Push-out strength of 3 warm obturation techniques: Warm Vertical Compaction, GuttaCore, Gutta Fusion.

M. Hanna[1], M. Daou[1], A. Naaman[1], C. Zogheib[1]
[1]*Université Saint-Joseph, Beirut, Lebanon*

INTRODUCTION: One of the main objectives of endodontics is to perform a hermetic seal of root canals, in order to maintain the sterilization result of root canals obtained during canal preparation. Schilder introduced the concept of warm vertical compaction of gutta-percha in 1967 to attempt to obturate more canal irregularities[1]. In 1978, Johnson presented the use of stainless steel files with thermally plasticized gutta-percha[2]. Subsequently, the metal support was substituted by a plastic one[3], that was replaced recently by a gutta-percha core obturator GuttaCore (Dentsply, Tulsa, OK) and Gutta Fusion (VDW, Germany). The aim of this study was to evaluate the apical adaptation of these new obturation systems with warm vertical compaction technique, and compare the bond strength of GuttaCore and Gutta Fusion techniques to warm vertical compaction technique using the adhesion test.

METHODS: 36 single-rooted permanent teeth (incisors, canines, premolars) were selected and prepared. The teeth were randomly divided into 3 groups; each one was obturated using the warm vertical compaction technique, or with thermoplasticized technique (GuttaCore® and Gutta Fusion®). The samples were sectioned transversally at 1, 2, 3 and 4 mm from the apex, and an increasing force was applied at each section at a constant speed of 1 mm/min in the apico-coronal direction, until a fracture occured. The maximum load applied to the filling material before the separation was recorded in Newtons (N). The bond strength expressed in MPa, was then calculated. The data obtained was analyzed using Bonferroni pairwise comparisons, with a significance level of 5%.

RESULTS: No significant difference was found between the three groups concerning the bond strength in the apical third. And the mean bond strength was significantly different between the sections of each group.

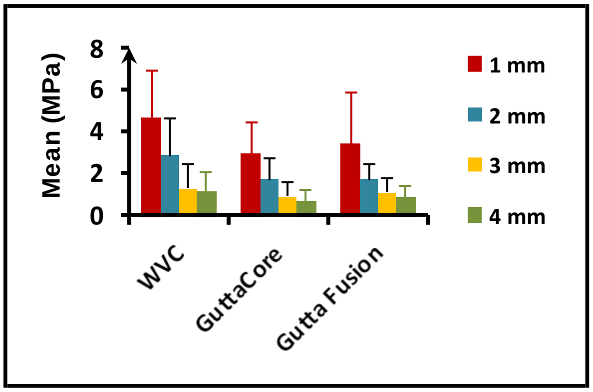

Fig. 1: Bond strength mean values and standard deviations (in MPa) necessary to dislodge the filling material comparing the groups.

DISCUSSION & CONCLUSIONS: The highest values observed after push-out tests were obtained at 1 and 2 mm, the lowest ones at 3 and 4 mm. In fact, the bond strength is inversely proportional to the interfacial area of the section, according to the formula of Gesi[4], and the plunger as well as the speed applied at all the sections are the same, we can deduce that as much as the section is small the resistance will be higher. In addition, a factor that could explain the difference in bond strength between the sections is the internal anatomy of each level of the root canal due to the variation in the number and diameter of tubules[5].
The apical adaptation of GuttaCore and Gutta Fusion obturators were equivalent to those of warm vertical compaction technique in the apical third regardless of canal level.

Influence of hyperbaric environment (diving conditions) on adhesive restorations: an *in vitro* study

C Mocquot[1], A Cabrera[1], N Pradelle-Plasse[1,2]

[1] UFR Odontologie, Université Paris Diderot, Hôpital Rothschild, Assistance Publique-Hôpitaux de Paris, France, [2] Laboratoire des Multimatériaux et Interfaces, UMR CNRS 5615, Université Lyon 1, Villeurbanne, France

INTRODUCTION: Microleakage is often described as a factor of barodontalgia, defined as dental pain caused by pressure variations of the environment. An *in vitro* study was conducted to measure the impact of a pressure increase on the microleakage of a dentine/composite interface:
- in a case where the restoration presented a perfect marginal adaptation to dental structures
- in an other case where the composite restoration contained porosity.

The objective was to evaluate if the dentist should follow specific protocols in restorative dentistry for divers patients.

METHODS: This study was conducted on 20 third molars recently extracted. Dentine samples were obtained by cutting the teeth horizontally to obtain plate surfaces and then divided into 4 groups of 5. Composite cylinders were made using nylon washers. In half of the samples, a polyester ball (2mm ø) was put inside the composite cylinder, before polymerization, to simulate a porosity (Groups 1,3). Then each sample of the composite was bonded to a dentin sample (*Fig 1*).

Fig. 1: Dentine and composite cylinders

Then, Groups 1 and 2 were placed inside a cylinder that simulated dives, under hyberbaric conditions *(Fig 2)*. The samples were sudjected 6 times to a pressure between 5,5 and 6 bars and immersed in a solution of silver nitrate. Then they were sectioned transversely to get 3 sections, ie 6 interfaces. A semi-quantitative method was used to measure the penetration of the silver nitrate. ANOVA and Mann and Whitney tests were carried out ($p<0,05$).

Fig.2: Simulated dives

RESULTS: The most important penetration was observed in group 1 which presented statistical differences with all the groups. Group 2 presented intermediary results between group 1 and groups 3 and 4 (*Fig. 3*).

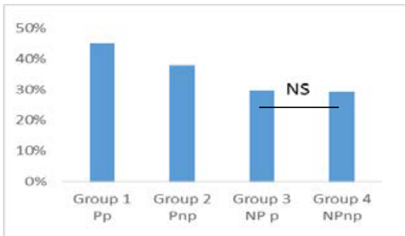

Fig. 3: Percentages of dye penetration (P: with pressure, NP: without pressure, p: with porosity, np: without porosity)

DISCUSSION & CONCLUSIONS: Highest percolation's percentages in groups 1 and 2 respectively, compared to groups 3 and 4 show that a simulated hyperbaric condition leads to a loss of sealing at the interface. This highlights the importance of the adhesive selection and the respect of the strict adhesive protocol. Prefer Etch and Rinse adhesive systems or Self Etch systems with a preliminary enamel etching. The greater dye penetration into the group 1 with porosity compared to the group 2 shows that a defect in the restoration will promote the microleakage between the inside and the outside of the interface. To limit this phenomenon it appears essential to obtain a perfect marginal adaptation between the restorative material and dental tissues. The use of flow composite, instruments generating vibrations on composite [1] or preheating composite could be solutions to limit the presence of air bubbles [2]. The protocol respect and quality of condensation are important in all situations, but especially among diver patients.

Biodentine® in an "open sandwich restoration": SEM observations and microleakage

B Metairie[1], P Bouchain[1], J Bosco[1-3], N Pradelle-Plasse[1-4]

[1] UFR Odontologie, Université Paris Diderot, France. [2] Laboratoire des Multimatériaux et Interfaces, UMR CNRS 5615, Université Lyon 1, Villeurbanne, France. [3] Hôpital La Pitié-Salpétrière, AP-HP Paris, France. [4] Hôpital Rothschild, AP-HP Paris, France

INTRODUCTION: The main purpose of conservative dentistry is to preserve pulp vitality. In the case of deep carious lesions, a dentin substitute may be used. The aim of this study was to evaluate, using a chemical tracer penetration methodology, the microleakage at the interface Biodentine®/adhesive restorations, in an "open sandwich restoration". SEM observations of the interfaces were also carried out. Two parameters were analyzed to conclude on the ability of this interface to be watertight:
1) The class or the chemical composition of the adhesive systems used.
2) The moment when the adhesive systems were layered out on the Biodentine® (D0 or D+7).

METHODS: 80 extracted human teeth were used. On each sample, two class II cavities, located in mesial and distal, were performed. They were then divided into two experimental groups each containing 8 batches (n=5). For the first experimental, group 1 (G1), Biodentine® and adhesive restorations were carried out the same day. For the other experimental, group 2 (G2), the adhesive restorations were performed 7 days after Biodentine®. Eight adhesive systems were used:
- total etch systems: Prime & Bond® NT (PB), Scotchbond Universal® (SB TE)
- one step self-etch systems: Xeno III® (XE), G-aenial Bond® (GB), Tri-S Clearfil Bond® (TSB), Scotchbond Universal® (SB SE)
- two steps self-etch systems : Optibond XTR® (XTR), Clearfil SE Bond® (SEB). The composite resin was Ceram X Mono®.

Each specimen was thermocycled 1500 cycles between 5°C and 55°C and then immersed in a silver nitrate solution. The teeth were sectioned and the penetration percentages were calculated. ANOVA and Mann and Whitney tests were carried out ($p<0,05$).

RESULTS: Considering the type of adhesive systems: the lowest percolation was obtained with total-etch systems (table 1 and fig. 1).

Table 1: Mean of percolation per family of adhesive system (G1+G2)/2

Adhesive system	Mean of percentage of percolation
Total-etch system	2,47%
Two step self-etch system	5,63%
One step self-etch system	7,04%

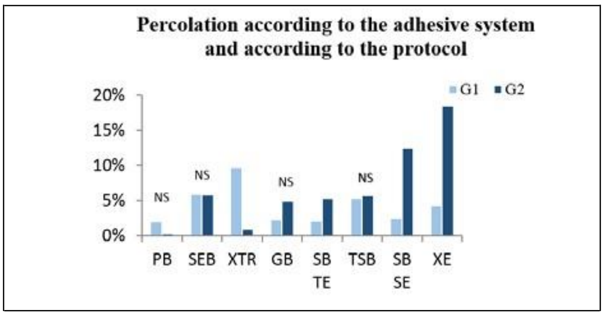

Fig. 1: Penetration rate (%) at the Biodentine®/composite resin interface

4, 31% was the mean percolation for the protocol where the Biodentine® and the adhesive restorations were both carried out the same day; 6,78% for the protocol in two operational times.
The SEM observations confirmed the quality of the different interfaces and corroborated the microleakage results.

DISCUSSION & CONCLUSIONS: Using orthophosphoric acid do not jeopardize the sealing of the Biodentine®/adhesive system interface as shown with the two Scotchbond Universal® handlings[1,2]. These results also illustrate that adhesive systems containing 10-MDP seem more stable and tolerant to the procedure. They showed that Biodentine® could be used in "open sandwich" restorations, regardless of the type of adhesive systems or the protocol used.

Three-dimensional modeling of the masticatory dynamics to the analysis by finite element method in restorative dentistry.

C Muraille[1, 2], A Legros[2], Y Josset[1], P Lestriez[2].
[1] U.F.R. Odontologie, Reims (France), [2] URCA/GRESPI/MAN, Reims (France).

INTRODUCTION: The purpose of this work was to describe the software sequence, from acquisitions by Micro-computerised assisted tomography (CT) and CT-Scan, getting a three-dimensional (3D) dynamic model of a couple of teeth used with the analysis by the finite elements method. This model must respect the original anatomy of the tooth initially used, as well as the physiology of mastication. This model was tested through an analysis software using the finite element method.

