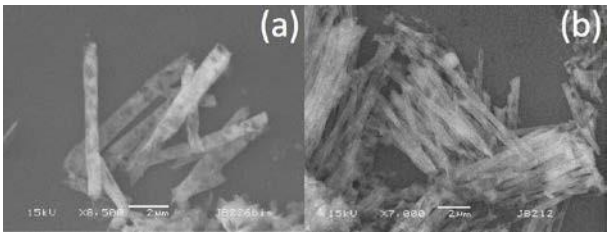

Fig. 1: SEM micrograph of CaP nanowires (1a : deposition in potentiostatic mode, 1b : deposition with pulsed potential).

DISCUSSION & CONCLUSIONS: The XRD spectra and SEM analysis coupled to EDX spectroscopy confirmed the successful synthesis of CaP nanowires. CaP growth inside nanopores but differently according to the potential modes. The pulsed electrodeposited nanowires present better cristallinity and an aspect ratio (length/diameter) of 20.5 which is higher than the value obtained with static potential (6.6). Those nanowires were more dense, regular, longer and thinner. With pulsed mode, deposition is more homogeneous with less deformation of the nanopores. Those observations corroborate with others [2-3] that show that pulsed deposition prevents hydrogen bubble formation and favours a better calcium phosphate crystal nucleation, more homogeneous deposit and better composition and structure of the synthetised materials.

ACKNOWLEDGEMENTS: This work was supported by the Fondation pour la Recherche Médicale, grant number DCM 20111223750 to Chopart.

Endodontic management of a dens invaginatus: a case report of a Biodentine root filling

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INTRODUCTION: The aim is to report the diagnosis and the management of a dens invaginatus maxillary lateral incisor and to report the use of Biodentine as a material for root filling in surgical endodontics.

METHODS: A 13-year-old male was examined for teeth check-up without complaint. Radiographic examination revealed the presence of an infolding of enamel and dentin into the pulp cavity of the upper left lateral incisor. This was associated with a periapical lesion which was confirmed by the CT scan views. This tooth was clinicaly asymptomatic.

Dens invaginatus is a relatively rare phenomenon that occurs primarily in maxillary lateral incisors. In dens invaginatus there is usually an anatomical communication between the invagination and the pulp. The inflammatory process quickly extends into the pulp. Only the radiograph allows to confirm the dens invaginatus. In the case of pulp disease, necrosis requires the elimination of the invagination and the complete desinfection of the root canal before an endodontic filling.

The treatment involves an interdisciplinary approach: endodontic and surgical.

The complete treatment involved (i) the endodontic cavity, (ii) the use of ultrasonic alloy tips to aid debridement of the invagination, (iii) an intracanal medication with calcium hydroxide was placed for 15 days, (iv) the use of a calcium silicate material (BiodentineTM) for permanent obturation in entirety of the root canal and (v) the surgical treatment. For the endodontic obturation, the tricalcium silicate based BiodentineTM was selected for its biocompatibility, sealing ability, mechanical and physical properties, and ease of handling.

RESULTS: The follow-up radiographs at 3, 6 months and 1 year has revealed the healing of the periapical lesion (fig.1). During the treatment period, the patient was clinically asymptomatic. The clinical success observed after a 1-year follow-up indicated that this calcium silicate cement could be used successfully in this indication.

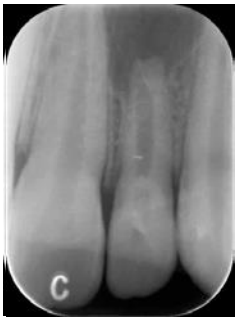

Fig. 1a Pre-operative radiography

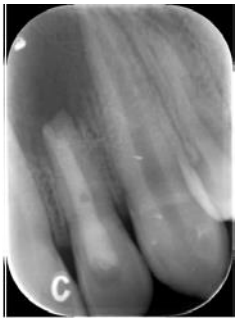

Fig. 1b Root canal filling with Biodentine

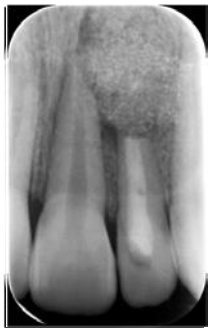

Fig. 1c Post surgical radiography

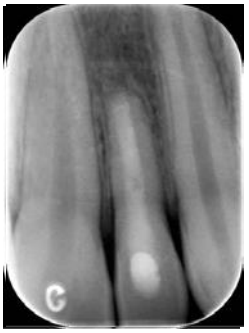

Fig. 1d Radiography at 6 months

Fig. 1: Follow-up radiographs

DISCUSSION & CONCLUSIONS: A radiographic status is recommended to all patients at the first dental appointment. The treatment of a dens invaginatus requires interdisciplinary approach. Optical assistance as well as specific endodontic equipments are beneficial for the success of the dens invaginatus management. BiodentineTM seems to be an appropriate material in case of a dens invaginatus treatment success.

MM-MTA™ versus MTA. A review

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INTRODUCTION: Mineral trioxide aggregate (MTA) has been used for more than 10 years in dentistry and is reported to preserve pulp vitality, promote pulp healing and provide natural substitute for dentine through bioactive sti mulation of the dentino-pulpal complex. One of the reported drawbacks to MTA is the difficulty in handling and placement (sandy consistency), as well as its slow setting time, which often necessitates another treatment appointment for the final restoration A new material MM-MTA™ was recently introduced. Micromega MTA™ is a new version of MTA.
The aim of this review is to provide a detailed analysis of the physical and biological properties of MicroMega MTA™ and to compare these properties with those of MTA.

