"The New Materials and the New Restorative Dentistry-Opportunities and Challenges"

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LEHIGH VALLEY HEALTH NETWORK
CONTINUING EDUCATION PROGRAM
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Kornberg School of Dentistry
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THE MAJOR CURRENT TRENDS OF TECHNOLOGY CHANGE

- NON-IONIZING DIAGNOSTICS
- REMINERALIZATION & REMINERALIZING MATERIALS
- MORE STABLE ADHESIVE STRATEGIES
- ADVANCES IN LASERS
- BIOMIMETIC, BIOACTIVE MATERIALS
- LASERS – SMALLER, LOWER COST, MORE "REAL" USES
- TISSUE ENGINEERING, ADVANCED IMPLANT SURFACES
- ANTIMICROBIAL, MORE DURABLE COMPOSITES
- TECHNOLOGY FOR MINIMALLY INVASIVE DENTISTRY (MID)
- STRONGER ALL CERAMIC MATERIALS

PRODUCT TRENDS 2015

- **MINIMALLY INVASIVE DENTISTRY (MID)/EARLY DIAGNOSTICS/EARLY TREATMENT**
- **BULK FIL RESTORATIVES**
- **THE LATEST EMERGING CLASS OF ADHESIVES - UNIVERSAL ADHESIVES**
- **NON-RADIOGRAPHIC DIAGNOSTICS**
- **REGENERATIVE PULP THERAPY & ENDODONTICS**
- **NEW RESIN CEMENT FORMULATIONS**
- **BIOACTIVE RESTORATIVES & LUTING AGENTS**
- **CAD/CAM GENERATED-FABRICATED RESTORATIONS**
- **HIGH-STRENGTH ALL-CERAMICS**
- **REPAIR & MAINTAINANCE OF EXISTING RESTORATIONS**

DRIVERS/OBTACLES FOR TECHNOLOGY ADOPTION

- Improved Performance
- Improved Efficacy
- Reduced treatment time
- Reduced procedure cost
- Less invasive
- New information forces change
- Reasonable payback on investment

- More complex
- High cost
- Increased procedure time
- Limited/Poor Training
- "Too New"
- Lack of efficacy data
- Lack of effectiveness data
- Limited or no clinical data

MINIMALLY INVASIVE DENTISTRY (MID)

EARLY DIAGNOSTICS - EARLY TREATMENT

REMINERALZATION TECHNOLOGY

INFILTRATION TECHNOLOGY

INCIPIENT/EARLY ENAMEL DEMINERALIZATION

Early Interproximal Lesions

Smooth Surface Demineralization (Ortho "White Spot Lesions")

New Diagnostic Technologies in Caries Management & Treatment

- Caries Risk Assessment
- Caries Diagnostics
- Prevention
- Early Intervention - Remineralization
- Patient Monitoring

What's new in caries diagnosis & treatment?

- Early diagnostics
- Transmission of organisms
- Risk Assessment
- Virulence factors
- NEW DIAGNOSIS DEVICES
- Populations in need/access to care
- Individualized treatment planning
- REMINERALIZATION TECHNOLOGY

Caries Diagnostic Technologies/Techniques

- Visual
- Radiographic – Computer Assisted Interpretation - Logicon
- DiagnoDent
- SoproLife & Spectra (Caries Detection/Intra-Oral Camera)
- Conventional Translumination
- Dexis CariVu
- The Canary System
- Intraoral Microscopy (Microscope)

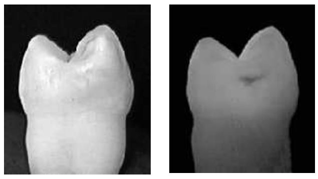
Useful diagnostic?

- **Sensitivity (false negatives?)**
- **Specificity (false positives?)**
- **Reliability**
  - **Intra-examiner**
  - **Inter-examiner**

Laser-Induced Fluorescence of Carious Tissue

- Kutsch, in 1992, illuminated carious and non-carious tissue together with an argon laser together with dark field photography.
- He reported that while illuminating, carious lesions in teeth had a clinical appearance of dark, fiery, orange-red color.
- Will discuss hard tissue fluorescence further in the section of new caries diagnostic devices.

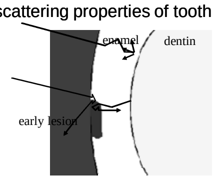
QLF contrast enhancement



white light **QLF**

Principle of operation

- Contrast enhancement follows from scattering properties of tooth tissue



Translumination & An Idea?

- Why not combine a quality transluminator with a high-resolution intra-oral camera?

Caries Diagnostic Technologies/Techniques

- Visual
- Radiographic – Computer Assisted Interpretation - Logicon
- DiagnoDent
- SoproLife & Spectra (Caries Detection/Intra-Oral Camera)
- Conventional Translumination
- Dexis CariVu
- The Canary System
- **Intraoral Microscopy (Microscope)**

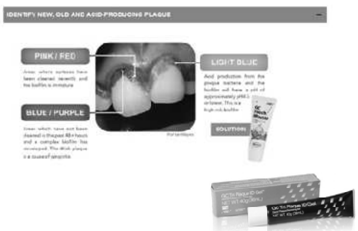
Operating Microscope

Advantages of the operating microscope are:

- homogeneous illumination;
- a 3-dimensional view,
- together provide clear visualization of the examination site.

A NEW APPROACH IN CARIES DISCLOSING DYE

GC Tri Plaque ID Gel



AN UNMET CHALLENGE IN CARIES DIAGNOSIS

- WE DO NOT YET HAVE A DIAGNOSTIC METHOD OF DEVICE THAT WITH <u>ACCURACY OR PRECISION</u> INDICATION THE SIZE AND DEPTH OF THE CARIOUS LESIONS.

THE FINAL CHALLENGE

- WE DO NOT YET HAVE A DIAGNOSTIC TEST OR DEVICE WHICH WILL TELL US IF THE CARIOUS LESION IS “ACTIVE” OR “INACTIVE”!!!

ADVANCES IN REMINERALIZATION FOR EARLY CARIOUS LESIONS: THE EMERGING QUEST IN ORAL HEALTH

New Remineralization Technology

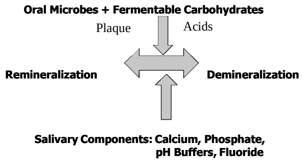
Treatment of Incipient Carious Lesions

Integration with Minimally Invasive Dentistry (MID)

Caries Therapies

- Early – remineralization techniques
- Late – restorative techniques
- Mid – combination of above

The Oral Equilibrium Between Demineralization/Remineralization

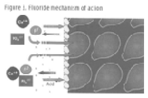


FLUORIDE THERAPY

Table 1. Fluoride ion concentration

Topical fluoride	Fluoride concentration
1.23% APF gel and foam	12,300 ppm
2% NaF gel, foam and rinse	9,040 ppm
5% NaF varnish	22,600 ppm
Dual rinse (APF/SnF)	3,300 ppm

Figure 1. Fluoride mechanism of action



○ = calcium fluoride-like globules

New Calcium-Based, Remineralization Agents

AMORPHOUS CALCIUM PHOSPHATE (ACP)

CASEIN PHOSPHOPEPTIDE (RECALDENT)

TRI-CALCIUM PHOSPHATE (TCP)

PARTICULATE BIOGLASS (NOVAMIN)

Amorphous Calcium Phosphate

- A reaction product of dicalcium phosphate and tetracalcium phosphate, developed by Ming S. Tung at the American Dental Research Association’s Paffenbarger Research Center.
- The calcium and phosphate remain in a relatively “amorphous” or “non-crystalline” state, increasing their bioavailability.