METHOD: The method used included the scanning of a complete skull by X-rays CT (spiral CT Scan 16 strips Siemens®). Then, a reconstruction and segmentation were performed using AMIRA software (5.4.0 AMIRA®, Mercury Computer TGS® System®) and INVESALIUS (CTI, Renato Archer Information Technology). Dental couple recovered was built for a computer-aided design (C.A.D.) geometry using Rapidform software (XOR® Rapidform, Geomagic 3D Systems® Solutions®) (Fig. 1). The interferences of the chewing kinematics due to the acquisition by the opto-electronic system VICON ™ MX of capture of 3 D movements required a treatment with by creating a software http://www.modjaw.com/app/) to process data from different movements (Fig. 2). Finally, to demonstrate the effectiveness of the model, it was imported into the analysis software using Abaqus finite element method (Abaqus® Systèmes® Simulia Dassault Corp®) (Fig. 3). The physiological constraints that the couple tooth/restoration may suffer during the chewing movement were analyzed in this way.

RESULT: The result showed that the model was able to develop a physiological movement of chewing during its use within the software of analysis using the finite element method.

DISCUSSION AND CONCLUSION: This work ended by the demonstration of the effectiveness of the protocol to provide an accurate 3D model, used for the analysis by the finite element method. In addition, this model could approach the human physiology at a greater accuracy than before.

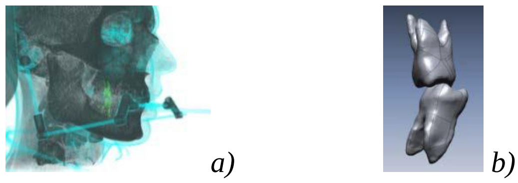

Fig. 1: a) Tomographic acquisition, b) Couple of isolated teeth.

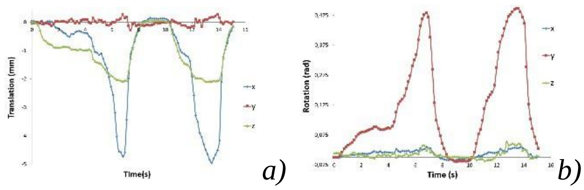

Fig. 2: Registration of mandibular movements curves chews for the first two cycles. a) Translation, b) Rotation.

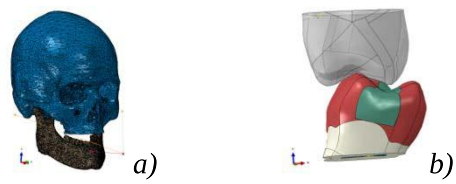

Fig. 3: a) Capture mastication b) FE model with chewing motion.

ACKNOWLEDGEMENTS: We thank the ROMEO computing center of the University Reims Champagne-Ardenne (https://romeo.univ-reims.fr/).

Tensile bond strengths of two adhesives on irradiated and non-irradiated human dentin

C Bernard, C Villat, B Grosgogeat

Laboratoire de Multimatériaux et Interfaces, UMR CNRS 5615, Faculty of Dentistry, University of Lyon, Hospices Civils de Lyon, France

INTRODUCTION: Management of irradiated patient as part of head and neck cancer treatment is a challenge for odonto-stomatologist. Indeed, placement of all types of restoration on specific carie known as "post-radiation carie" seems complicated [1]. These restorations of irradiated teeth generally end up on early failures. Very few studies have examined radiation effects on teeth and impact on bond strength. The aim of this study was to assess radiotherapy effects on tensile bond strength test [2] after artificial ageing [3], of two adhesive systems on human dentin.

METHODS: Twenty extracted teeth after radiotherapy (>50 Gy) and twenty extracted third molar were used. The specimens of each group were randomly split into two subgroups in order to test two different adhesive systems. Optibond FL (FL), three step/etch-and-rinse, and Optibond XTR (XTR), two-step/self-etch, were bonded to dentin after cavity preparation (2 mm thick, 4 mm width by Komet 188782 bur). Herculite XTR composite was put in place. Thermo-cycling process (10000 cycles) was used to perform an accelerated ageing on specimens. The resin-bonded specimens were sectioned occluso-gingivaly in serial slabs (1 mm thick) and subsequently in 1 mm^2 match-sticks (Fig. 1). Microtensile bond strength tests were performed and their results analyzed using ANOVA and Fisher test (α=0.05).

Fig. 1: Tooth section before stick individualization

RESULTS: The two adhesive systems (XTR and FL) used on irradiated teeth did not show any significant differences on bonding performance (Fig. 2: comparison between blue columns). The results were similar for adhesives used on non-irradiated teeth (Fig. 2: comparison between red columns). XTR bond on irradiated and non-irradiated teeth did not show any significant differences. On the other hand, FL bond strength was more effective on non-irradiated teeth than on irradiated ones as shown on Fig. 2.

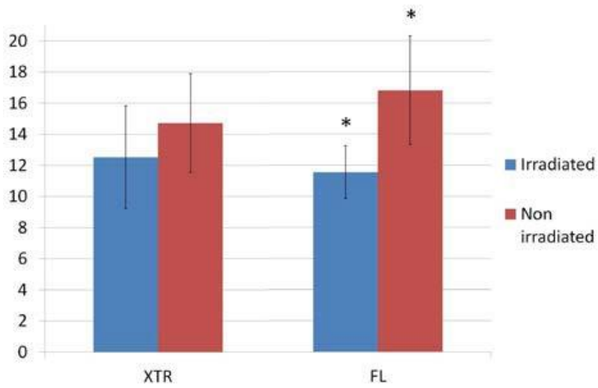

Fig. 2: Tensile bond strength results (MPa)

DISCUSSION & CONCLUSION: Within the limitations of this *in vitro* study, it can be concluded that radiotherapy seems to have significant detrimental effects on bond strength. However, the adhesive system could be adapted. This study recommended Optibond XTR which is two-step/self-etch adhesive. This one allows the preservation of tensile bond strength on irradiated dentin. It's probably due to its intrinsic hydrophilic molecules.

ACKNOWLEDGEMENTS: We thank the respective manufacturers (Kerr, Komet) for the generous donation of materials.

Weight variations of coated Glass-ionomer cement (GIC) stored in water

T Prud'homme[1,2,3], K. Khairoun[1], S Lopez-Cazaux[2,3], P Weiss[1,2,3], F Jordana[1,2,3]

[1] *LIOAD (Center for OsteoArticular and Dental Tissue Engineering), INSERM U S 791, Nantes, France* [2] *Faculty of Dentistry, University of Nantes, France,* [3] *CHU of Nantes, France*

INTRODUCTION: Glass-ionomer cements were developed by Wilson and Kent in 1969. Glass ionomers are water-based, self-adhesive restorative materials in which the filler is a reactive glass called fluoroaluminosilicate glass and the matrix is polymer or copolymer of carboxylic acids. The setting reaction of these materials involves an acid-base reaction.[1-5]. The aim of this in vitro study was to measure the weight variations two high-viscosity GIC stored in distilled water.

METHODS: The self-curing materials tested were two high-viscosity GIC: a condensable coated GIC (GC Fuji IX ®, GC + Equia™-Coat, GC) and a resin-coated GIC (GC Equia™ + Equia™-Coat, GC).

Ten samples (1 mm high, 10 mm diameter) were manufactured for every material (polymerisation with a LED light, Acteon Satelec) for 20 s. In a steam room (37°C), five samples for each material were immersed in distilled water. Samples are weighed every day during one week with a balance (Sartorius® Extend, 10^{-4}g precision). For every sample, evolution of weight per volume unit (µg/mm3) versus time was plotted and mean of weight variation (µg/mm^3) obtained at the end of the study was computed. A Mann-Whitney test (M-W) was performed on the data.

RESULTS:

Materials	Day 7
GC Fuji IX ®, GC + Equia™-Coat, GC	+1,7%
GC Equia™ + Equia™-Coat, GC	+2,6%

Table 1. Weight variation of two high-viscosity GIC stored in distilled water.

DISCUSSION & CONCLUSIONS: The weight of all samples stored in the water increases. The sample weight increase for high-viscosity GIC, despite the presence of the coating. The sample weight increase more importantly for the newly commercialized high-viscosity material (GC Equia™ + Equia™-Coat, GC).

The results of this in-vitro study showed that the weight increase of glass-ionomer cements stored in distilled water depends on the employed glass-ionomer cement.

Longer term studies are needed to better understand the water intake of GIC.

Effect of the silane ageing on the shear bond strength of lithium disilicate ceramic luted to dentin.

L Anckenmann[1], D Favier[2], L Jacomine[2], C Gauthier[2], H Pelletier[2], N Liewig[3], O Etienne[1,2]

[1] School of Dental Medicine, Strasbourg University, France. [2] Charles Sadron Institute, CNRS 22 Strasbourg University, France. [3] Pluridisciplinary Hubert Curien Institute, Strasbourg University, France.

INTRODUCTION: The purpose of this study was to assess the shear bond strength (SBS) and microleakage after cyclic shear loading of two resin cements (Variolink II/total etch Excite F DSC and Multilink Automix/self-etching primer A+B) fixing dentine to lithium disilicate ceramic (e.max Press) following two different pre-treatments: hydrofluoric acid (HF) etching + 2 months expired silane coupling agent (Monobond Plus) or HF etching + fresh silane coupling agent.

METHODS: Cylindrical specimens (5x5mm) of lithium disilicate-based ceramic were prepared for bonding to human ground flat dentin. 4 groups (n=5) *MLns*, *MLes*, *VLns*, *VLes*, were designed according to ceramic surface pretreatments (fresh silane *ns* or expired silane *es*) and luting cements (Multilink *ML* or Variolink *VL*). Specimens were shear load cycled (50N, 120 000 cycles, 2Hz) in an electrodynamic Instron universal testing machine. The liquid chamber at 37°C contained a fluorescent marker solution (rhodamine, 5µmol.L^{-1}). Samples were then stressed in shear until failure at a constant crosshead speed of 0.5mm/min. Statistical analysis was performed by ANOVA. Each specimen was then observed using fluorescence microscopy, scanning electron microscopy, and optical profilometry.

RESULTS: Variolink II (12,8$\pm$3,5MPa) showed the highest bond strength when fresh silane coupling agent was used (*fig.1*) but the differences between Variolink and Multilink (10,4$\pm$1,4) were not significant (p>0,01).

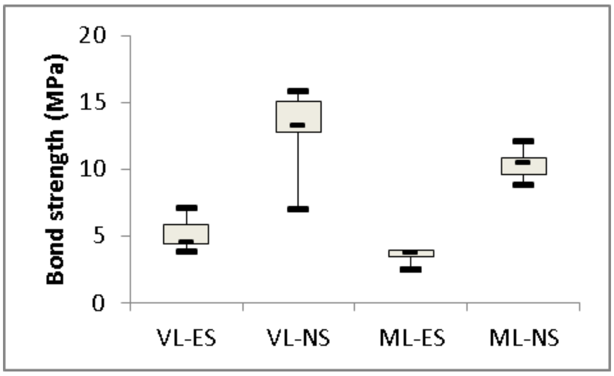

Fig. 1: Shear bond strength results for the four groups

Expired silane significantly decreased bond strength for both resin luting cements (*fig.1)*. SBS was not dependent on microleakage values. Microleakage was observed for each specimen.