METHODS: A comprehensive systematic literature search for all publications to date was performed using the search terms mineral trioxide aggregate, MTA, Micro Mega MTA, "dentine substitute", dental pulp exposure, dental pulp capping, biocompatibility, MM-MTA™.

This novel material will be compared to MTA together with the results of experimental laboratory-based investigations and on-going clinical in vivo investigations.

RESULTS: MM-MTA™ has excellent physiochemical characteristics. Micro Mega MTA™ and MTA produced similar responses in the pulp when used for pulp capping in intact, caries-free molars of rats. MMTA exhibited good biocompatibility and promoted mineralization. MM-MTA could be an efficient alternative to MTA to be used in a variety of clinical applications. There appears to be a wide range of clinical applications where MM-MTA™ could be used in the field of endodontics, dental traumatology, restorative dentistry and pediatric dentistry.

DISCUSSION & CONCLUSIONS:

MM-MTA™ offers many advantages compared to MTA. Those advantages include a presentation in predosed capsules and mechanical trituration, a reduced setting time (20 minutes) with a pasty consistency for easy handling and placement**.**

There is little clinical evidence to support all potential indications.

The lack of long-term clinical studies, however, may justify a certain reservation in a replacement of MTA with MM- MTA™. A definite need for randomized clinical studies comparing MM-MTA™ and MTA is required.

Influence of heating and/or ultrasonic vibration on the properties of a glass ionomer cement

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[1]University Nord de France; [2]Faculty of Dentistry, University Lille 2; [3]INSERM U1008 Groupement Recherche Biomatériaux, University Lille 2; [4]LMCPA, University of Valenciennes.

INTRODUCTION: Glass ionomer cements (GIC) materials are increasingly used to restore coronal defects of both primary and permanent teeth. GIC offers the advantages of chemical adhesion to enamel/dentin, cariostatic properties from sustained fluoride release, humidity tolerance and free of Bisphenol A.

However, slow curing reaction and poor mechanical properties limit clinical longevity of GICs compared to composites. Among the efforts of improving GIC's properties, several researchers investigated the influence of heat treatment (H) or ultrasound application (US) on the mechanical properties of cement and showed some promising results. Even so, very few studies assessed their influence on the chemical setting process of GICs and no one tried yet to use combined treatment of heating and ultrasound (H+US) on GIC.

The aims of this study were to examine the effect of different treatments (H, US and H+US) on evolution of GIC's properties and optimize the treatment duration for future clinical application.

METHODS: Samples of GIC material, EQUIA™ (GC America), were prepared by four different methods, namely the one in user's manual (C), H, US and H+US. To study the effect of treatment duration on material's setting, 35 s or 55 s for US and 90 s, 5 and 10 min for H were set basing on the data in previous literature [1-2] and our preliminary study. The setting process was evaluated by infrared spectrometry, calorimetry and microhardness analysis.

Effects of treatments on evolution of GIC's properties were then assessed on the samples that were prepared under above optimized condition and incubated in artificial saliva (37°C, shaking at 80 rpm) for 24 hours, 1 month and 3 months. The mechanical properties such as microhardness, microtensile bond strength (μTBS), three-point bending (3PB) flexural strength, microleakage, and characterization of GIC/dentin inter-diffusion zone (scanning electron microscope) were thoroughly assessed.

Statistical analysis was performed by non-parametric Mann-Whitney and ANOVA tests.

RESULTS: For the optimal treatment duration, with US treatment, cement setting was found more rapid with 35 s than 50 s ($p < 0.05$); and with H treatment, micro-hardness increased faster with 5 min than 90 s or 10 min ($p < 0.05$). H+US, combined the advantage of H and US, further accelerated reaction kinetics ($p < 0.05$).

For the evolution of mechanical properties, at 24 h, H+US treatment increased GIC's microhardness, μTBS, and 3PB strength comparing to other methods ($p < 0.05$) (Fig. 1); while at 1 month and 3 months, no significant difference could be observed among different treatment methods ($p > 0.05$).

Regardless of applied treatments, no leakage was found on GIC/dentin interface at 24 h, 1 month, and 3 months ($p < 0.05$). No morphological change was found on the interface for any group.

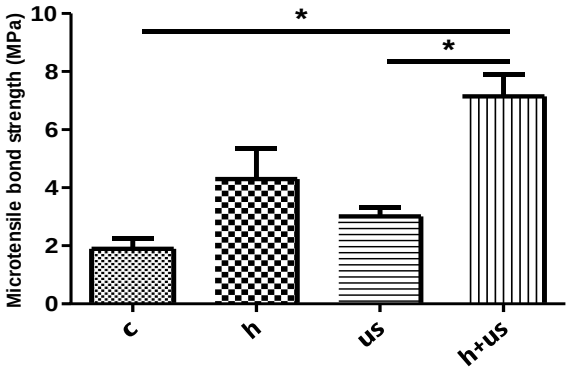

Fig. 1: Mean microtensile bond strength of GIC bonded to dentin 24 hours after different treatments: control (C), ultrasonic (US), heating (H) and combined treatment (H+US) (:p < 0.05)*

DISCUSSION & CONCLUSIONS: Optimal treatment duration was 35 s and 5 min for US and H, respectively. Combined treatment (H+US) affects GIC's properties at initial setting stage, but influences disappeared after 1 month. Thus, association of H and US treatments can improve short-term properties of GIC restoration and might be recommended for clinical use after further validation.