ACP

- AMORPHOUS Calcium Phosphate
- NO Structure
- ACP is created through chemical reaction
- TCP is a crystal put into rosin medium
- ACP dissolves into saliva and is delivered directly to teeth (4X and 2X)

Recaldent®

- Recent developments by Recaldent have made it possible to bring calcium and phosphate in an amorphous form to the mouth.
- By means of casein phosphopeptide, a complex is created with the amorphous calcium phosphate and the resulting CPP-ACP molecule binds to biofilms, plaque, bacteria, hydroxyapatite and surrounding soft tissue, thus localizing the bio-available calcium and phosphate.
- Recaldent is available in a MI Paste and MI Paste Plus (contains fluoride) from GC Dental.
- Numerous claims: remineralization, desensitization, caries inhibition (MI Plus – has Fluoride).

Recaldent

- A **phosphopeptide** is a peptide incorporating one or more phosphate groups, typically associated with protein phosphorylation.
- Caseins are a special group of phospho-peptides found usually in milk and milk products.
- May enhance stability and transport of calcium via phospho-peptide group interactions

What is NovaMin?

NovaMin is the brand name of a particulate bioactive glass that is used in dental care products for Remineralisation of teeth. It was developed and patented by NovaMin Technology, Inc..

In aqueous solutions, NovaMin consists of 45% SiO_2, 24.5% Na_2O, 24.5% CaO and 6% P_2O_5. The active ingredient is called **Calcium Sodium Phosphosilicate**[1]

NovaMin delivers an ionic form of calcium, phosphorus, silica, and sodium which are necessary for bone and tooth mineralization.

SO IS THERE CLEARLY A SUPERIOR PRODUCT FOR REMINERALIZATION

- NOT CLEAR AT THIS TIME.
- FLUORIDE IS STILL THE MAJOR COMPONENT – BOTH IN RESISTENCE TO DEMINERALIZATION & PROMOTION OF REMINERALIZATION.
- ALL CONTAIN THE MAXIMUM AMOUNT OF FLUORIDE (i.e. VARNISH – 5%).
- ONLY RCT CLINICAL DATA CAN SOLVE THE ISSUE – VERY EXPENSIVE!!!

Assessment & Therapy

New Approaches to the Management & Treatment of Dental Caries

- New diagnostic technologies are emerging in dentistry & will provide a wider range of treatment options.
- Legal, insurance, and standards of care will influence this trend.
- Treatment protocols and decisions will also be influenced.
- THANK YOU!!

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EXPLORING NEW TECHNOLOGIES FOR:

MINIMALLY INVASIVE DENTISTRY
"MID"

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Light Amplification by Stimulated Emission of Radiation "LASER"

Two Basic Laser Categories in Medicine/Dentistry

1) HARD LASERS
- Longer wavelengths
- Cuts by ablation of tissue
- Used for tooth and bone applications

2) SOFT OR LOW ENERGY LASERS
- Low energy wavelengths
- Cuts tissue by coagulation, vaporization, and carbonization

Clinical Uses – Dental Lasers

- **Caries Diagnosis**
- **Cutting Soft Tissue**
- **Cutting Hard Tissue**
- **Wound healing**
- **Tooth whitening**
- **Removal of Porcelain Veneers (Er:YAG)**
- **Periodontal Therapy (PerioLase)**
- **Endodontic Cleaning & Debridement (PIPS)**

Dental Lasers

Diode Laser
-630nm-980 nm wavelength
-Laser vibrates tip molecules, which are converted to heat

Diode Laser Uses
-Gingevectomy
-Gingivoplasty
-Crown preparation troughing

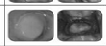
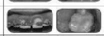
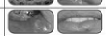
Dental Lasers

Diode Laser

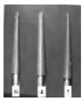
Advantages
- -Affinity for
  - pigments in tissues
  - hemoglobin
  - bacteria
- -Little contraction and scarring
- -Little postoperative gingival recession
- -Compact size
- -Affordable
- -Reduced chance of tissue/tooth damage

Disadvantages
- -unable to cut bone or tooth (can be an advantage)
- -Cost
- - Slower cutting than electrosurgical

Clinical Uses – Diode Laser

Procedure	Clinical Images	Total Diode Solution	CDT Codes	Savings/Added Revenue (50% Fees)
Laser Curettage / Sulcular Debridement		Decreased Recurring Pain; In-office Procedure; Minimally Invasive; Access & Field of Vision; Minimal Post op Discomfort	No Definitive Code	Add $30-$100 per Visit
Troughing for C&B Impressions		No Cord Required; Accelerated Treatment; Decreased Impression Re-takes; Minimal Post op Discomfort	No Definitive Code	Saves approx. 5 min. per crown prep [$35/crown prep at $400/hr.]
Gingival Recontouring, Hyperplastic Tissue & Operculectomy		Minimally Invasive; Minimal Collateral Tissue Damage; Accelerated Treatment; Minimal Post op Discomfort	4210, 4211	$191-$500/quad
Frenectomy		In-office Procedure; Topical Anesthetic; No Sutures/Laser Bandage; Minimal Post op Discomfort	7960	$355
Aphthous Ulcers & Herpetic Lesions		Immediate Comfort	7465	$388
Whitening		In-office Procedure; Accelerated Treatment Time	9972	$250/arch
Temporary Relief of Minor Pain (such as TMD condition)		In-office Procedure for Temporary Relief of Minor Pain	No Definitive Code	$49-$500

Other "MID" or Tooth Preparation Technology



Fissurotomy Bur creating access

Fissure is clean and restored

Icon™ Resin Infiltration System

- **•Incipient caries indication still needs further clinical documentation & lacks reimbursement codes.**
- **•Fluoride Gel/Varnish interproximal application are alternative treatments.**
- **•Esthetic treatment of white spot lesions has attracted more attention, especially in the US.**

ADVANCES IN MATERIALS & RESTORATIVE PROCEDURES

- **CAD/CAM & HIGH STRENGTH CERAMICS**
- **ADVANCES IN COMPOSITE RESIN DIRECT RESTORATIVES**
- **NEW MATERIAL CATEGORY – BIOACTIVE MATERIALS**

AN OVERVIEW OF CAD-CAM DENTAL TECHNOLOGY

LAVA COS
Itero
CEREC
E4D

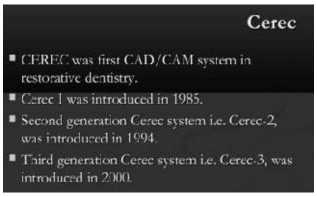
THE FABULOUS FOUR OF DENTAL CAD-CAM

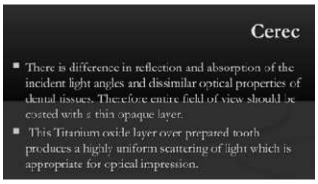
SYSTEM OPERATING FACTORS

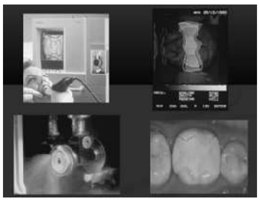
- OPTICAL VS. LASER SCANNER
- POWDER VS. NO POWDER
- STILL IMAGES VS. VIDEO IMAGES

THE EVOLUTION OF CHAIRSIDE CAD-CAM - CEREC

- First restorations placed in 1985
- 2D to 3D images
- Separation of the imaging and milling units.