SEM fracture surface analysis showed mixed failure. When pulled out from dentin tubules, resin tags and hybrid layer were visible. Resin tags were longer for VL (*fig. 2*).

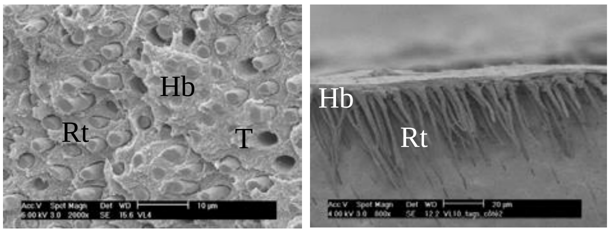

Fig. 2: SEM images after VL sample fracture, on the right side sample has been transversally sectioned. Hb, hybrid layer; T, tubule; Rt, resin tag

DISCUSSION & CONCLUSIONS: An ideal adhesive restoration should obtain high bond strength value without microleakage [1]. In this study nor VL, nor ML were able to seal the marginal join between dentin and ceramic perfectly. As shown in other studies [2] no significant differences were obtained between VL and ML bond strength values. However these values were greatly influenced by the silane ageing, which demonstrated to play a major role in ceramic bonding.

Despite the actual tendency for microSBS tests, macroSBS test has the advantage not to cut fragile ceramic and may present a bonding surface more representative of *in vitro* conditions. Experimental parameters vary a lot between *in vitro* studies, making the comparison of results difficult, even for the same luting resin cement.

Application of the essential work of fracture (EWF) concept for fracture toughness analysis of several luting agents under simulated oral conditions

H Bouckenooghe[1], G Stoclet[2], P Behin[1]

[1] Faculté de Chirurgie Dentaire, Université de Lille, Lille, FR. [2] UMET CNRS UMR 8207, Université de Lille, Villeneuve d'Ascq, FR

INTRODUCTION: The aim of this study was to investigate the fracture toughness of various luting agents under different temperatures and levels of humidity using the Essential Work of Fracture (EWF) method, which is mainly applied to ductile materials. In this investigation, substantially thinner test samples were used, compared to those used in other studies[1] on luting agents, to approach as much as possible of clinical conditions. Samples of glass-ionomer, self-adhesive, resin based and 4-Meta luting agents were tested: firstly, under ambient temperature and humidity and then, under simulated oral temperature and humidity levels.

METHODS: 16 test specimens of each cement type were prepared with a Polyvinyl Chloride (PVC) mold, made by punching 0.150mm thick PVC sheets in order to obtain thin cement films by injection molding between two silicone-coated PVC sheets. Samples were maintained under pressure by 6 clamps to ensure a uniform film thickness. Complete cure of the samples were occured in a dark enclosure at 100% humidity level and 36°C for an hour.

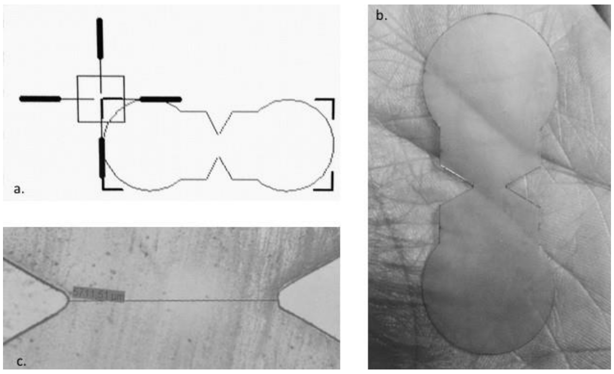

Fig. 1: a. Computerized template of the sample ; b. DENT sample after laser cut ; c. Microscopic view of the sample ligament (x1.25 magnification)

Then, samples maintained between silicone coated PVC films were laser-cut (Speedy 400, Trotec, France) to obtain a DENT (Double Edge Notched Tensile specimen) sample following the EWF method guidelines[2] (Fig. 1). Specimens were maintained in distilled water at 36.6°C between microscope slides and then fractured on a universal testing machine (Instron, Canton, Mass.) after 7 days, in a tensile mode, with a displacement rate of 0.5 mm/min. 8 samples of each material were fractured under ambient conditions and 8 samples under simulated oral conditions. Areas under load-displacement curves were measured to determine total work of fracture (wf).

RESULTS: ANOVA and Tukey's test demonstrated significant differences for several tested cements, under ambient and oral conditions (Fig. 2).

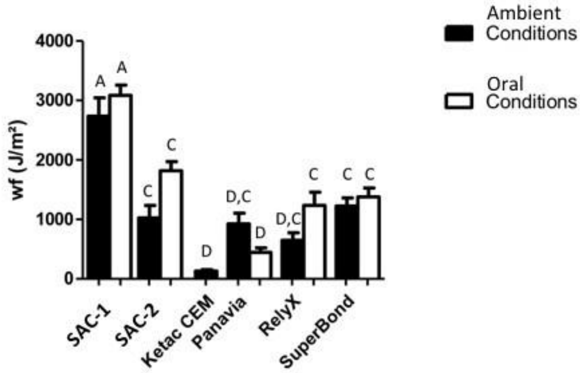

Fig. 2: Mean work of fracture (wf) for cements tested in J/m². Groups labeled with same letter are not significantly different from one another.

DISCUSSION & CONCLUSIONS: The EWF method seems to be applicable for the analysis of luting agents. The resin-based cements exhibited improved fracture toughness when compared to the glass ionomer cement. The relative ranking of the materials has to be compared to other studies on fracture toughness of luting agents.

 ISSN 1473-226

Resin infiltration of proximal caries lesion: a systematic review

E Daniel[1,2], C Chatelain[1], R Kheng[1,2], E Dursun[1,2,3]

[1] *Faculty of Dental Surgery, University of Paris Descartes, France.* [2] *A. Chenevier Hospital, Créteil, France.* [3] *Research Unit of Dental Materials, Innovation and Interface (EA4462), University of Paris Descartes, France.*

INTRODUCTION: To arrest non-cavitated proximal carious lesion progression, a new procedure has been recently developed: the infiltration of enamel micropores by a resinous material, to create the diffusion barrier inside the lesion, replacing lost mineral with resin (Fig. 1). This technique is between the prevention therapy (remineralization) and the invasive restorative dentistry (even minimally). The aim of this study was to perform a systematic review of the published literature concerning the caries infiltration.

METHODS: An electronic search on the PubMed database was attempted to identify all relevant *in vitro*, *in situ* and *in vivo* studies on the proximal caries infiltration and on the shear bond strength to resin-infiltrated enamel. Papers published in English were selected after a critical review of theirs titles, theirs abstracts and finally theirs full texts (Tab. 1).

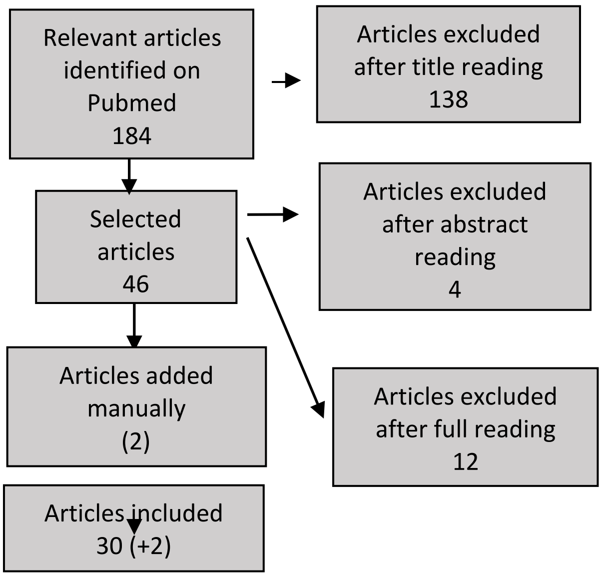

Table 1: Flow diagram

RESULTS: The initial search found 184 eligible papers and finally 30 were included in this systematic review. The articles allowed to determine the justification of each protocol step, to optimize the resin penetration in the body of the carious lesions and inhibit its progression (the acid type and concentration; the resin type, duration and number of applications) [1-4]. Other articles allowed to discuss the opening possibility to broader indications (for cavitated lesions) and to underline some unstudied steps of the protocol.

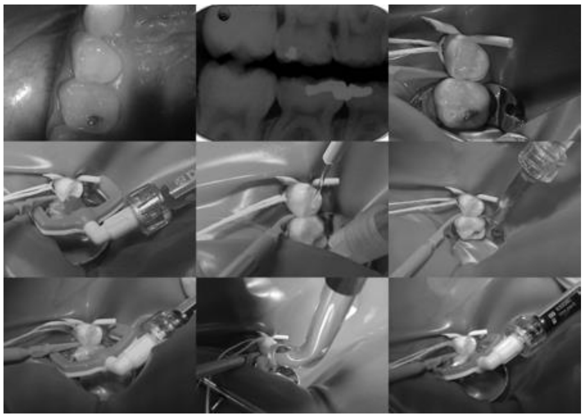

Fig. 1: Resin infiltration procedure of a proximal carie lesion.

DISCUSSION AND CONCLUSION: The infiltration of subsurface lesions with low-viscous light-curing resins is an extremely conservative approach. Only three clinical studies - during one and three years - were performed. This technique seems very promising, but has to prove itself in the long term.

 ISSN 1473-226

Production of human dental pulp cells for cellularized biomaterials with a GMP approach

M Ducret[1,2,3], H Fabre[1], O Degoul[4], G Atzeni[4], C McGuckin[4], N Forraz[4], J-C Farges[1,2,3], F Mallein-Gerin[1], E Perrier-Groult[1]

[1] LBTI, Lab. Biol. Tiss. Ing. Therap., UMR CNRS/UCBL 5305. [2] Univ. Lyon 1, Fac. Odontol. [3] Hosp. Civils Lyon, SCTD, France. [4] Lab. CTI-BIOTECH, Cell Therap. Res. Inst., Meyzieu, France.

INTRODUCTION: Human Dental Pulp Cells (HDPC) have been previously used to cellularize biomaterials for regenerative medicine application [1,2]. However, cells have been generally isolated, cryopreserved and amplified with xenogeneic products and in stress conditions that may alter their biological features (Fig 1). Today, guidelines from the US Food and Drug Administration and the European Medicines Agency recommend the use of protocols compliant with medicinal manufacturing. The aim of this study was to design an *ex vivo* procedure complying with these international recommendations, in order to produce clinical-scale amounts of HDPC for dentin/pulp and bone engineering.