ACKNOWLEDGEMENTS: The authors would like to thank GRB-U1008 and LMCPA labs, Mr. G. Moreau and Mr. J. Karaouzene.

Effect of abutment materials on peri-implant tissues integration: A study in minipigs

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INTRODUCTION:

The formation of an early and long-standing effective barrier to protect the peri-implant structures is overriding in implant treatment. This barrier call 'Biological width' (BW) is influenced by several factors such as connection design, surface physic-chemical characteristics of abutments, prosthodontics procedures. The aim of this study was to evaluate the effect of 4 types of materials routinely used in implant dentistry on mucosal interface between implant abutments and peri-implant soft tissues and peri-implant bone remodeling in a minipig model.

METHODS:

Mandibular premolars and first molars of 5 minipigs were extracted and after a healing period of 3 months, 4 implants and 4 abutments were randomly placed at each hemi mandible in a single stage surgery. The following types of abutment were used: titanium (Ti) (control), CAD-CAD PMMA (Te), Zircone (Zi), and Glazed Fluorapatite Veneering Ceramic (VC). A plaque control program was followed for 3 months until minipigs sacrifice. The mandibles were dissected and each implant was retrieved to process histology. The peri-implant hard and soft tissue dimensions were evaluated. The measurements described in Fig. 1 were performed for both, mesial and distal side of each implant:

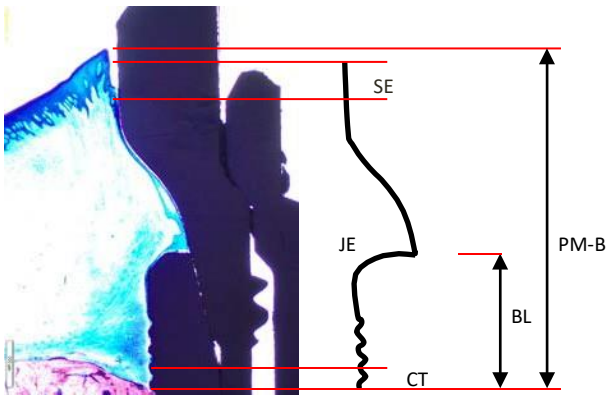

Fig. 1: Mesial cross section of titanium abutment; SE: sulcular epithelium; JE: junctional Epithelium; CT: connective tissue; linear measurement: BL: bone loss; PM-B: distance between the marginal portion of peri-implant mucosa and first bone to implant contact

RESULTS:

The soft tissues measurements and peri-implant bone loss did not display any statistically significant difference between the 4 studied abutment materials. A long junctional epithelium was found with on all abutments and the mean connective attachment was smaller than 0.2 mm. The detailed are presented in table 1.

mm (SD)	Ti	Zi	VC	Te	P value
BL	0.83 (0.37)	0.87 (0.77)	0.99 (0.45)	0.99 (0.56)	0.93
JE	3.34 (0.55)	3.81 (0.55)	3.73 (0.78)	3.65 (0.38)	0.27
CT	0.14 (0.15)	0.16 (0.14)	0.19 (0.17)	0.18 (0.14)	0.93

Table1. Mean histomorphometric values.

CONCLUSIONS:

In this conditions, the findings from the present study demonstrated that all abutment materials allowed the soft tissue adhesion. These results are in contrast with other finding showing the decisive importance of transgingival component materials on BW positioning[1].

Nevertheless, the epithelial / connective tissue ratio of the BW is different than previously described[2.3] Most of the BW consisted in a long junctional epithelium extended almost in contact with the bone with a rather portion of connective tissue interface inferior to 0.2 mm in between.

Release of monomers from orthodontic adhesives : The Transbond ™ Supreme LV example

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INTRODUCTION: In orthodontics, composite resins allow the metal and ceramic brackets to bond on the tooth enamel. The toxicity of dental materials based on resins is essentially due to the residual monomers in the first 24 hours[1-4].

The aim of this work is the identification and the quantification of monomers released by a flowable photopolymerizable composite used in orthodontics, Transbond™ Supreme LV (3M).

METHODS: Cylindric samples were prepared and polymerized with a 3M ESPE Elipar S10 LED lamp (power of 1200 mW/cm^2, wavelength 430-480 nm) for 20 seconds.

Each cured sample is immersed in water contained in a glass tube for 24 hours at 37 ° C.

The analysis of the eluates composition was performed by GC-MS (gas chromatography - mass spectrometry).

RESULTS:

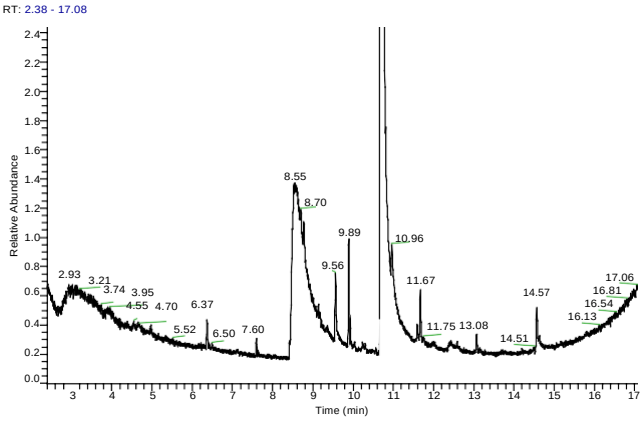

Figure 1: Peaks in the chromatogram correspond to mass spectra.