EVIDENCE-BASED, LONG-TERM CLINICAL OUTCOMES

CEREC 1, 1a, & 2
CAD/CAM RESTORATIONS

CERAC 1 & 2 – LONG-TERM CLINCIAL DATA

- **Conclusion:**
  The long-term results (95.5% survival after nine years) are excellent, although CEREC 1 and CEREC 2 did not achieve today's level of clinical precision and quality of the marginal integrity (however compensated for using macrofilled luting materials).
- Posselt A, Kerschbaum T, Longevity of 2328 chairside CEREC inlays and onlays, Int J Comput Dent; 6: 231–248

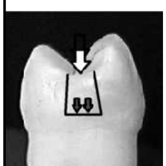
A CONUNDRUM?

TERRIBLE MARGINS

BUT
EXCELLENT, LONG-TERM CLINICAL RESULTS?

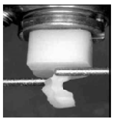
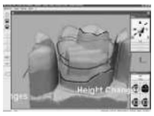
WHY?

Occlusal forces on Proximal Box



AMALGAM	COMPOSITE
CS: 300 – 500 MPa	CS: 200 – 380 MPa
FS: 130 – 170 Mpa	FS: 90 – 150 MPa
Modulus: 15 – 55 GPa	Modulus: 2 – 12 GPa

CEREC 3D

CEREC: 3D INFRARED VS AC BLUC CAM

3D Infrared Camera vs. AC Blue Camera

	3D infrared camera	AC Blue Camera
Measuring Technique	Active Triangulation	Active Triangulation
Pixel Size	25 x 2[illegible] µm	2[illegible] x 2[illegible] µm
Low-Noise CCD sensor	[illegible] pixels	[illegible] pixels
Light Source	Infrared, polarized, [illegible] nm	Blue LED, polarized, 470 nm
Image acquisition	Philips PNX 1500, 133MHz TriMedia TM processor	Image control inside the camera
memory	16MB ultrafast SDRAM	16MB ultrafast SDRAM
image processing	Intensity measurement of 1.4 mil. Pixels in 0.133 sec	Intensity measurement of 1.4 mil. Pixels in 0.07[illegible] sec
image data transfer	Max. 30 MB/sec	Dependent on fast USB 2.0 Standard

LAVA C.O.S.

- The LAVA C.O.S. captures the 3-D surfaces of the teeth directly in the mouth using video capture.
- This data is then used to create SLA resin models from which any restoration can be fabricated.
- *Unique features*:

 a. Real-time Video Capture and feedback (3-D-in-motion)

 b. Intuitive touch screen interface

 c. LAVA (Zirconia) copings can be milled in the

 d. laboratory direct from the capture data.

iTero

- **<u>User interface.</u>**
 The iTero utilizes a wireless foot pedal during the image capture process to allow the operator to confirm or retake each image. The pre- and post-capture input is done with a wireless mouse and a sealed keyboard

iTero

- **<u>What it does.</u> The iTero captures the 3-D surfaces of the teeth directly in the mouth using a confocal (laser and optical) image series (usually about 21 images). This data is then used to create CAD/CAM resin models (Figure rt) from which any restoration can be fabricated.**

- **Features**
 a. True powder-less image capture
 b. Talks user through each of the 21 images
 c. Geller-type (resin) models.

E4D System

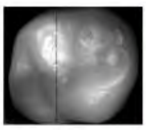
- Workflow for E4D is similar to CEREC, but there are system differences.
- E4D captures images from 3 separate angles (buccal, lingual, and occlusal) for each tooth using a laser. This reduces any error that might be introduced by automated "patching" (filling in) of areas that are below the height of contour and cannot be picked up from a top-down image alone. However, it does increase the number of images that must be taken.

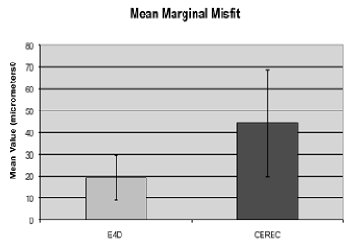

E4D System

- The E4D mill can produce all types of indirect restorations (inlays, onlays, crowns, veneers, etc) from a variety of materials (composite, leucite-reinforced and lithium disilicate ceramics.)
-

Fig 1. Final design before milling

NYU Marginal Fit Study: E4D vs. Cerec





Observations & Conclusions of the NYU Marginal Fit Study

- E4D exhibited a reduced and more homogeneous fit based on assessment of fit at buccal, lingual, and center positions. This might be due to software improvement and/or different machining approaches used in the E4D system.
- The CEREC-produced specimens in this study fit least well at the center.
- Studies by the NYU group (*Silva NR, de Souza GM, Coelho PG, Stappert CF, Clark EA, Rekow ED, Thompson VP. Effect of water storage time and composite cement thickness on fatigue of a glass-ceramic trilayer system. J Biomed Mater Res B Appl Biomater. 2008 Jan;84(1):117-23*) suggest that increased cement thickness reduces the load required to initiate a radial crack in this area of the crown, potentially making crowns with less precise fit more vulnerable to fatigue failure.
- The CAD/CAM technology has been considerably improved in the past years. However marginal accuracy of CAD/CAM restoration is still dependent upon adequate cavity preparation and equipment operation.

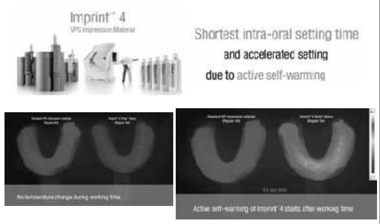
HOWEVER, THIS MARGINAL FIT STUDY INDICATES THAT BOTH THE CERAC & E4D SYSTEMS CAN PRODUCE MARGINAL FIT WELL WITHIN CLINICALLY ACCEPTABLE VALUES (I.E. <80-100 MICRONS)

Critical Problem for Optical & Conventional Impressions – margins at or below the margin of the gingival sulcus

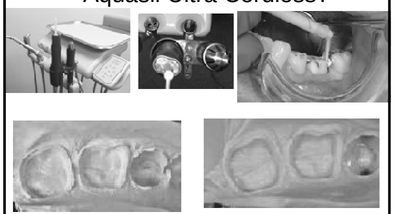
What's New In Impression Materials?