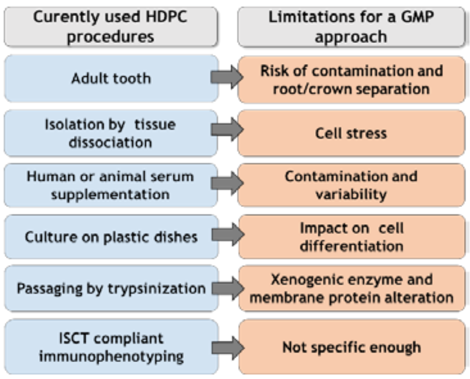

Fig 1: Some HDPC culture procedures are not fully adequate for a GMP-compliant approach.

METHODS: HDPC were isolated from pulp explants of impacted third molars collected after informed consent was obtained (CODECOH: DC-2014-2325). After appropriate serum-free medium selection, cells were immunophenotyped with flow cytometry (17 cell surface markers). Samples were then cryopreserved for 510 days. Post-thaw cell doubling time was determined up to passage 4 (P4). HDPC osteo-odontoblastic differentiation capability was determined after culture in a differentiation medium by gene expression and mineralization quantification.

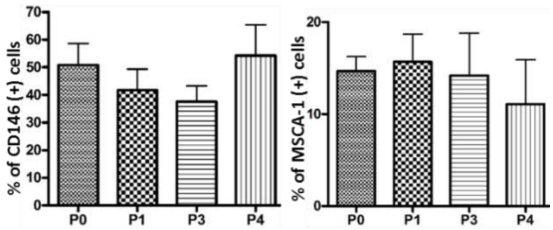

Fig 2: Immunophenotypic analysis showing constant expression of the stem/progenitor cell markers CD146 and MSCA-1 from P1 to P4.

RESULTS: Immunophenotyping of cultured HDPC revealed a mesenchymal profile, some cells also expressing stem/progenitor cell markers CD271, Stro-1, CD146 and/or MSCA-1 (Fig. 2). Doubling times of post-thaw cells were stable and similar to fresh HDPC. Alkaline phosphatase, osteocalcin and dentin sialophosphoprotein gene expression, as well as mineralization were increased in cultures of post-thaw HDPC performed in the differentiation medium compared to cultures in the control medium.

DISCUSSION AND CONCLUSIONS: Human dental pulp cells were successfully Isolated, cryopreserved and amplified with a medicinal manufacturing approach. These findings may constitute a basis to investigate how HDPC production could be optimized for regeneration of human pulp/dentin or bone with cellularized biomaterials [1,2].

ACKNOWLEDGEMENTS: Supported by CNRS, the French Ministry of Higher Education and Research, IFRO, the Rhône-Alpes Region, the Société Française de Rhumatologie and the Société Française d'Endodontie

Contribution of infrared thermography in the diagnosis of pulp vitality

ML. Jourdain[1], L. Budin[1], AC. Taron[1], D. Lantz[1], M. Krall[2], P. Millet[1], JL. Bodnar[2]

[1]UFR Odontologie Reims Champagne Ardennes, France.

[2]UFR Sciences Exactes et Naturelles, Reims Champagne Ardennes, France

INTRODUCTION: Pulp vitality is an important diagnostic and prognostic element for dental organ. It reflects the nervous response of pulp tissue and not the quality of the vascularization thereof; therefore the vitality tests currently used generate many misdiagnosis[1,2]. The purpose of the study was to demonstrate the value of infrared thermography in the diagnosis of pulp vitality. A thermal stimulus was generated on a vital tooth and a non-vital tooth to study how to take back to the initial temperature.

METHODS: The thermal behaviour of the maxillary incisors was investigated on a patient with an endodontic treatment of his left central incisor and two healthy control patients. Measurements were performed in the cervical region, in the middle of the crown and at the incisal edge[3]. Teeth were stimulated with three stimuli (body temperature + 2°C, 53°C and 2°C)

RESULTS: The first case was a 30 years old female patient with endodontic treatment on her left central incisor (21). After stimulation at 53°C the return to the initial temperature of 21 is slower than on 11. Similarly, when applying a stimulus to 2°C the thermal behaviour differs between 11 and 21 with a less rapid warming for 21.

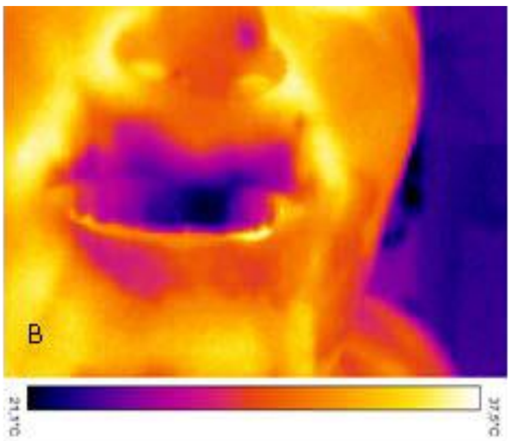

Fig. 1: Thermogram of the upper incisors (t = 40s after stimulus at 2° C)

When amplification of a thermal stimulus to body temperature + 2°C, the thermal behaviour is different depending on the corresponding tooth (11 or 21) but also according to the measuring point location at the tooth (Fig. 1).

The same procedure was performed on a control patient who had all her teeth healthy. When different thermal stimuli were applied the resulting temperature, curves were homothetic and converged toward the same point (Fig. 2).

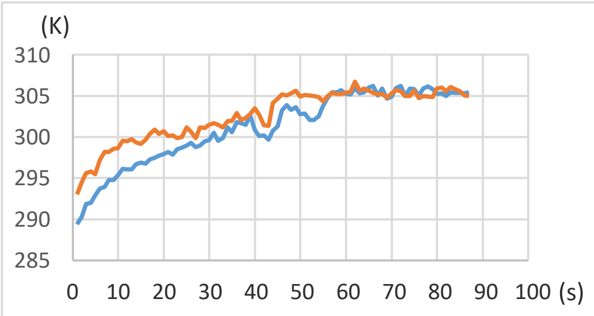

Fig. 2: Evolution of the temperature (K) of 11 (blue curve) and 21 (orange curve).

DISCUSSION & CONCLUSIONS: Thermal behaviour between healthy tooth and non-vital tooth after thermal stimulation were investigated in this study. Thermal curves are different for both studied teeth after cold or warm stimulation. Parameters such as thermal stimulation intensity and measuring point location can influence the results. Furthermore, the humid environment of the oral cavity and the heat generated by the respiration can complicate thermal infrared measurements.This study should be extended to a larger sample of patients with necrotic teeth instead of teeth with endodontic treatment.

ACKNOWLEDGEMENTS: Master 1 BBB Reims

Pulp capping materials and Complement activation: implication in dentin-pulp regeneration

T Giraud[1], P Rufas[1], C Jeanneau[1], J Dejou[1], I About[1]

[1] Aix Marseille Université, CNRS, ISM UMR 7287, 13288, Marseille, France

INTRODUCTION: Complement activation is known for its involvement in initiating the inflammatory reaction. However, we have also demonstrated its involvement in the pulp regeneration process. Indeed, human pulp fibroblasts can synthetize all Complement components required for efficient Complement activation[1]. This activation leads to the production of the biologically active C5a fragment. This potent inflammatory mediator is involved in STRO-1^+ pulp cell recruitment[2]. Interestingly, it has been reported that biomaterials can activate the Complement[3]. The objective of this study was to investigate, *in vitro*, the involvement of pulp capping biomaterials on pulp fibroblast Complement activation and to investigate their effects on regeneration and inflammation process.

METHODS: Three biomaterials of different chemical classes were chosen: Biodentine™, TheraCal® and Xeno III®. Biomaterials were prepared according to the manufacturer's instructions and samples of set Biomaterials were incubated in the culture medium for 24-h. The resulting media will be called conditioned media in the next steps of the protocol. Human pulp fibroblasts were prepared from immature third molars, by the explant outgrowth method and pulp progenitor cells were directly sorted from pulp cell cultures with anti-human STRO-1 antibodies. Confluent pulp cells were injured with scalpels (control) and incubated with conditioned media containing extracts of biomaterials. C5a concentration was determined by sandwich ELISA (enzyme linked immunosorbent assay). The role of biomaterial-induced complement activation on pulp progenitor cell and monocyte cell THP-1 (monocytic leukemia cells) recruitment was investigated using the dynamic transwell migration assays.

RESULTS: These preliminary results showed an increased C5a release and inflammatory cells migration in the presence of Xeno III® conditioned medium. TheraCal® inhibited the migration of both progenitor and inflammatory cells without affecting C5a secretion level. A decrease in inflammatory cell migration was observed with Biodentine™ and no effect was observed on C5a secretion or progenitor cell migration with this material.

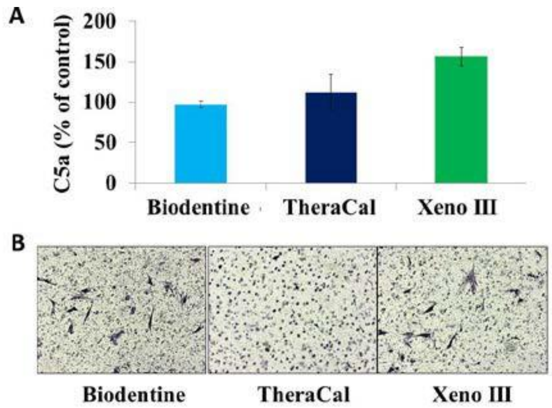

Fig. 1: (A) C5a complement fragment is detected in human pulp fibroblast supernatants incubated with the capping materials (B) Migration was assayed in transwell inserts. Migrating progenitor cells, localized to the lower surface of the porous membrane, were counted in 5 random fields under a light scope (×100).

DISCUSSION & CONCLUSIONS: While both Biodentine™ and Xeno III® had a similar effect on progenitor cell migration, Xeno III® induced a higher inflammatory reaction than Biodentine™. TheraCal®, which is made of both Tricalcium silicates and resinous components, inhibited both inflammatory and progenitor cell migration. Taken together, these data confirm the contribution of resin-based materials in the pulp inflammatory reaction and the suitability of Biodentine for direct pulp capping through the recruitment of progenitor cells and the subsequent dentin bridge formation.

ACKNOWLEDGEMENTS: The authors wish to thank Dr Jean-Charles Gardon for providing the teeth used in this work.

Chitosan based hydrogels for vascular applications

A Aussel[1,2,3], X Berard[3], NB Thebaud[1,2,3], R Bareille[2], R Siadous[2], V Brizzi[3], A Montembault[4], L David[4], L Bordenave[1,2,3]

[1] University of Bordeaux, Tissue Bioengineering, Bordeaux, France. [2] INSERM, Bordeaux, France. [3] CHU Bordeaux, Bordeaux, France. [4] IMP, CNRS UMR 5223, Villeurbanne, France.

INTRODUCTION: Vascular engineering has emerged to provide constructs that can repair or replace damaged macro- or microvessels (necessary for bone reconstruction). Chitosan is a linear polysaccharide obtained industrially from deacetylation of chitin particularly interesting for Tissue Engineering (TE) applications. The main of the study was to produce planar and tubular constructs of chitosan based hydrogels to check in vitro *(i)* propensity to be cellularized by EPCs (endothelial progenitor cells), *(ii)* shear stress resistance of EPCs *and in vitro/in vivo* hemocompatibility.