The compounds found are mostly monomers or their derivatives, and additives. They are presented in table 1.

Table 1. Found compounds.

Compound	Formula	Molecular Weight
Camphorquinone	$C_{10}H_{14}O_2$	166
Camphoric anhydride	$C_{10}H_{14}O_3$	182
Derivatives of TEGDMA		
Dimethyl benzocaine	$C_{11}H_{15}NO_2$	193
Derivatives of cyclopentane carboxylic acid		
TEGDMA	$C_{14}H_{22}O_6$	286
Triphenyl stibine	$Sb(C_6H_5)_3$	353
An unidentified compound		

DISCUSSION & CONCLUSIONS: Camphorquinone is a photoinitiator and Dimethyl benzocaine a coinitiator. Qualitative analysis revealed the presence of monomers such as triethylene glycol dimethacrylate (TEGDMA). The triphenyl stibine is a toxic contaminant that may be genotoxic.

No trace of BPA has been identified. This implies that the amount of BPA does not exceed the detection threshold, if present.

The probability of release of TEGDMA is strong, the use of composite without TEGDMA would be preferred. No trace of BPA has been identified in this orthodontic resin.

CONFLICT OF INTEREST:

The authors have no conflicts of interest to declare

Elaboration of bioactive surfaces by immobilization of antimicrobial and anti-biofilm biomolecules: the BioADBD and METABIO projects.

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INTRODUCTION: The engineering of surfaces with innovative features such as improved hygiene, easy to clean, anti-soiling, etc., awakens more and more the interest of industry and consumers. The BioADBD project aims at conferring to surfaces treated by atmospheric pressure plasma, antibacterial properties thanks to a surface functionalization with specific biomolecules.

METHODS: Several biomolecules, the nisine and the mélimine peptides (antimicrobial peptides) and the Dispersine B (anti-biofilm proteins) were immobilized thanks to different strategies. The elaboration of these functional surfaces has been successfully carried out at the CRP-GL which tested diverse approaches (plasma exposing NH_2-group, COOH-group, epoxy-group, or halogenated group) and two different surfaces (inox and copolymer). Resulting antibacterial and anti-adhesion properties were characterized at the GIGA and the results of each strategy will be exposed.

RESULTS: The biocidal effect of these surfaces was demonstrated against Gram+/- bacteria. Functionalised inox surfaces led to 85% reduction of *Staphylococcus epidermidis* adhesion *vs* bare substrate.

DISCUSSION AND CONCLUSION: Our promising results on inox have allowed us to apply for a new project called METABIO. This name stands for an innovative METhod to elaborate bio-inspired stable Antibacterial surface on metallic BIOmaterials for dental implants. The mission of METABIO project is to develop an original multifunctional coating to prevent dental-implant associated infections, by conferring simultaneously to dental implant surfaces bactericidal and anti-biofilm properties in order to kill bacteria and prevent their adhesion, without reducing or influencing the osseointegration and mechanical properties of the implant.

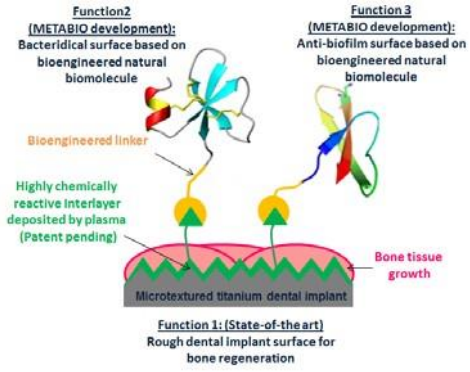

Fig. 1: Presentation of the METABIO approach

Cytocompatibility of calcium-phosphate based biomaterials made by additive manufacturing for bone regeneration. An *in vitro* pilot study

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INTRODUCTION: Bone regeneration is frequently used in dentistry especially in implantology. The use of biomaterial for bone regeneration or alveolar bone preservation is a reliable and effective treatment option compared to the use of autologous bone involving higher morbidity. 3D custom-made structure for intra-oral bone regeneration made from calcium-phosphate and realized by an additive process may allow a 3D and macrostructural optimization of biomaterials together with reproductive physical properties. The objective of the present study is to evaluate the cytocompatibility of 3D printed structures made of hydroxyapatite (HA) or a combination 60:40 of hydroxyapatite (HA) and Tricalcium Phosphate (HA/TCP)

METHODS: Three different types of pellets made by an additive process (Optoform, France) were prepared: HA pellets sintered at 1125°C for 5 hours (HA 1125), HA/TCP pellets sintered at 1125°C for 5 hours (HAT 1125) and HA pellets sintered at 1250°C for 5 hours (HA 1250).
The structure of the three materials was characterized by scanning electron microscopy (SEM). MG 63 osteoblastic-like human cells were seeded on pellets at a density of 5000 cells in 24 wells plates and incubated at 37°C in 5% CO_2 for 72 hours. The cell morphology was observed by SEM. The cell viability was quantified by MTS assay. The cell behaviour on pellet surfaces were evaluated after DAPI and actin staining .
All experiments were realized in triplicate and repeated three times.