- Aquasil Ultra Cordless
  (Dentsply/Caulk)
- Imprint 4
  (3M ESPE)

What's New in Impression Materials Imprint 4 – 3M ESPE



What's New In Impression Materials – Aquasil Ultra Cordless?



ADVANCED LABORATORY FABRICATED CERAMIC MATERIALS

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The PFM Restoration

- The gold standard for ceramic restorations is clearly porcelain-fused-to-metal (PFM). With PFM, it is reasonable to expect a 10- to 15-year survival rate of 95%, with the incidence of porcelain chipping around 4 to 10%.
- With the use of porcelain facial margins and proper tooth preparations, good to excellent esthetic results can be anticipated.
- PFM restorations have been popular for decades because they provide a combination of reasonable esthetics coupled with maximum longevity.

Winds of Change

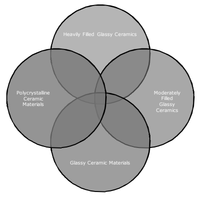
- However, recent years have seen dramatic increases in the basic price of gold and other noble metals used with porcelain bonding alloys, which has resulted in a significant increase in laboratory costs.
- This increase in cost, coupled with society's obsession with esthetics, has resulted in increased interest in ceramic restorations.

Ceramic Materials - 2015

- **There are four (4) groups of ceramic materials that have a sufficient level of clinical testing and/or anecdotal evidence that clinicians should investigate and consider for use with their patients:**

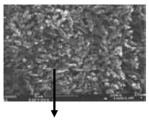
1) *Leucite-reinforced glass-ceramics*
2) *Lithium disilicate glass ceramic* restorations
3) *Layered zirconia* crowns
4) *Monolithic zirconia* restorations

Dental Ceramic Classification by Composition



Pressable Ceramics – 2nd Generation

Empress 2 now eMax



Lithium Disilicate ~ 85%

- Material type: Lithium disilicate glass ceramics
  - Strength ~ 350 MPa
  - Toughness ~ 2.0
- Brand examples: Empress 2 –NOW eMAX
- Advantages: Highly esthetic, translucent, slightly stronger
- Indications: Single crowns, anterior 3 unit bridges (large 4x5mm connectors)
- Bonding & conventional cementation

eMax

Lithium Disilicate Reinforced Ceramic

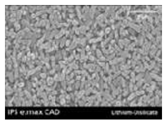
Table 1. Properties of IPS e.max Press.

CTE (100-400°C [10^{-6}/K]	10.2
CTE (100-500°C) [10^{-6}/K]	10.5
Flexible strength (biaxial) [MPa]	400
Fracture toughness [MPa $m^{0.5}$]	2.75
Modulus of elasticity [GPa]	95
Vickers hardness [MPa]	5,800
Chemical resistance [µg/cm^2	40
Press temperature EP 600 [°C]	915 to 920

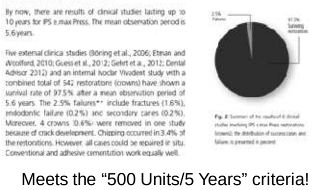
Table 2. Properties of IPS e.max CAD.

CTE (100-400°C [10^{-6}/K]	10.2
CTE (100-500°C) [10^{-6}/K]	10.5
Flexible strength (biaxial) [MPa]	360
Fracture toughness [MPa $m^{0.5}$	2.25
Modulus of elasticity [GPa]	95
Vickers hardness [MPa]	5,800
Chemical solubility [µg/cm^2	40
Crystallization temperature [°C]	840 to 850

Microstructure – Lithium Silicate Crystals



Clinical Results: eMax Press Crowns



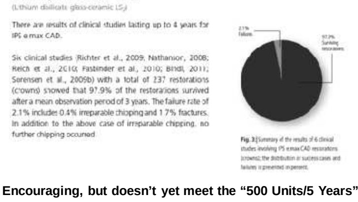
Summary of IPS e.max® Press
Lithium disilicate glass-ceramic (LS$_2$)

By now, there are results of clinical studies lasting up to 10 years for IPS e.max Press. The mean observation period is 5.6 years.

Five external clinical studies (Böning et al., 2006; Etman and Woolford, 2010; Guess et al., 2012; Gehrt et al., 2012; Dental Advisor 2012) and an internal Ivoclar Vivadent study with a combined total of 542 restorations (crowns) have shown a survival rate of 97.5% after a mean observation period of 5.6 years. The 2.5% failures** include fractures (1.6%), endodontic failure (0.2%) and secondary caries (0.2%). Moreover, 4 crowns (0.6%) were removed in one study because of crack development. Chipping occurred in 3.4% of the restorations. However, all cases could be repaired in situ. Conventional and adhesive cementation work equally well.

Meets the “500 Units/5 Years” criteria!

Clinical Results: eMax CAD Crowns



Summary of IPS e.max® CAD
(Lithium disilicate glass-ceramic LS$_2$)

There are results of clinical studies lasting up to 4 years for IPS e.max CAD.

Six clinical studies (Richter et al., 2009; Nathanson, 2008; Reich et al., 2010; Fasbinder et al., 2010; Bindl, 2011; Sorensen et al., 2009b) with a total of 237 restorations (crowns) showed that 97.9% of the restorations survived after a mean observation period of 3 years. The failure rate of 2.1% includes 0.4% irreparable chipping and 1.7% fractures. In addition to the above case of irreparable chipping, no further chipping occurred.

Encouraging, but doesn’t yet meet the “500 Units/5 Years” cr

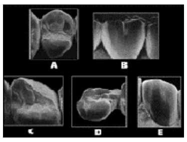
Zirconia – Framework Restorations

Status - 2015

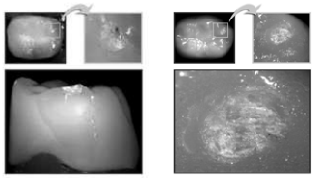
Introduction - 2001

- Limited clinical data was available.
- Nevertheless, use of CAM and CAD-CAM was a considerable driving force;
- As was the possibility of a high-strength, metal-free alternative;
- As was laboratory efficiencies in production; including overseas production.

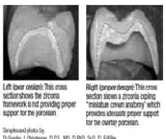
CRA Zirconia Study Data & Specific Framework Recommendations



NYU In-Vitro Fatigue Study: Zirconia vs. eMax



Possible Solutions to the Zirconia Problem?



Possible Solutions to the Zirconia Problem?

ALL ZIRCONIA vs Emax

Choices

- Strength vs Durability?
- Esthetics?
- Clinical Data (of any kind)?

Clinical Data on All Zirconia

Limited – But now available

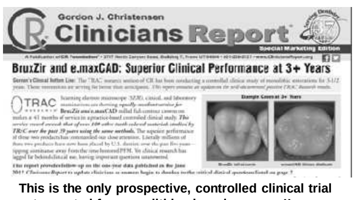
Two Sources

- Trac Research (Formerly CRA)
- The Dental Advisor

Retrospective Clinical Evaluation: BruxZir Monolithic Zirconia

Clinicians Report – TRAC Research

Drs. Gordon & Rella Christensen



This is the only prospective, controlled clinical trial yet reported for monolithic zirconia crowns!!