METHODS: *Material and cells.* Chitosan (450,000 g/mol) was purchased from Mahtani, purified and structurally characterized [1]. H6 chitosan were produced (concentration 5%w/w with 5% degree of acetylation and hydro-alcoholic gelation routes). EPCs were isolated from umbilical cord-blood, cultured and characterized as described by Thébaud et al [2].

EPCs ability to line H6 : EPCs were seeded on H6 disks and tubes. At 24h, 3d, 7d, 15d, proliferation of EPCs on disks were evaluated by CyQuant. After 7 days tubes and disks were observed in epifluorescence (Live/Dead).

Shear stress resistance of EPCs. EPCs were exposed to shear stress (1.2 Pa) during 24h and 30h in comparison with static conditions. The angle deviation of aligned cells in the flow direction was quantified. Immunofluorescent stainings (Actin, von Willebrand Factor (Vwf) and VE-Cadherin (VE-Cad)) were performed.

Hemocompatibility. In vitro: According to standards ISO and ASTM, the following tests were performed after contact of H6 with human blood and in comparison with negative and positive controls: partial thromboplastin time (PTT), hemolysis, CH50, C5b-9 and C3a. *In vivo:* Arteriotomy was performed and repaired with either a H6 patch, or a polyester urethane (PU) patch in 3 anesthetized sheep [3]. Patency was assessed peroperatively and every 30 min by carotid Doppler ultrasound (US) exam. Animals were sacrificed at 2h. Tissues including patches were harvested for SEM

.

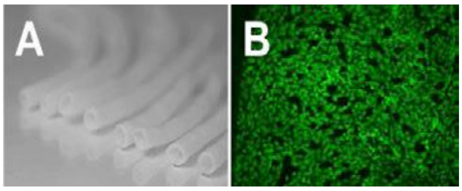

Fig. 1: (A) H6 tubes. (B) Confocal microscopy after EPCs Live staining (scale bar: 400µm)

RESULTS: *In vitro:* EPCs were able to grow on H6 disks and confluence was obtained at day 10. Concerning tubular constructs, live/dead staining confirmed the presence of EPCs at the graft luminal surface (Fig. 1). When exposed to laminar shear stress (1.2Pa), EPCs aligned in the flow direction at 24H and 30H when compared with static conditions and EPC phenotype was maintained. After contact of H6 with human blood, a minimal contact activation of the intrinsic pathway of blood coagulation was observed in the presence of H6 and H6 did not induce *in vitro* hemolysis, nor complement activation. *In vivo*: US showed no flow obstruction inside carotids repaired by H6 or control at 2h. SEM results indicated a lower fibrin deposition and platelet aggregation on H6 than on PU.

DISCUSSION & CONCLUSIONS: In this study tube elaboration and their endothelialization have been shown. Then, *in vitro* and *in vivo* results are promising for vascular TE. H6 seemed to be an interesting material for vascular engineering. In the future, in place of patch, cellularizable chitosan based hydrogel tubes could be implanted in large animal model for small diameter vascular TE.

ACKNOWLEDGEMENTS: Agence Nationale de la Recherche for financial support (Chitoart). LEMI for hemocompatibility testing in vitro.

Effects of two calcium silicate cements on human dental pulp stem cells

LS Loison-Robert[1,2], M Tassin[2], E Bonte[1,2], T Berbar[2], A Berdal[2,3], BP Fournier[2,3]

[1] Faculty of Dentistry, Paris Descartes University, Sorbonne Paris Cité, France. [2] INSERM UMR 1138, Cordeliers research center, Paris, France. [3] Faculty of Dentistry, Garancière, Paris Diderot University, Sorbonne Paris Cité, France.

INTRODUCTION: Calcium silicate–based cement is a biomaterial composed of calcium silicate, calcium oxide and carbonate filler, and zirconium oxide[1]. This biomaterial possesses dentin-like mechanical properties and may be used for the treatment of crowns, pulp and root. The aim of this study was to evaluate *in vitro* the biological effect of two calcium silicate cements on human dental stem cells.

METHODS: Stem cells were extracted from human dental pulp (DPSC) and were cultured with or without two calcium silicate cements at the concentration of 2 mg/mL. Cell proliferation and cytotoxicity were studied, DPSC were incubated with biomaterials and MTT colorimetric assay after 1, 5 and 8 days was performed. Indirect contact was studied through a 2% agarose gel above the cells. For cell adhesion assay, biomaterials were examined with scanning electron microscope and fluorescence microscope on coated coverslips. Migration was investigated by microphotographs of wound migration assays. Bio-mineralization induction (Table 1) was evaluated using Alizarin Red S staining after 14 days while qRT-PCR (quantitative real-time reverse-transcriptase polymerase chain) was used for further analysis of the mRNA expression of several stress and differentiation markers.

RESULTS: The effects of the two biomaterials were similar and they did not modify DPSC proliferation at 2mg/mL. Biomaterials showed no evidence of cytotoxicity in direct contact compared with indirect contact. No apoptosis nor oxidative stress were observed on DPSC. The messenger RNA level of mineralization associated genes increased significantly in the two biomaterials compared to control. These results seem to be suggesting that calcium silicate–based cement is bioactive because of biomineralization increase when compared to controls, whatever the culture medium used.

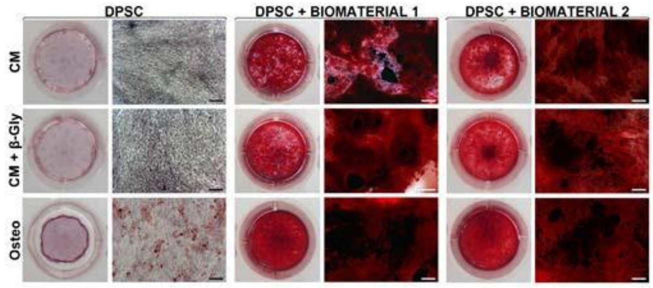

Fig. 1: Alizarin Red S staining cells with or without biomaterials. Scale bar = 200µm

Table 1. Mineralization induction medium

Classic Medium (CM)	DMEM 1X - GlutaMAX™ + 10% serum + 50 µg/mL ascorbic acid
CM + β-Gly	CM + 10 mM β-glycerophsophate disodium salt
Osteo	(CM + β-Gly) + 100 nM dexamethasone

DISCUSSION & CONCLUSIONS: The data imply that the two biomaterials are bioactive and biocompatible materials, with DPSC proliferation, migration and adhesion abilities. Because of its bioactivity, they might be used for clinical indications of dentin-pulp complex regeneration[2].

ACKNOWLEDGEMENTS: This template was modified with kind permission from eCM Journal.

Oral stem cells behaviour with new experimental dental biomaterials

E Bonte*[1,2], M Tassin*[2], LS Loison-Robert[1,2], MJ Sadoun[1,3], BP Fournier[2,4]

*[1] Faculty of Dentistry, Paris Descartes University, Sorbonne Paris Cité, France. [2] INSERM UMR 1138, Cordeliers research center, Paris, France. [3] URB2i, Faculty of Dentistry, Paris Descartes University, Sorbonne Paris Cité, France. [4] Faculty of Dentistry, Garancière, Paris Diderot University, Sorbonne Paris Cité, France.*Both authors equally participated to this work.*

INTRODUCTION: In order to assess new biomaterials, gingival (GSC) and pulp (DPSC) stem cells were used to evaluate three High-temperature-pressure Polymerized Resin-infiltrated Ceramic Networks (HTP-RICN) and a control resin based composite (Z100, 3M Co., St. Paul, MN, USA). These tests were integrated into an approach for assessing the biological tolerance of these materials in CAD - CAM blocks. Some articles reported cytotoxicity of their monomers but few articles looked at their polymerized forms, this later being closer to their clinical use.

METHODS: Three HTP-RICN were assessed: Enamic (VITA Zahnfabrik), Experimental hybrid material (EHM) and EHM with initiator (EHMi) which consist of a silanized ceramics networks infiltrated under high pressure and, as control, a commercialized photopolymerized composite resin: Z100. These materials have been described previously by Nguyen *et al.* [1]. All materials were grinded in cold conditions (-20°C) and used at 2 mg/ml. Proliferation, viability, cytotoxicity assays, cytomorphology, inflammatory response and oxidative stress studies and SEM examination were conducted. Statistical analysis (ANOVA) was performed using GraphPad Prism6 (Graphpad Software inc, 6.0) software.

RESULTS: Most of the stem cells in contact with biomaterials appeared alive according to Calcein-AM. Little cytotoxic effect was observed only for Z100 using MTT assay. Contact with biomaterials was necessary to observe such effect. However no apoptosis was noticed. A slight decrease in proliferation occurred in presence of biomaterials although non-significant. These materials did not disturb neither cell cytoskeleton nor major extracellular matrix components expression. SEM observations revealed a decrease in cell number in contact conditions and also intimate contact between cells and materials (Fig. 1). Lastly, these materials did not provoke neither release of anti-oxidant enzymes nor expression of inflammation markers such as IL-1β or MMP-9.

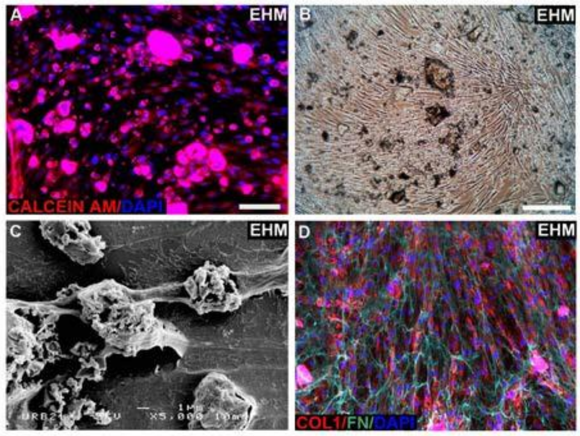

Fig. 1: Stem cell in contact with EHM. A - Cell viability. B - Phase contrast microscopy. C - SEM. D - Collagen and Fibronectin immunostainings.

DISCUSSION & CONCLUSIONS: Although these materials are not intended to come into direct contact with the pulp or gingival cells, the choice of these stem cells was justified by previous studies [2] and the possible recruitment of such cells during healing phenomena. This study showed that all these biomaterials did not modify proliferation, extracellular matrix synthesis, morphology or inflammatory response in the experimental conditions. Only slight cytotoxicity was observed for conventional composites (Z100). This highlight the biocompatibility of the new materials compared to Z100 which is widely used for 20 years with no declared adverse effect. These new materials may be safe and may be an interesting alternative to ceramics or composite based CAD - CAM blocks. Especially stem cells seem to behave physiologically with normal ECM secretion and no inflammatory response. However, further analysis would allow us to assess the effects on multipotency and on reparative properties.