RESULTS: HA 1125 presented the most porous structure. HAT 1125 presented an alternation of porous and compact zones. HA 1250 presented a dense surface with few pores (Figure 1a, b, c, left). The roughness was less important on HA1250.
Osteoblastic cells exhibited more cytoplasmic extensions and filopodia on HA 1125 and HAT 1125 than on HA 1250 where they exhibited a more round shaped form (Figure 1a, b, c, right). At 3 days, the cell viability was slightly reduced for HA 1125 and HAT 1125 compared to HA 1250 and polystyrene control well taken as 100% growth.

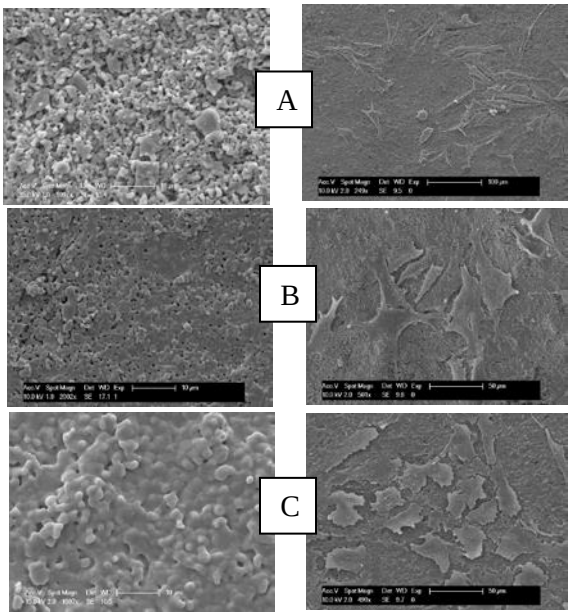

Fig. 1: SEM images of (A) HA 1125, (B) HAT 1125, (C) HA 1250 (left column: structure, right column: with MG63 cells).

DISCUSSION & CONCLUSIONS: reduced cell viability and higher spreading could be related to cell differentiation, suggesting that the porosity and the lower size of granular structures of the pellets appeared more favourable *in vivo* for the osseointegration of bone calcium phosphate substitute. Further experiments are necessary to improve the bone substitute surface and to test these biomaterials in an animal model in an osseous site.

ACKNOWLEDGEMENTS: SIRRIS (Liege, Belgium) for biomaterial fabrication.

Characterization of the mechanisms involved in human primary osteoblasts in contact with titanium oxynitride coatings (TiNOx)

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INTRODUCTION: Titanium Nitride Oxide (TiNOx) coatings are known for their biocompatibility, hardness and high resistance to corrosion and wear. Further, they can be applied by plasma vapor deposition onto a wide variety of metallic, mineral, or organic substrates.

We have previously shown that human primary osteoblasts grow 1.5 times faster on TiNOx coatings compared to the bare substrate, either rough titanium or stainless steel, while still maintaining a high degree of cell differentiation.

When applied onto titanium or cobalt-chromium implants, TiNOx coatings enhance osseointegration during the first month of healing.

The objectives of the present study were (i) to determine whether these effects depend on the film chemical composition and (ii) to explain and depict the cellular mechanisms involved in osteoblasts in contact with TiNOx.

METHODS: TiNOx coatings with various N/O compositions were deposited on microrough titanium plates (Ti-SLA, 11x11mm). Human primary osteoblast proliferation was measured during a period of 21 days using resazurin assays; Ti-SLA was set as a reference. An optimal TiNOx composition was defined and served to conduct a global gene expression analysis with DNA microarrays at day 1, 3 and 7. A profile of gene expression emerged on TiNOx as compared to Ti-SLA and was confirmed by RT-PCR.

RESULTS: The rate of cell proliferation increased with the amount of oxygen contained in the TiNOx coatings. (Fig.1). The effect was observed from day 7 to reach a maximum at day 10, with a 1.8 fold increase for the optimal coating compared to Ti-SLA. As computed by microarrays analysis, at day 1, approximately 1500 genes showed variation in their expression between the 2 surfaces (TiNOx vs. TiSLA). Several genes implied in the cell adhesion mechanisms (e.g. integrins), in the cytoskeleton- (e.g. actin) and extracellular matrix composition (e.g. fibronectin) were sequentially overexpressed on TiNOx at day 1 and on Ti-SLA at day 3. At day 7, no further gene variation was recorded between Ti-SLA and TiNOx.

CONCLUSIONS: The effect of TiNOx coatings on osteoblast cells is dependent on the chemical composition of the coating. The increase is more pronounced with higher proportions of oxygen. TiNOx coatings may act as a catalyst for cell - adhesion and proliferation early after seeding.

ACKNOWLEDGEMENTS: This study was supported by a grant (CR32I2 137739) from the Swiss National Science Foundation (SNF).