TRAC Conclusions:

- "BruxZir and e.maxCAD full-contour crowns on molars have demonstrated clinical service superior to all other tooth-colored materials studied clinically by TRAC over 39 years. To date, their service record resembles that of cast metal."
- "Clinical service over three plus years has begun to answer many critical clinical questions, but important questions remain on possibility of phase change of zirconia in 100% humidity of the oral cavity, glaze use, service life, and failure mode."
- "Status reports will be forthcoming as answers to these and other pertinent questions emerge through this study."

Bruxzir Clinical Video

https://www.youtube.com/watch?v=f2-sWcSPlbk

Major Clinical Issue – Zirconia Frames/All - Zirconia

RETENTION
Why???

Surface Contamination - Zirconia

- **Salivary Phospho-Proteins**
- **Ivoclean**

A SILENT REVOLUTION???

RESTORATION TYPE	2007	2012
PFM	~72%	~24%
ALL CERAMIC	~22%	~73% (~50-70% as all zirconia)
OTHER	~6%	~3%

Comparative Unit Costs of Metal-based & All Ceramic Crowns

TABLE 1 Type of crown and average cost (based on survey of five commercial laboratories)

PFM (high noble)	$273
PFM (noble)	$248
Cast Gold	$314
IPS Empress (layered)	$219
IPS e.max (layered)	$212
IPS e.max (monolithic)	$196
Zirconia (layered)	$242
Zirconia (monolithic)	$171

Ahmed & Donovan. Evaluation of Contemporary Ceramic Materials. 2015; Journal of Esthetic and Restorative Dentistry. 27(2) 59–62.

Partial List of Currently Available Zirconia Crowns

SO IF THERE WASN'T A PROBLEM WITH PORCELAIN-VENEERED ZIRCONIA SUBSTRUCTURES, WHY DID THE MAJOR COMPANIES DEVELOP THEIR OWN VERSIONS OF MONOLITHIC ZIRCONIA??????

FOR EXAMPLE:

Lava Plus – Monolithic zirconia

Cercon ht – Monolithic zirconia

TABLE 2. Brand names and manufacturers of zirconia crowns

Brand names	Manufacturer
Lava	3M ESPE, St. Paul, MN, USA
BruxZir	Glidewell Laboratories, Newport Beach, CA, USA
Zenostar	Ivoclar Vivadent, Inc., Amherst, NY, USA
KATANA Zirconia HT (high translucency) and ML (multilayered)	Kuraray Noritake, Tokyo, Japan
Prettau Zirconia	Zirkonzahn USA, Norcross, GA, USA
NexxZr	Sagemax Bioceramics, Inc
Cercon ht	Dentsply Prosthetics, York, PA, USA
Vita IN-Ceram YZ	Vident, Brea, CA, USA
GC Initial	GC America Inc., Alsip, IL, USA
Zirlux	Zahn Dental Laboratories, a division of Henry Schein, Melville, NY, USA
CAP Multi FZ	Advanced Dental Technologies, Stoneham, MA, USA

Partial List of Currently Available Zirconia Crowns

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CAP Multi FZ	Advanced Dental Technologies, Stoneham, MA, USA

Layered Zirconia Crowns

- One problem with layered zirconia crowns, which has been seen in almost all clinical trials, is the cohesive chipping of the veneering ceramic.
- This chipping, which occurs approximately five times more frequently than with PFM restorations, does not always necessitate replacement of the crown, but it has been a persistent problem.
- Causes of the chipping may be lack of support of the veneering ceramic by the core and the low thermal conductivity of the core material.
- The latter problem may have been resolved by utilization of slower cooling cycles, and the former issue has been resolved with improved software programs to insure optimum support by the core.

Ahmed & Donovan. Evaluation of Contemporary Ceramic Materials. 2015; Journal of Esthetic and Restorative Dentistry. 27(2) 59–62.

Update & Key Facts: Zirconia Restorations

- *Monolithic zirconia* restorations have only been in use for a few years, so no long-term clinical trials are available.
- Most authorities are optimistic regarding survival rates based on the fact that so few zirconia cores have fractured in clinical trials, and a monolithic or full-contour zirconia crown is essentially an unveneered zirconia core.
- They have very high flexural strength (1200–1400 MPa) and have been used experimentally with large multi-unit restorations.
- Because of these excellent properties, more conservative tooth preparations are possible compared with those used with PFM, lithium disilicate, or layered zirconia crowns.

Update & Key Facts: Zirconia Restorations

- Another advantage of monolithic zirconia crowns is that when polished well, they are very kind to opposing tooth structure, and multiple in vitro studies have shown much less wear of enamel than with other types of ceramic.
- These restorations are relatively opaque, resulting in reduced esthetics compared with layered restorations.
- They are also relatively inexpensive with an average cost of $171.
- The major indication for monolithic zirconia crowns is for posterior teeth where esthetics is not critical, especially for second molars when patients decline cast gold restorations.
- Because zirconia crowns can be fabricated with significantly less tooth reduction, another indication is for crowns on mandibular anterior teeth.

Update & Key Facts: Zirconia Restorations

- Zirconia cannot be etched with hydrofluoric acid because their molecular structure is different from glass ceramics.
- Protocols involving airborne particle abrasion bonding with MDP primers and resin cements have been tested in vitro, but they generally form relatively weak bonds that deteriorate with aging and run the risk of transformation of the entire crown or core as a result of particle abrasion.
- In the opinion of the authors, zirconia crowns are best used with retentive preparations and cemented.

Update & Key Facts: Zirconia Restorations

- It should be noted that the internal surface of zirconia crowns is usually contaminated with saliva and possibly blood during try-in, and has a strong affinity to salivary proteins that are not easily removed. If these are not removed, crowns can be prematurely dislodged.
- The best protocol for cleaning the internal surface is to use a solution of zirconium oxide (zirconia) in sodium hydroxide (Ivoclean, Ivoclar Vivadent) for 20 seconds followed by rinsing with water.

SUMMARY & CONCLUSIONS: ALTERNATIVES TO PFMS

SUMMARY AND CONCLUSIONS

- Clearly PFM is the gold standard for esthetic crowns restorations, but the price of noble metals has driven laboratory costs to unprecedented levels.
- Advances in materials and technology have resulted in the development of four ceramic systems that can be considered as economic alternatives to PFM, which provide good to excellent esthetic results and have demonstrated adequate clinical longevity.
- Layered leucite-reinforced crowns provide excellent esthetic results on maxillary anterior teeth and premolars when etched and bonded in place.

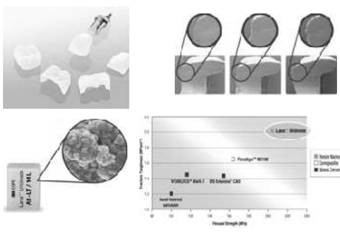
SUMMARY & CONCLUSIONS: ALTERNATIVES TO PFMS

SUMMARY AND CONCLUSIONS

- Monolithic lithium disilicate crowns are indicated for premolars and first molars, whereas layered lithium disilicate crowns can be used with maxillary incisors.
- Layered zirconia cored crowns can be predictably used on anterior teeth and premolars.
- Monolithic zirconia crowns are best used for molars and mandibular anterior teeth.