Interest of bone substitute material in immediate complete denture: a randomized controlled trial

C Wulfman[1,2], A Aidan[3], A Hadida[3], H Fron-Chabouis[1], C Rignon-Bret[1,3]

[1] Sorbonne Paris Cité, Faculté de chirurgie dentaire, Biomaterials department (URB2i, EA4462), Université Paris Descartes, France. [2] Louis Mourier Hospital, Assistance Publique – Hôpitaux de Paris, France. [3] Albert Chevenier Hospital, Assistance Publique – Hôpitaux de Paris, France

INTRODUCTION: In the present implantology era, bone preservation is an essential issue in the context of last teeth extraction and complete edentulism. The realization of the intended treatment, whether it be complete denture or implant placement, would be facilitated with a voluminous residual ridge. Resorption after multiple extractions has not been studied as single tooth extraction. Recent advances in bone substitute materials have revived this issue [l-2].

The purpose of this study is to evaluate the interest of using bone substitute material after last teeth extraction in an immediate complete denture procedure, in comparison with the conventional protocol without socket filling.

METHODS: A randomized controlled clinical trial was designed. 34 participants, eligible for immediate complete denture, were divided in two groups. Complete dentures were prepared despite persistence from the last anterior teeth. The controlled group received a conventional treatment including denture placement immediately after extractions. In the test group, in addition to the immediate denture placement, a bone substitute material (Bio-Oss Collagen®, Geistlich©, Wolhusen, Switzerland) was placed in fresh sockets.

The primary outcome of the study was to compare bone ridge height one year after maxillary immediate complete denture placement (D10-D365), with or without bone substitute material, in incisors and canines sockets. The secondary outcomes were to compare average bone ridge height and width, between D10 and D90 and between D10 and D365.

An original quantitative evaluation method using Cone Beam Computer Tomography (CBCT) was designed to perform reproducible measurements, using a radio-opaque denture duplicate.

Two independent operators perform radiologic measurements. Radiographic analysis was performed with a duplicate of the complete denture made of acrylic resin containing barium sulfate powder (20 wt%), which provides radio opacity and was used as a radiographic guide for each patient [3].

Two measurements were performed for each extraction site during the three evaluation times (Fig 1):

- A vertical measurement (h): the distance between the palatal pit end (reference point O) and the buccal top of the outer cortical bone.
- A horizontal measurement (l): the bone ridge width was measured on a bucco-lingual line crossing the alveolar socket, perpendicular to the palatal pit axis and at a distance of 6mm or 2/3 socket depth (depending of the patient bone morphology) from the reference point O.

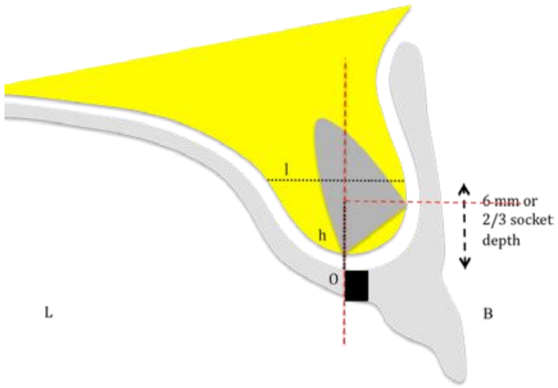

Fig. 1: Schematic measurement principles

DISCUSSION & CONCLUSIONS: The immediate complete denture technique limits bone resorption in multiple extraction situations. In order to compare the benefit of using any bone socket filling material, it was necessary to propose a quantitative evaluation protocol of resorption in the specific case of the last anterior maxillary teeth extractions.

TRIAL REGISTRATION: NCT02120053, 2014

Effect of recasting of cobalt-chromium alloy on its mechanical properties

AS Vaillant[1,2], P Corne[1,2], P De March[1,2], S Fleutot[2], F Cleymand[2], JP Jiehl[2]

[1] Care, teaching, and research dental center of Nancy, Nancy Cedex, France. [2] Research group Dolphin, Department N2EV, Institut Jean Lamour, UMR 7198, CNRS, Parc de Saurupt, 54042 Nancy Cedex, France

INTRODUCTION: Dental alloy manufacturers advise against the reuse of previously melted alloy. However, for economic reasons, dental laboratories often reuse the casting surplus. Such reuse remains a controversial topic in dental practice. Evidence supporting the addition of 50% new metal at each recasting is limited [l]. The purpose of this *in vitro* study was to evaluate the effect of repeated casting of cobalt-chromium alloy on mechanical properties.

METHODS: Specimens, 10x5 mm and 1 mm thick were prepared from a predominantly based alloy (Colado CC). Castings (n=25) were made using lost wax. The groups included an as-received (100% as-received alloy) group, 25% to 75% group (25%wt new alloy, 75 weight% (wt%) once-recast alloy), 50% to 50% group (50%wt new alloy, 50 wt% once-recast alloy), 75% to 25% group (75%wt new metal, 25 wt% once-recast alloy), and recast group (100% once-recast alloy). Specimens were polished with SiC papers of ascending grits. The surface structures of 4 specimens from each group were examined under scanning electron microscopy (SEM), the elemental compositions were determined using x-ray energy-dispersive spectroscopy at 3 sites on the specimen, and the composition's data were averaged. Further, specimens were re-polished down for Vicker's microhardness (VHN) measurement and nanoindentation experimentation.

RESULTS: The microstructure was affected by recasting: a heterogeneity increase in the structure of alloys with more recycled material was noticeable. Moreover, the occurrence of precipitates of various types of carbides and the presence of intermetallic phases which have a determining effect on the mechanical properties of received castings were noted. No significant differences were found for VHN values. Considering modulus of elasticity, the differences are either not significant.

DISCUSSION & CONCLUSIONS: The results in this study demonstrated light degenerative changes in cobalt-chromium alloy, when casted with more than 50% new alloy. Microporosity is a recurrent problem when casting alloys. Airborne contamination was minimized throughout this investigation by careful attention to detail in all phases of the technique. Indeed, results can dramatically differ with airborne contamination [2]. Results are in concordance with some published studies [3]. But as no consensus protocol for evaluation of casting exists, and as this study shows still preliminary results, further studies should work toward confirming or countering these results. Despite the likelihood of increased contamination when alloy is recast, this does not seem to cause severe detrimental changes in the mechanical properties of alloy. Therefore, the recast of casting surplus can be a good alternative to reduce costs involved, contributing to the reduction of waste and preserve natural sources, when addition of new alloy is at less 50 wt%.

A new shape memory alloy for endodontic canal preparation: the single crystal CuAlBe

M Vincent[1,2], AM Gevrey[1,2], F Thiébaud[2], M Engels-Deutsch[1,2], T Ben Zineb[2]
[1] Université de Lorraine - Faculté d'Odontologie, Nancy, France. [2] Université de Lorraine – LEMTA - CNRS - UMR 7563-2, Nancy, France

INTRODUCTION: The shape memory alloys (SMAs) are very interesting in endodontics because of their super-elastic properties. However, only the polycrystalline nickel-titanium (NiTi) is used in endodontics. The Cu-based single crystal SMA shows better responses in bending than the NiTi or Cu-based polycrystalline SMAs. This work investigated a new SMA with very promising properties for endodontic canal preparation: the single crystal CuAlBe.

METHODS: After developing a penetration/removal (P/R) protocol in continuous rotation (Zwick / Roell®), two prototypes of single crystal CuAlBe files 25.04 and 30.04, issued from a finite element analysis, were tested. The resin blocks were pre-prepared in 15.06 and 20.04 for the CuAlBe files 25.04 and in 25.04 for the CuAlBe files 30.04. The HyFlex files were as well tested, as a reference, following the same protocol. The vertical components of the force and displacement was measured. Each test was performed in triplicate at a rotation speed of 350 rpm and a torque of 2 Ncm (X-Smart®, Dentsply®). The used resin blocks had a 40° curved canal and a length of 16 mm (Dentsply®).

RESULTS: The CuAlBe files showed an adequate response with an endodontic practice with maximum P/R values of +1/-4 N. CuAlBe files exhibited a quasi-constant force of penetration whatever the experimental conditions, but a force of removal which increased in the narrowest canals (20.04) (*Fig. 1*). One CuAlBe file 25.04 fractured during the last loading/unloading in a block pre-prepared in 20.04.

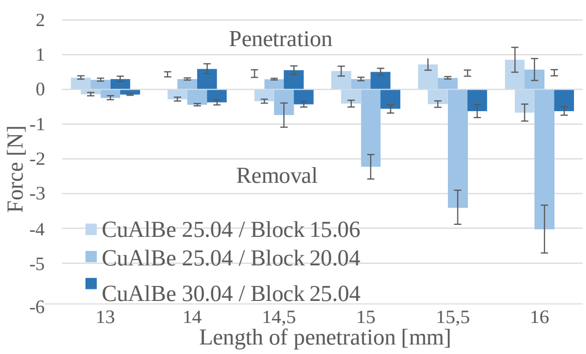

Fig. 1: Responses of CuAlBe files in canal P/R.

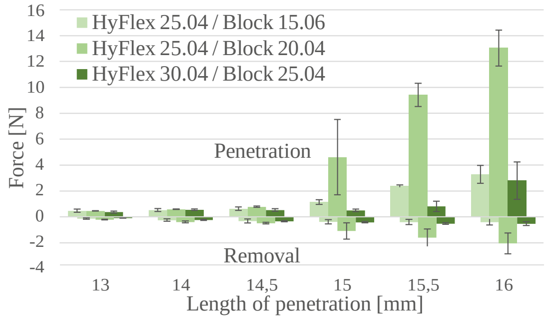

Fig. 2: Responses of HyFlex files in canal P/R.

DISCUSSION: Single crystal CuAlBe is a more flexible shape memory alloy than NiTi but its torsional resistance is lower[1]. In bending, CuAlBe had a low stress-strain slope, resulting in a very small gap of force, contrary to the NiTi. However, the single crystal Cu-based SMA exhibited torsional responses worse than the NiTi (*Fig. 3*). These results showed systematically a small gap for the penetration force whatever the experimental conditions. However, for the removal force, a large gap was present in the narrow canals wherein the torsional stresses were higher, explaining the observed instrumental fracture. Effectively, in resin blocks pre-prepared in 15.06 or 25.04, CuAlBe files showed results in removal (screwing) significantly better than those pre-prepared in 20.04. Results are in agreement with the literature[1].

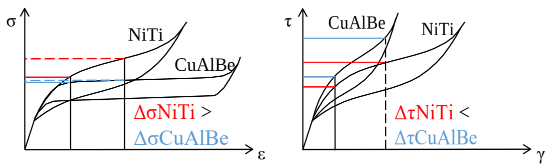

Fig. 3: Mechanical behaviour of CuAlBe and NiTi SMA in bending (left) and torsion (right).

The screwing effect was increased by the triangular reamer cross-section type of the CuAlBe prototypes and by the continuous rotation. Further studies are needed on the cross-section and motion to improve this torsional resistance. Furthermore, copper-based alloys with high copper content have antimicrobial properties that may be useful in endodontics, contrary to the NiTi[2].