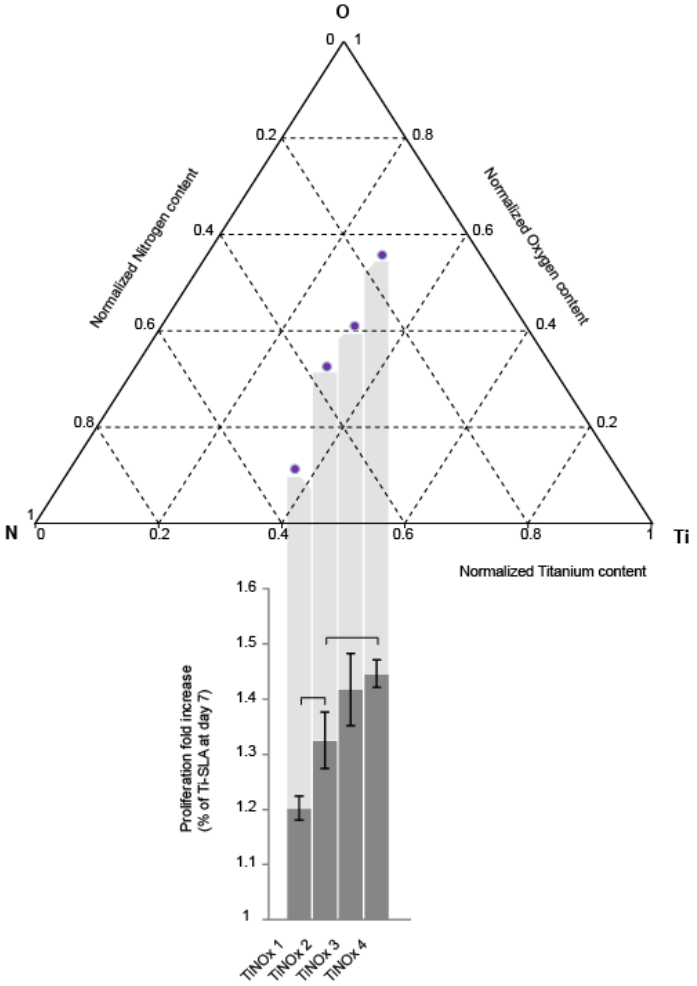

Figure 1, Relationship between the composition of TiNOx coatings and osteoblast proliferation at day 7, as compared to Ti-SLA. Brackets, $p<0.05$.

HPLC analysis of monomer release from conventionally and high-temperature high-pressure polymerised urethane dimethacrylate

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INTRODUCTION:

The major drawback of composites is their incomplete polymerization, resulting in unreacted monomers, which could leach from the material in a wet environment. Problems associated with inadequate polymerization include poor physical and mechanical properties, increased solubility in the oral environment with release of components and increased microleakage. All these problems may result in recurrent decay and/or irritation of the pulp. In an effort to improve the mechanical and physical properties of RCB, a novel high-pressure high-temperature (HP/HT) polymerization procedure was proposed and successfully used. Besides the significantly improved physical and mechanical properties, it was speculated that HP/HT polymerization would alter the type of polymer network formed, which may result in less monomer release. In this study, we set out to test the null hypothesis that there is no difference between monomer releases from conventionally and HT/HP polymerized urethane dimethacrylate (UDMA). To test the hypothesis, this study aimed to determine, using HPLC, and compare monomer release from conventionally and HT/HP polymerized UDMA.

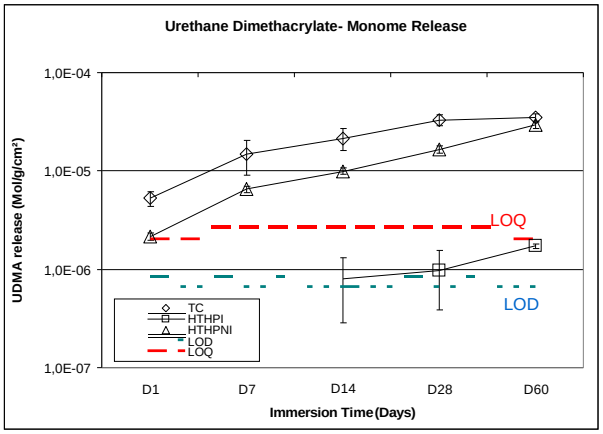
METHODS:

Three UDMA (MW=470.56; CAS 41137-60-4; Evonik, Essen, Germany) polymers were made: a) a control polymer, obtained by conventional thermo-polymerization of UDMA at 90 °C and atmospheric pressure (0.1 MPa) with 0.5 % (by weight) benzoyl peroxide (BPO) as initiator (group **TC**); b) an experimental polymer, obtained by HT/HP (180°C, 250 MPa) polymerization of UDMA with 0.5 % (by weight) BPO as initiator (group **HTHPI**); and c) another experimental polymer, obtained by HT/HP polymerization of UDMA without initiator (group **HTHPNI**). Bar-shaped polymer specimens were immersed in HPLC-grade 75% ethanol for 1d, 7d, 14d, 28d and 60d prior to monomer determination by HPLC with an Agilent 1260 Infinity Quaternary LC. A Poroshell 120 EC-C18 (4.6x50 mm; 2.7µm) column and HPLC-grade 65% acetonitrile in water, with a flow rate of 1 µL/min, were used. A calibration curve was constructed using standard UDMA solutions in the range of $1x10^{-5}$M to $1x10^{-7}$M. The limits of detection (LOD=$2.62x10^{-6}$M) and quantification (LOQ=$7.65x10^{-6}$M) for UDMA were determined.

RESULTS:

Results are summarized in Figure 1. Monomer release was statistically higher in the control group at all time intervals; the lowest release was detected in the BPO-containing HT/HP polymerized group. The results suggested that there was a significant reduction in free monomer content in HT/HP polymerized UDMA.

Figure 1. Urethane Dimethacrylate – Monomer Release



DISCUSSION & CONCLUSIONS:

The results of this study suggest that polymerization under HT/HP conditions results in polymers that exhibit a significant (even dramatic) decrease in monomer release. It could be postulated that polymers obtained under HT/HP conditions could be more biocompatible, less likely to illicit adverse effects.