ULTRA-HIGH DENSITY, PROCESSED THEN MILLED COMPOSITE/CERAMIC INDIRECT MATERIALS

CAD/CAM NANOFILLER COMPOSITE: LAVA ULTIMATE (3M)



Advances in Composite Resin Technology

Steven R. Jefferies, MS, DDS, PhD

Kornberg School of Dentistry
TEMPLE UNIVERSITY

New Composite Developments

-NEW MONOMERS

-NANOTECHNOLOGY (NANOFILLERS)

History

- 1962 – Bis-GMA
  - stronger resin
- 1969 – filled composite resin
  - improved mechanical properties
  - less shrinkage
  - paste/paste system

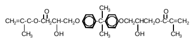
- 1970's – acid etching and microfills
- 1980's – light curing and hybrids
- 1990's – flowables and packables
- 2000's – nanofills
- 2010's – New monomers, low shrinkage

Rueggeberg, J Prosthet Dent 2002

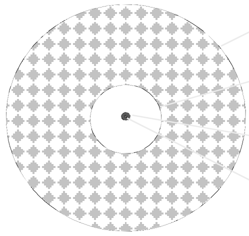
Composition

- Resin matrix
  - monomer
  - initiator
  - inhibitors
  - pigments
- Inorganic filler
  - glass
  - quartz
  - colloidal silica
- Coupling Agent

Bis-GMA



Phillip's Science of Dental Materials 2003



Relative Particle Sizes
(not to scale)

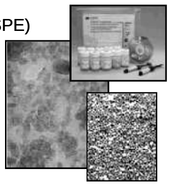
Nanofill vs. Nanohybrid

- Nanofills
  - nanometer-sized particles throughout matrix
- Nanohybrids
  - nanometer-sized particles combined with more conventional filler technology

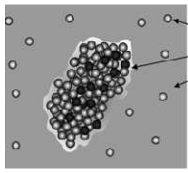
Swift, J Esthet Restor Dent 2005

Nanofilled Composite

- Filtek Supreme (3M ESPE)
- Filler particles
  - filled: 78% wgt
  - nanomers
    - 0.02 – 0.07 microns
  - nanocluster
    - act as single unit
      - 0.6 – 1.4 microns



Nanoparticles & Nanoclusters/3M



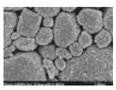
CURRENT "NANO" COMPOSITES

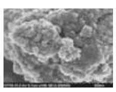
NANO-HYBRIDS:

Grando (Voco)
Synergy (Coltene/Whaledent)
Kalore (GC Dental)
MI Flow (GC Dental)
Tetric EvoCeram (Ivoclar-Vivadent)
Venus Diamond (Heraeus Kulzer)
Ceram-X (Dentsply/DeTrey)
Premise (Kerr USA)

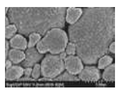
NANOFILLED:
Filtek Supreme (3M-ESPE)

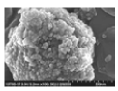
Filler Improvements in Filtek™ Supreme Ultra Universal Restorative



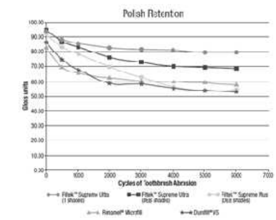


As the particles are not as strongly sintered, the cluster size range could be broadened (vs. Filtek Supreme Plus restorative) without affecting physical properties.





Comparative Retention of Polish



MICROSTRUCTURAL CHARACTERIZATION: FILTEK SUPREME VS. Z-250

- Rodrigues Junior, Scherrer, Ferracane, Della Bona. Dental Materials 24 (2008) 1281-88.
- Fracture toughness, Flexural Strength, Weibull Modulus, Characteristic Strength, and Critical Crack Strength – Very Similar

OTHER IN-VITRO DATA: NANOCLUSTER REINFORCEMENT?

- "Mechanical properties of nanofilled resin-based composites: Impact of dry & wet cyclic preloading on bi-axial flexure strength"
- Curtis, Palin, Fleming, Shortall, Marquis. Dental Materials 25 (2009) 188-197
- Materials Tested: Heliomolar, Z100, Z250, Filtek Supreme (body and translucent), Grandio, Grandio Flow.
- Cyclic pre-loading increased the Weibull Modulus of both Filtek Supreme Body (FSB) and Filtek Supreme Translucent (FST) compared to other composites.
- Biaxial fleural strength of both FSB and FST was maintained or increased after cyclic loading compared to other composites tested.
- **Nanoclusters appear to provide distinct reinforcing mechanism compared to microfil, microhybrid, or nano-hybrid systems.**
- **Silane infiltration of nanoclusters may enhance damage tolerance in the composite, with the potential for improved clinical performance.**

CLINICAL DATA: NANOFILL VS. MICRO-HYBRID COMPOSITE

- **Clinical Wear Performance of Filtek-Supreme and Z100 in Posterior Teeth: 5 YR CLINICAL WEAR PERFORMANCE**
- S. PALANIAPPAN, D. BHARADWAJ, D. MATTAR, M, PEUMANS, and B. VAN MEERBEEK, & P. LAMBRECHTS Katholieke Universiteit Leuven, Department of Dentistry, BIOMAT Research Cluster, Belgium
- Dental Material 27 (2011) 692-700
- No statistical difference in volume wear between the materials, but nanofill was lower.
- 36-60 Month steady state vertical wear was lower for the nanofill (0.263 vs 0.486 microns per month).

CLINICAL DATA: NANOFILL COMPOSITE – ANTERIOR TEETH

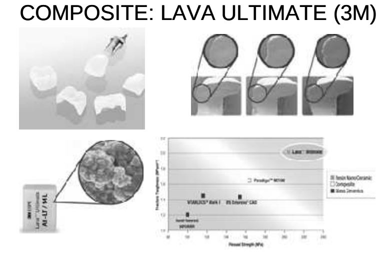
- ***Three Year Clinical Evaluation of Filtek Supreme in Anterior Teeth***
- J. DUNN[1], C. MUNOZ[2], A.WILSON[1], M. ARAMBULA[1], and R. RANDALL[3], [1]Loma Linda University, CA, USA, [2]SUNY at Buffalo, NY, USA, [3]3M ESPE Dental, St. Paul, MN, USA
- IADR/AADR ABSTRACT

Conclusions: At the 3-Year recall:
- **1) Retention, surface staining, and secondary caries were unchanged from baseline;**
- **2) Surface polish remained high throughout study as the composite appeared to display a "self-polishing" effect.**
- **3) Overall clinical performance is high and is acceptable for routine clinical use.**
- **Study partially funded by 3M ESPE**

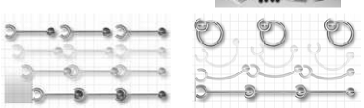
CLINICAL DATA: NANOHYBRID VS. FINE PARTICLE HYBRID

- **Nanohybrid (Grandio, Voco) vs. fine hybrid composite (Tetric Ceram, Ivovlar) in extended Class II cavities after six years**
- **N. Krämer, F. Garcia-Godoy, C. Reindt, A.J. Feilzer, R. Frankenberger.**
- **Dental Materials, 27 (2011) 455-464**
- **NO DIFFERENCE IN CLINICAL PERFORMANCE BETWEEN NANOBYBRID AND FINE HYBRID;**
- **SUCCESS RATE WAS 100% FOR BOTH MATERIALS AND NO SUBJECT DROPOUTS.**

CAD/CAM NANOFILLER COMPOSITE: LAVA ULTIMATE (3M)



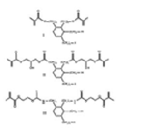
Filtek LS (Low Shrinkage)



- Silorane chemistry (right) has a ring-opening reaction, thus reducing polymerization shrinkage to 0.6 to 1 %.
- Requires separate chemistry for bonding agent.
- Uses quartz filler, which modifies esthetics.
- Good documented clinical performance up to 3 yrs.