Comparison of the tensile strength of yttrium-stabilized zirconia substructures bonded to dentin substrate and various core materials

M Atallah[1], M Abboud[2], EA Zebouni[1], N Rizk[1], M Daou Eggerickx[1], HY Rahme[1]
[1] *Faculty of Dental Medicine, Saint-Joseph University, Beirut, Lebanon.* [2] *Faculty of Science, Saint-Joseph University, Beirut, Lebanon.*

INTRODUCTION: Adhesion of zirconia to resin cement is believed to be poor and unstable. Thus, sandblasting of zirconia at a controlled pressure seems to be a mandatory prerequisite to achieve a durable bond on zirconia ceramics. Hydrolytic stable bonds were obtained with resin cements containing phosphate monomers after sandblasting the zirconia surface. The purpose of this study was to determine the retentive bond strength of yttrium-stabilized zirconia substructures, resin cemented on dentin and different core materials.

METHODS: Preparations identical in size and shape were obtained on natural teeth, zirconia, composite, and cobalt-chromium (CoCr) replicas via a pantograph, computer-aided design and manufacturing technology, and metal casting. Zirconia substructures were then resin cemented to the specimens following their sandblasting at a controlled pressure, application of a primer phosphate monomer (MDP) based and the use of an MDP containing resin cement. Tensile bond strengths were evaluated after 24 hours without thermocycling.

RESULTS: The adhesion strength was the highest on CoCr replicas (8.7±2.5MPa) and the lowest with resin replicas (3.6±1.4MPa). Intermediate values were obtained on natural teeth (4.8±2.1MPa) with the failures being cohesive in these three groups whilst failures were mainly adhesive in the zirconia group (5.85±1.7MPa).

DISCUSSION & CONCLUSIONS: These findings are supported by the review of Heintze[1] in which cohesive failures pass from 20% to 80% as the retentive tensile strength increases from 3MPa to 7MPa. The bonding of RelyX Unicem to CoCr replicas sandblasted and surface treated with a phosphate monomer primer could be better than to dentin. This is related to the covalent bond (M-O-P) as described by Yoshida et al.[2] at the interface CoCr-resin cement between metal oxides at the metal surface and phosphate contained in the primer retained in the surface roughness, and between the methacrylate terminal groups in the primer to the methacrylate groups of the resin cement *(Fig.1)*.

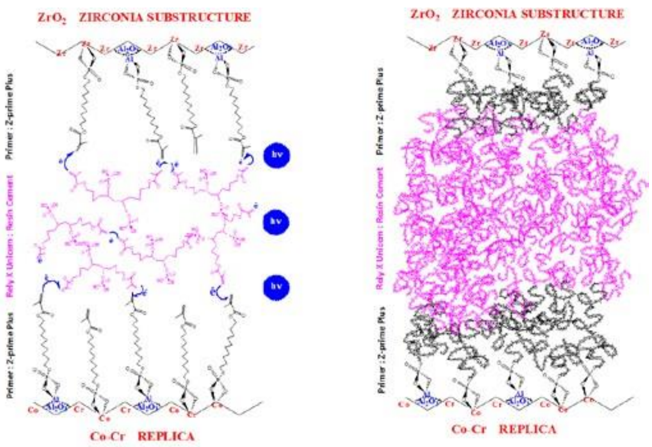

Fig. 1: Chemical bonds formed on the different interfaces in CoCr group.

Adhesive failures on zirconia replicas show that the assembly of resin cement to zirconia is lower than in the three other groups of the study. It is therefore necessary to increase the mechanical retention using another procedure than sandblasting, such as selective infiltration technique[3]. However, 40% of failures are cohesive with values close and sometimes higher than those noted in the literature when bonding zirconia to natural teeth[4]. Within the limits of this study we can conclude that appropriate surface treatment of zirconia provided a satisfactory assembly between this material and dentin as well as various coronal materials used in the daily practice, i.e. metal alloys such as cobalt-chromium, composite, and zirconia.

ACKNOWLEDGEMENTS: The authors thank the Research Council of Saint-Joseph University (Beirut-Lebanon) for their support.

In vitro evaluation of internal/marginal fit of CAD/CAM glass ceramic (IPS e.max® CAD®) and composite nano ceramic (Cerasmart™) inlays

A Goujat[1,2], H Abouelleil[1], M Ducret[2], D Seux[1,2], B Grosgogeat[1,2]

[1] *Laboratoire de Multimatériaux et Interfaces, UMR CNRS 5615, Faculty of Dentistry, University of Lyon, France.* [2] *Service de consultations et de traitements dentaires, Hospices Civils de Lyon, France.*

INTRODUCTION: A good marginal/internal adaptation is essential for the longevity of restorations. Inversely, a poor adaptation can promote dissolution of cement, microleakage, plaque retention, secondary decay, and pulpal/gingival inflammation (1). It has been reported that the maximum acceptable gap in clinical situations is 100-120 µm (2,3). The manufacturer states that the new CAD/CAM resin composite nano ceramic block (CERASMART™) presents better machinability than glass ceramic block which could improve marginal/internal adaptation. The aim of this study was to compare marginal/internal adaptation of new composite block to lithium disilicate glass-ceramic mesio-occluso-distal (MOD) inlays.

METHODS: Thirty human mandibulary molars were selected and prepared for standardized MOD cavity preparations. Then, they were randomly divided into two groups: 15 lithium disilicate glass ceramic IPS e.max® CAD® (Ivoclar Vivadent, Liechtenstein) and 15 resin composite nano ceramic CERASMART™ (GC, Japan) MOD inlays were fabricated using the CEREC 3D system (Sirona, Germany). Internal fit was evaluated using the replica technique by molding the internal surface with addition silicone and the thickness of the pulpal and axial walls was measured (nine preselected locations) (fig.2). Marginal adaptation was measured along occlusal and proximal margins (fig.1) (sixteen preselected locations).

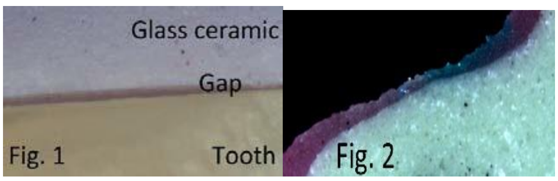

Fig.1: Marginal adaptation Fig.2: Internal adaptation

The measurements were performed using a stereomicroscope (Leica M165 C, Germany) at x 20 magnification.
The data obtained were analyzed statistically using the Student's t-test. The selected level of statistical significance was $p < 0.05$.

RESULTS:

Materials	Internal fit	marginal fit
IPS e.max CAD	**161 (59)**	**41 (22)**
CERASMART ™	**174 (61)**	**59 (38)**

Table 1: mean internal/marginal fit (µm)
(Standard Deviations in parentheses)

The two materials did not show significant differences on marginal/internal fit.

DISCUSSION & CONCLUSION:
Preliminary results demonstrated that glass ceramic IPS e.max® CAD® and resin composite nano ceramic block CERASMART™ produced similar marginal gaps, less than 100 µm (reference value). A recent study have shown a mean marginal gap of 51-54 µm for IPS e.max® CAD® onlays (1) which are in line with our results. The different structure composition of the two materials (CERASMART™ and IPS e.max® CAD®) seems to have no influence on marginal/internal fit.

ACKNOWLEDGEMENTS: We thank the manufacturers (Ivoclar Vivadent, GC), L. Viriot and B. Thivichon for the access of the stereomicroscope (IGFL, UMR CNRS 5242 Lyon, France).

First investigation in fretting corrosion against dental implant and abutment

P Corne[1-2], A-S Vaillant-Corroy[1-2], A. Alsaabi[3], F. Cleymand[2], P. De March[1-2], J. Geringer[3]

[1] *Care teaching and research dental center of Nancy, France.* [2] *Research group Dolphin, Department N2EV, Institut Jean Lamour, UMR 7198, CNRS, Lorraine University, Nancy, France.* [3] *Mines Saint-Etienne, CIS, B2M, UMR, CNRS 5306, Saint-Etienne, France.*

INTRODUCTION: Studying fretting corrosion related to dental implant connections is a new approach for understanding the degradation of mechanism between dental implant and abutment. Two combinations of materials have been investigated corresponding to two links in actual junctions. The behaviour of fretting corrosion between titanium alloy against titanium alloy and titanium alloy against zirconium in artificial saliva has been highlighted.

METHODS: The samples were pure titanium alloy (Ti-6Al-4V, grade V) like screw, implant or abutment and zirconia stabilized with Yttria like abutment. The friction observed was cylinder against plan in order to control contact. The experiments have been carried out thanks to a tribocorrosimeter (fretting) developed by Mines Saint-Etienne and Bose Company [l]. In this way, the sliding distance was sinusoidal of 80 µm during 4 hours. The contact stress was been estimated from the actual junction between implant and abutment (Astra™ TX4.5, Dentsply™/Atlantis™ titanium abutment). The average contact stress was of 130 MPa.

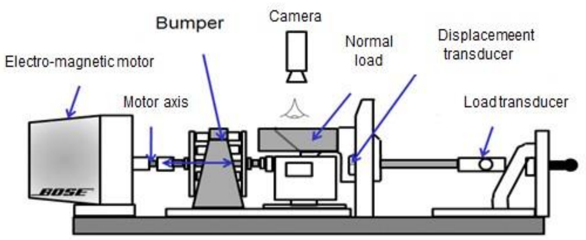

Fig. 1: Fretting-corrosion device [l].

The investigated solution was a Ringer solution added with bovine albumin [2]. Notwithstanding the ionic strength was the same than the one of the human saliva, i.e. is 0,154 mol.L^{-1} [3-4]. The ionic strength was as following:

$$I = 1/2\ z_i.C_i$$

Z_i: number of electrical charges for each ion; C_i: concentration (mol.L^{-1})

Two types of experiments was been carried out: titanium alloy against titanium alloy and titanium alloy against zirconium, in order to reproduce the friction between implant and abutment or abutment and screw.

RESULTS: The total average wear volume of zirconia against titanium alloy was higher that the one related to titanium alloy against titanium alloy. The Open Circuit Potential (OCP) evolution concerning both couples was as expected: decrease at the beginning (corrosion) and increase at the end of fretting phase. The values were the same at the beginning and at the end with combination of titanium alloys. However the OCP evolution of metal combined with zirconia showed that the end-value was lower, sign of corrosion of metal even after fretting test. Some investigations on Electrochemical Impedance Spectroscopy showed the same tendency. Further studies are in progress on this topic.

DISCUSSION & CONCLUSIONS: It seems that friction between zirconia and titanium alloy involves more damage and fragments than titanium alloy against titanium alloy. This alloy seems to be so insulating at the beginning. Under friction, due to OCP decrease, it involves oxides/metal dissolution. The potential goes back up at the end of the experiment because new oxides may appear and protect titanium samples. The experiment with zirconia shows a long and slow rise of potential. That might explain the higher wear volume due to active dissolution even after fretting stop.

ACKNOWLEDGEMENTS: The authors are grateful to the manufacturing lab of Mines Saint-Etienne and hospital of Saint-Etienne, CHU, Orthopedic service, Pr Farizon.