Resin-composite shear bond strength on Biodentine in relation with its compressive strength

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INTRODUCTION: Due to the numerous qualities of tricalcium silicate cements, direct pulp capping outcomes are improving[1]. Following pulp-capping, these cements have to be covered by a coronal restorative material. It is therefore paramount to analyse the efficiency of a bonding procedure on Biodentine. Factors such as cement mechanical properties and delay before bonding and testing need to be considered.

METHODS:

Compressive strength: Biodentine cylinders (6mm thick, 4mm diameter) were prepared following manufacturers' recommendation. The compressive strength was tested with a universal testing machine at fifteen minutes, one day, one week and 28 days (n=5). The fracture strength was recorded in Newton and converted in MPa using the following equation: $CS = 4P/\pi d^2$

Shear bond strength: 120 Biodentine (cement disks were realized (6mm diameter, 2mm thick, n=40 in each group) and let to set at 37.5°C and saturated humidity. They were subjected to either immediate or delayed bonding procedure (IB-DB) followed by immediate or delayed testing (IT-DT), constituting three groups: Group I (IB-IT)(n=40): The samples set during fifteen minutes and then prepared for bonding procedure and tested; Group I (IB-DT)(n=40): The samples set during fifteen minutes, prepared for bonding procedure but tested one week later; Group III (DB-DT)(n=40): the samples set during one week and then prepared for bonding procedure and tested. Before bonding, the cements were grinded with a 1000-grit silicon carbide abrasive paper. Four bonding systems were tested (n=10): Optibond FL, Optibond FL without etching, Clearfil SE Bond and Optibond XTR. They were light-cured during 20 s. Then, a 4mm diameter, 2mm thick composite disk (Grandio-Voco) was applied on the cement and light-cured. The shear bond strength was tested using an universal testing machine. The fracture strength was recorded (in Newton), and the shear bond strength was calculated using the following equation: $SB = P/\pi r^2$

Data were statistically analysed using one-way Anova and Tukey test (JMP Software).

RESULTS: Compressive strength and shear bond strength results are summarized in graph 1 and table 1, respectively. Most of the fractures were cohesive in the Biodentine. Biodentine IB-DT showed significantly higher shear bond strength values compared to the two other Biodentine groups ($p<0.05$). There was no significant difference between bonding systems used ($p>0.05$).

Graph 1. Compressive strength of Biodentine (MPa) in function of time.

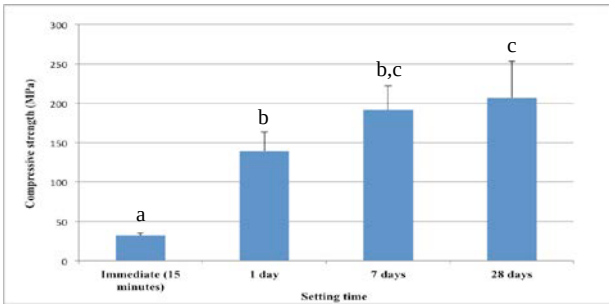

Table 1. Shear bond strength of Biodentine groups in MPa

	Mean (SD)
Biodentine IB-IT	9.25 (3.62)b
Biodentine IB-DT	13.46 (4.81)a
Biodentine DB-DT	10.97 (3.48)b

Mean values followed by different letters are significantly different ($P<0.05$)

DISCUSSION & CONCLUSIONS: As most of fractures were cohesive, the strength of the interface relies to a large extent on the mechanical properties of the cements. The highest results, of both compressive and shear bond strength, were obtained when the cement was able to mature, with or without the adhesive, before being stressed. These results tend to demonstrate that clinically, immediate bonding on biodentine can be considered, but that delaying the occlusal stress on the restoration is best for the interface.

Biodentine used as a pulp capping agent in permanent teeth in young patients – case reports

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INTRODUCTION: The aim is to report the use of Biodentine for direct pulp capping after pulp exposition in permanent teeth in different cases: management and follow-up of an extensive carious lesion and of a pulp exposition due to a dental trauma.

METHODS: Biodentine is a bioactive calcium silicate cement used in conservative dentistry as a dentin substitute. This material has a positive effect on vital pulp cells and stimulates tertiary dentin formation. Thus, it can be used for direct pulp capping after pulp exposure. It's also a biomaterial that can be used in pulp therapy of traumatized immature teeth. The purpose of these case reports is to illustrate step by step the management of a extensive carious lesion and a dental trauma with pulp exposition.

RESULTS: At the follow-up examination at 6 months after direct pulp capping, the tooth demonstrated a dentinal bridge formation in the two cases and these results confirm the biological observations of the lack of toxicity and genotoxicity of this biomaterial. The teeth were clinically asymptomatic and positive response were registred to vitality tests.

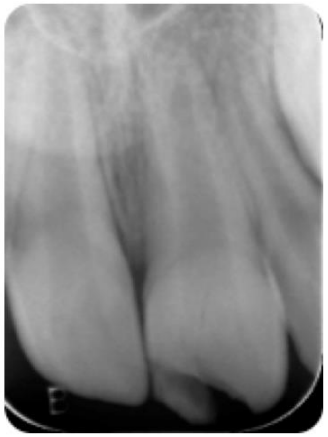

Fig. 1: Radiograph showed traumatic fracture

So, clinically, it was shown an absence of inflammatory pulp response which means that Biodentine is able to maintain pulp vitality after direct pulp capping.