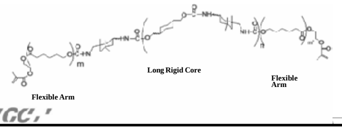
N'Durance - Septodont

- New "Dimer Acid" Monomer system
- Improves Conversion – 75%
- Reduced volumetric shrinkage (1-1.5 %)
- High compressive strength & toughness
- Good clinical evidence

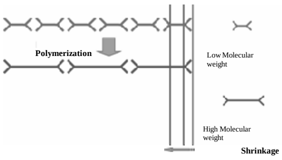


The DuPont Monomer

DX-511 Monomer (New Monomer Technology from DuPont)
- The long rigid core helps reduce polymerization shrinkage.
- The flexible side arms help increase monomer reactivity.
- High molecular weight (895) and low number of C=C double bonds help reduce polymerization shrinkage.
- The monomer is compatible with current adhesive and composite products.



Increasing the size and molecular weight of monomers reduces overall shrinkage



Class I Direct Restoration

"Single Shade KALORETM A2 Universal Only"

Dentistry by Dr. Mark Pitel, NY

Direct, Tooth Colored Restoratives

BULK FILL RESTORATIVES

"BULK FILL" RESTORATIVE COMPOSITE RESINS

DEFINITION – 2015:

Light-cured composite resin materials for direct restoration of posterior teeth, which can be placed and cured in bulk increments of 4 – 5 mms thickness.

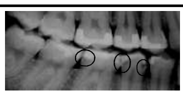
BULK FILL Materials

Advantages of "New Class" of materials

- **Saves Time?**
- **Easier?**
- **Better adaptation to tooth?**
  - **Reduce chance for air entrapment**
  - **Better conformity to cavity walls**
  - **Better marginal integrity**
- **Less shrinkage stress?**
- **Greater Depth of Cure?**
  - **4-5 mm**

National Institute for Dental and Craniofacial Research

"… Studies have shown that dental resin composites have an **average replacement time of 5.7 years due to secondary decay and fracture of the restoration.**"



PRIMARY MODES OF FAILURE OF POSTERIOR COMPOSITES

- **SECONDARY CARIES**
- **RESTORATION FRACTURE**

OTHER FACTORS CONTRIBUTING TO FAILURE

- **MARGINAL BREAKDOWN**
- **RESTORATION WEAR**
- **INADEQUATE POLYMERIZATION**
- **PULPAL DEATH**
- **TOOTH FRACTURE**

Why do we need bulk fill?

Why incremental filling?
- Limited depth of cure
- Reduce shrinkage stress

- Decreased biocompatibility
- Potentially increased DNA damage due to leachates
- Increased bacterial colonization of resin

J Can Dent Assoc 2010;76:a23

BULK FILL Materials

They are NOT all the same!

- Increment thickness - 4mm, 5mm
- Single increment use vs. "capping layer"
- Sculptable (paste-like) or flowable (syringe)

BULK FILL Materials

Questions / Concerns

- Depth of cure [degree of conversion]
- Adaptation – microleakage
- Strength
- Mechanical properties
- Wear
- Contraction force and rate
- Handling
- Durability – clinical performance over time

Thermal Manipulation of Composite Resin

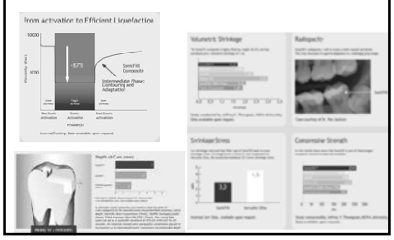
- VISTA DENTAL
- **Therma-Flo™ Composite Warming Kit**
- **Benefits of HEAT:**
- Increased flowability = Easy extrusion
- Improved polymerization= Reduced voids
- Reduced curing time

Sonic Delivery of Composite

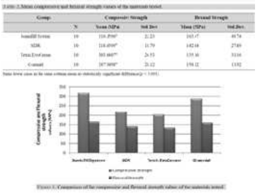
Kerr Dental (Danaher)

So Where Did the Idea Come From

SONICFILL – TECHNICAL DATA



Comparative Strength – Bulk Fill Restoratives



From: Open Journal of Composite Materials, 2014, 4, 117-121

SONICFILL 2

BULK FILL MATERIAL

WHAT'S THE DIFFERENCE?

SONICFIL 2
VS
SONICFIL (1)

According to the Kerr Product Manager

- Better color matching
- Better esthetics

JADA, Vol. 130, September 1999 ;1347–1353

Localized and Generalized Simulated Wear of Resin Composites

Operative Dentistry, 2015, 40-3, 322-335

WW Barkmeier T Takamizawa RL Erickson
A Tsujimoto M Latta M Miyazaki

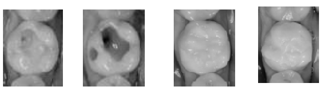
Clinical Relevance

Wear is an important parameter for the selection of resin composite materials.

Are there other options for bulk-fill restorations???

- **Glass Ionomers ??? Maybe – in selected situations?**

ANOTHER CONCEPT IN BULK FILL RESTORATIVES:
EQUIA™
Self-Adhesive, Aesthetic Posterior Restorative
Clinical Case clinical images courtesy of Dr. Lassocinski & GC Dental



EQUIA PHYSICAL PROPERTIES

Physical properties		EQUIA: GC Fuji IX GP EXTRA	EQUIA: G-Coat PLUS	GC Fuji IX GP EXTRA without G-Coat PLUS
Working Time		1'15"		
Net Setting Time (37°C)		2'00"		
Final Finishing Commencing Time		2'30"		
Application			5"	
Light-curing (> 500mW/cm²)			20"	
Flexural Strength (MPa)	1 day	31,9 (3,3)		18,5 (6,8)
Flexural Modulus (GPa)	1 day	11,1 (1,8)		12,8 (1,6)
Fracture Toughness (MPa)	1 day	0,056 (0,011)		0,016 (0,009)
Vickers Hardness (Hv)	1 day	99		73
Vickers Hardness (Hv)	60 days*	112		94
Tensile Bond Strength (MPa, 1 day)	to bovine enamel	7,2 (1,8)	5,9 (0,7)	
	to bovine dentin	5,3 (1,2)	1,4 (1,4)	
	to GC Fuji IX GP EXTRA		6,1 (1,1)	