Ceramic veneers design preparation: evaluation with 3d finite elements

F Heichelbech[1], J Krier[2], O Etienne[1,2]

[1]*School of Dental Medicine, Strasbourg University, France.* [2]*National Institute of Applied Science (INSA) of Strasbourg, France.*

INTRODUCTION: The purpose of this study was to evaluate the failure risk of ceramic veneers with 3d finite elements according to 3 designs of preparation[1]: windows preparation **(WP)**, butt margin preparation **(BM)** and incisal overlap preparation **(IO)** (*fig. 1).*

METHODS: The finite elements method is a mathematical tool, which mimics the object's elastic strain, stress and shear elastic strain when strength is applied. For this study, 3 plastic identical teeth were prepared according to the 3 preparation designs.

Fig. 1: Lateral views of design preparations: WP (left), BM (middle), IO (right)

Prepared teeth were scanned with CAD scanner (3Shape), loaded in software (Patran 2010, MSC Corp., Germany) and transformed in 2 objects: enamel and dentin. Adhesive resin cement (100µm thickness) and ceramic veneers were computationally designed and completed the model. Young's modulus and Poisson ratio were inserted in the software (table 1)[2].

Table 1. Tissues and materials physical proprieties

	Young's modulus	Poisson ratio
Lithium disilicate	95 GPa	0.24
Adhesive resin cement	8.3 GPa	0.3
Enamel	84.1 GPa	0.33
Dentin	18.6 GPa	0.32

These tissues and materials were converted in 3D finite elements (Marc 2010, MSC Corp., Germany). A 20N strength[3] was applied at an angle of 135° along the axis of the teeth[4].
Two sites of loading were tested:
i) strength was applied on the palatal face of the veneer **(site 1)**
ii) strength was applied on the incisal edge **(site 2)**.

Maximum stress and shear elastic strains were obtained for veneers and adhesive resin cement layers, respectively.

RESULTS:

Table 2: Maximum stress in ceramic veneers (MPa)

	WP	BM	IO
Site 1	0.45	2.6	2.3
Site 2	0.04	0.49	0.88

Table 3: Maximum shears elastic strains in adhesive resin cement (no units)

	WP	BM	IO
Site 1	4.5^{e-4}	4.1^{e-4}	3.4^{e-4}
Site 2	5.4^{e-4}	4.8^{e-4}	4.1^{e-4}

DISCUSSION & CONCLUSIONS: The tooth preparation design influences the retention and resistance of veneers. According to these results, preparations with incisal edge reduction induce a failure risk in ceramic, contrary to the WP. The adhesive resin cement of WP showed more shear stress, contrary to the IO.

Therefore, some clinical recommendations could be offered. When dentin is exposed in a large area, which compromises the bonding, IO could be recommended to optimize the retention. When preparation is limited to the enamel and when incisal edge should not be modified, WP decreased the failure risk. At least, when preparation is limited to enamel and incisal edge should be modified, the BM design could be recommended.

eCM Meeting Abstracts 2015,
; SFBD (page 23)

Manufacturing alumina dental ceramic by stereolithography

M Dehurtevent[1,2], P Béhin[1], L Robberecht[1,2], E Deveaux1[2],JC Hornez[2]
[1]*Faculty of dentistry, University Lille 2;* [2]*LMCPA, University of Valenciennes, France.*

INTRODUCTION: Ceramic materials are widely used to restore teeth. Ceramic offers the advantages of aesthetics, biocompatibility and high mechanical resistance compared to traditional metallic materials.

However, different shaping processes exist to shape dental ceramics but only direct substractive methods are compatible with the computer-aided design and manufacturing (CAD/CAM). Moreover, this process wastes material and the hardness of ceramic makes it difficult to shape. Several researchers [1] investigated the influence of stereolithography and particle size effects on the 3-point bending (3PB) strength of alumina ceramic and showed some promising results. Bridge infrastructure need at least 300 MPa 3PB strength following ISO 6872:2008 standards. However, the influence of ceramic layer direction - horizontal (H) or vertical (V) - on the porosity and mechanical properties of the ceramic has not been assessed yet.

The aims of this study were to examine the effect of particle size, dry mater content and printed layer direction on viscosity, porosity and 3PB strength of stereolithography manufactured ceramics.

METHODS: Samples for this study were designed by CAD software (Catia, Dassault Systèmes) and oversized to compensate the shrinkage of ceramic densification. Data were sliced by Creation Workshop software (Envisionlabs) and transferred to stereolithography software (CryoCeram Printer, CryoBeryl Software) and equipment (CryoCeram, CryoBeryl Software) for 3D printing. After sintering, sample size was 1.6 x 4 x 20 mm (ISO 6872:2008).

Particle size of alumina powders – small (S, CT3000, Almatis) and big (B, CT1200, Almatis) - were assessed by laser scattering (Malvern 2000, Mastersizer). Four slurries of alumina (S and B powders; 75 and 70% dry matter content in weight, S-75, S-70, B-75, B-70 respectively) and a photosensitive acrylic resin (C1-alumina, CryoBeryl Software) were mixed (PM100, Retsch). After layer-by-layer manufacturing, samples were debinded (650°C, 1°C/min) and densified (1650°C, 15°C/min) under atmostphere. Dedinding temperature was confirmed by differential thermal analysis and thermogravimetric analysis (LabSys evo, Setaram).

Ceramic density was determined by the Archimedes's method (n=3), and 3PB strength (DY30, Adhamel Lhomarghy) (n=6) was assessed for all samples. Slurry viscosity was evaluated at day 0, 1 week and 1 month (Haake, Roucaire).

Statistical analysis was performed by analyse of variance (ANOVA) and Tukey multiple comparison post-test.

RESULTS: Median alumina particle size was 0.5 µm for S and 1.6 µm for B. The high viscosity of S-75% (0.06 Pas) restrained stereolithography. Viscosity of all slurries increased in time, exceeding 0.09 Pas after 1 month.

Porosity of B-70 and S-70 was higher than B-75 ($p < 0.05$). There was no statistical difference between B-75-H and V concerning porosity ($p > 0.05$).

B-75-H (343.7 ± 18.59 MPa) and B-75-V (388.67 ± 66.84 MPa) showed both 3PB strength superior to 300 MPa (Fig.1).

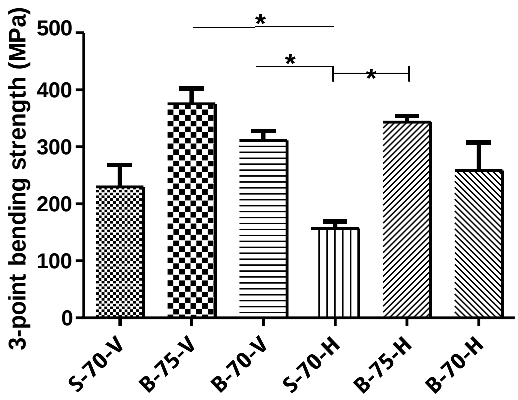

Fig. 1: Mean 3-point bending strength of densified alumina samples (: p < 0.05)*

DISCUSSION & CONCLUSIONS: Ceramic porosity was inversely related to dry matter content. Slurries degraded after 1 month. B-75 showed good printing behavior. Its porosity and 3PB strength respond to ISO 6872:2008 dental crown standards, but particular attention has to be paid to printing parameters.

3D modeling of sinus lift technique - Volume analysis

C. Maillet[1-2], P. Millet[1-2], H. Citterio[1-2]

[1] *LISM EA4695, UFR Odontologie de Reims, URCA.* [2] *Pôle Odontologie, CHU Reims, France*

INTRODUCTION: Since the first researches published by Bränemark in the 50s, implantology is constantly evolving. This discipline tends to attract more patients and practitioners. One of the major criteria for implant placement and integration is the available bone volume. In the maxillary posterior regions in edentulous patients, the height of the residual bone in sinus may be less than or equal to 5mm. Bone grafting techniques can correct this deficiency by providing the needed bone volume. They are known as sinus lift technique. However during this surgery, the surgeons do not measure the volume of grafted material generated. It may happen that in the delayed placement of implants, a lack of hard tissue is observed. Therefore, knowledge of the average volume graft is particularly interesting. The objective of this research was to use a three-dimensional analysis of available volumes in order to anticipate the volume of bone fillers needed.

METHODS: The method was based primarily on a 3D reconstruction permitted by files obtained by Cone Beam CT. The acquisition of the cylindrical maxillofacial volume was permitted in a single rotation of the system. CBCT data are imported in Amira 5.2.0 software (Mercury System). On 5 patients, bone volume gained after 6 months of sinus lift was calculated. For one of them (G.C.), the volume of filler that should be injected in order to place a long implant, was tried to predict from 3D X-ray images (13mm). For the four others, no usable preoperative radiological data was available. In figure 1, the segmentation of bone filling is underlined in purple in 3 planes of space.

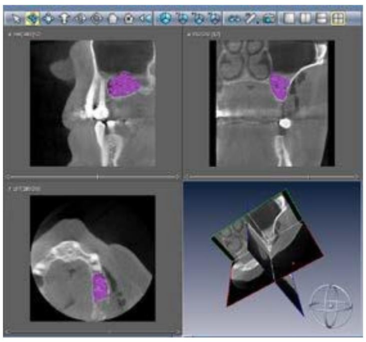

Fig. 1: On each section, the entire bone filler is selected manually using the segmentation editor.

RESULTS:

Table 1. Measurements of different bone fillings after 6 months of osseointegration.

Patients	Volume (cm^3)	Heigth (mm)	Depth (mm)	Thickness (mm)
G.C.	1,90	17,1	18,0	11,7
G.G.	2,42	15,0	22,3	16,7
V.C.	2,74	17,6	26,4	16,3
N.M.	2,86	17,0	27,1	14,0
B.C.	3,68	16,0	24,0	16,3

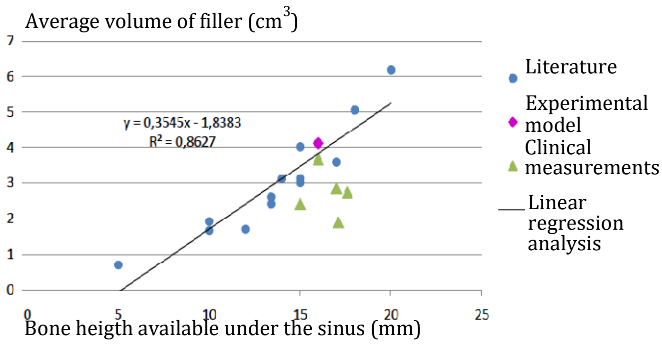

Fig. 2: Bone filling volumes achieved clinically (green), the simulation of this study (pink), the values found in the literature (blue).

DISCUSSION & CONCLUSIONS: This study revealed an average bone gain of 2.79 cm^3 at 6 months post-surgery. This result is similar to the study conducted by Kirmeier *et al.* (average 2.28 cm^3 on average at 6 months). The results of this study, obtained through CBCT examinations are similar with other results already observed, from files from medical scanners. CBCT has therefore proved to be a good CT system, equally effective, less radiant and cheaper, as the medical scanner.

ACKNOWLEDGEMENTS: Authors would like to Dr Philippe RUSSE for kindly providing the different cases presented in this work.