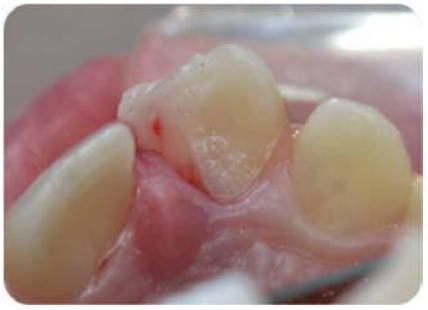

Fig. 2: The fracture was beveled with no other signs of damage. Obvious pulpal exposure with little bleeding.

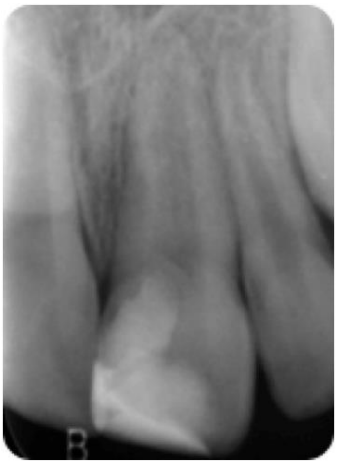

Fig. 3: Biodentine is radiopaque, making it easily identifiable.

DISCUSSION & CONCLUSIONS: Biodentine tricalcium silicate cement is an alternative therapeutic to calcium hydroxide to maintain pulp vitality. Clinically, Biodentine can be seen an appropriate material for direct pulp capping. Radiologically, a dentinal bridge was observed at 6 months follow-up

Multi-scale mechanical characterization of sound dentin

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INTRODUCTION: The dentin microstructure shows a hierarchical and complex organization. At the microscale, dentin can be seen as a continuous fiber-reinforced composite with peritubular cuffs as reinforcement and intertubular dentin forming the matrix. At the nanoscale, intertubular dentin consists of collagen fibrils, hydroxyapatite crystals and water.

The effective properties of dentin, resulting from its complex structure, determine the tooth's response to applied loads and enables one to predict tooth strength. However, there is great controversy about Young's modulus[1]. In this paper, the mechanical properties of dentin are investigated experimentally at different scales.

METHODS: Sound dentin specimens were obtained from sound human third molars**.** Three point bending tests were performed on dentin beams (8mm×1mm×1mm, supporting span: 5mm) under optical microscope in order to get the effective Young's modulus. The load was applied perpendicular to the tubular orientation. Strain and stress distributions were obtained respectively by Digital Image Correlation (DIC) and Finite Element (FE) simulation (Comsol Multiphysics). Nanoindentation was used to measure the local modulus of peri and inter-tubular dentin on a dentin specimen polished down to 0.25µm. A matrix of 10×10 indents with 200nm indentation's depth was applied to the sample surface.

RESULTS: Strain distribution along direction 2 obtained by DIC is shown in Fig. 1.

Fig. 1: (A) Scheme of the bending test and selected areas to acquire ε_{11} using DIC. (B) ε_{11} distribution along direction 2 (from DIC).

ε_{11} shows a linear relationship with respect to the location in direction 2. Five areas were selected to evaluate ε_{11} distribution. The three point bending test on the dentin beam was simulated and allows the obtainment of the stress distribution in the whole beam (especially σ_{11}). Dentin was considered as a homogeneous and isotropic material in these FE simulations as a first approximation. Young's modulus in direction 1 (perpendicular to the tubules) can thus be derived using Hook's law: $E_{11} = \sigma_{11} / \varepsilon_{11}$. Young's modulus is found to be 22.3±2.1GPa. At a lower scale, the local moduli were obtained by nanoindentation using two methods (continuum stiffness mode and unloading curve mode). The results are plotted as a histogram in Fig. 2.

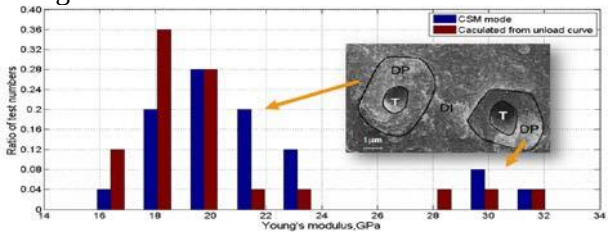

Fig. 2: Histogram of local modulus

DISCUSSION & CONCLUSIONS: Young's modulus measured by three point bending tests (22.3±2.1GPa) matches Kinney *et al.* results[2], in which elastic moduli are reported between 22 and 25GPa (determined by resonant ultrasound spectroscopy). More tests will be carried out in order to link the beam tubule fraction area and the mechanical characteristics. We also plan to achieve compression tests under the microscope on cubes to investigate dentin anisotropy and to map the mechanical properties of dentin within the whole tooth. Nanoindentation tests revealed two distinct families corresponding to peritubular and intertubular dentin. The average modulus for intertubular and peritubular are 20GPa and 30GPa, respectively. Those values are in accordance with the literature. Furthermore, it was verified that the fraction areas of peritubular and intertubular dentin (observed with an optical microscope) corresponds to the ratio of the two families revealed by nano-indentation tests.

ACKNOWLEDGEMENTS: This work has benefited from the financial support of the LabeX LaSIPS (ANR-10-LABX-0040-LaSIPS) managed by the French National Research Agency under the "Investissements d'avenir" program (n°ANR-11-IDEX-0003-02).