*Coating removed artificially at 60 days, samples stored in saline

GC's New Product Description for Equia

"Bulk fill, Self-adhesive, Rapid Restorative System"

GC EQUIA

GC EQUIA

2 & 4 YEAR CLINICAL DATA

CLINICAL DATA – GC EQUIA – 2 YEAR RESULTS

- **CONCLUSIONS: Within the limitations of this study it can be concluded that EQUIA can be used as a permanent restoration material for any sized Class I and in smaller Class II cavities.** However, results of ongoing prospective studies shall provide a more exact indication definition in Class II situations.
- **SIGNIFICANCE: Modern glass ionomer systems may not only serve as long-term temporaries, but also as permanent restorations in posterior teeth.**
- **What about interproximal contacts?**

Friedl K, Hiller KA, Friedl KH. Clinical performance of a new glass ionomer based restoration system: a retrospective cohort study. Dent Mater. 2011 Oct;27(10):1031-7.

CLINICAL DATA – GC EQUIA – 4 YEAR RESULTS

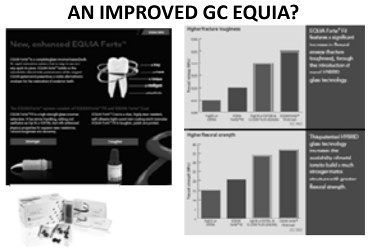
- **Objective:** The aim of this study was to evaluate the clinical performance of a glass ionomer restorative system compared with a microfilled hybrid posterior composite in a four-year randomized clinical trial.
- **Methods:** A total of 140 (80 Class 1 and 60 Class 2) lesions in 59 patients were either restored with a glass ionomer restorative system (Equia, GC, Tokyo, Japan), which was a combination of a packable glass ionomer (Equia Fil, GC) and a self-adhesive nanofilled coating (Equia Coat, GC), or with a microfilled hybrid composite (Gradia Direct Posterior, GC) in combination with a self-etch adhesive (G-Bond, GC) by two experienced operators according to the manufacturer's instructions. Two independent examiners evaluated the restorations at baseline and at one, two, three, and four years postrestoration according to the modified US Public Health Service criteria.
- **Results & Conclusions:** The use of both materials for the restoration of posterior teeth exhibited a similar and clinically successful performance after four years.

S Gurgan, ZB Kutuk, E Ergin, SS Oztas, and FY Cakir (*2015*) Four-year Randomized Clinical Trial to Evaluate the Clinical Performance of a Glass Ionomer Restorative System. Operative Dentistry: March/April 2015, Vol. 40, No. 2, pp. 134-143.

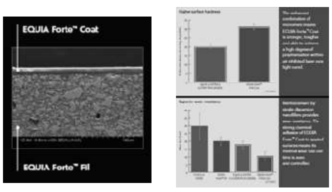
A NEW IDEA GAINING TRACTION: CURING A CONVENTIONAL GIC WITH AN LED LIGHT

Glass ionomer	Group 1 (SC)		Group 2 (HL30)		Group 3 (HL60)	
	Mean	SE	Mean	SE	Mean	SE
Chemfil Rock	41.4	1.1	73.7	1.2	75.5	1.3
EQUIA system	67.0	1.1	73.7	1.2	78.8	1.1
Fuji 9 Gold Label	43.4	0.6	52.7	1.2	54.5	1.1
Ketac Molar Easymix	29.6	0.6	31.7	1.1	33.2	1.1

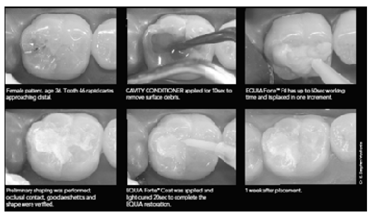
EQUIA FORTE AN IMPROVED GC EQUIA?



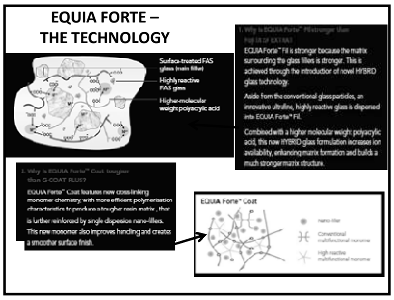
EQUIA FORTE AN IMPROVED GC EQUIA?



CLINICAL TECHNIQUE



EQUIA FORTE – THE TECHNOLOGY



Enamel and Dentin Adhesives

Steven R. Jefferies, MS, DDS, PhD

Department of Restorative Dentistry

Currently Available Generations

- Fourth Generation
  - Three-step Etch & rinse
- Fifth Generation
  - Two-step Etch & rinse
- Sixth Generation
  - Two-step Self-etch
  - One-step Self-etch
    - mix
- Seventh Generation
  - One-step Self-etch
    - no mix

Classification of Newer Systems

- Interaction with tooth surface
- Number of clinical application steps

1) Etch & rinse (i.e., total-etch)
2) Self-etch
3) Resin-modified glass ionomer

Van Meerbeek, Oper Dent 2003

Etch & Rinse (Three-Step)

- Conditioner
- Primer
- Adhesive resin

- Examples
  - Scotchbond Multi-Purpose
  - Optibond FL

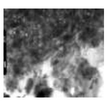
Prime & Bond NT – Modified Clinical Application Technique Can Improve Bond Strength & Clinical Performance

- 15 – 20 second enamel etch; 4-7 second dentin etch.
- Wet or Moist Dentin is Optimal; Dry Dentin Problematic (acetone).
- Apply copious amounts, let stand 5- 10 secs, then "light" air dry.
- Cure 20 seconds – then repeat for a second coat and second cure.

Adhesive Categories

- Etch & Rinse
  - Three-Step
    - conditioner, primer, adhesive
  - Two-Step
    - conditioner, (primer & adhesive)
- Self-Etch
  - Two-Step
    - (conditioner & primer), adhesive
  - One-Step
    - (conditioner & primer & adhesive)
- Glass Ionomer
  - Two-Step
    - conditioner, resin-modified glass-ionomer mixture

AFTER ALL THESE YEARS – TONS OF RESEARCH: WHY IS THE PERFORMANCE OF ADHESIVE RESIN MATERIALS IN QUESTION?



- **Pulpal Biocompatibility? Pressure? Especially in areas with low remaining dentin thickness (RDT)!**
- **Stability of the "Hybrid Zone"?**
- **Absence of real bioactivity or ability to actively remineralize/BIOLOGICALLY integrate with adjacent tooth tissue.**
- **Different amounts of pathogenic bacteria underneath composite resin vs. amalgam? Ref: 2003, Quint. Int.**
- **Enzymatic Degradation of composite resins??**

An Emerging Concern: Biofilm-Bacterial Challenge; Specific to Resin-Based Materials?

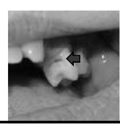
- "The enzymes in saliva degrade dental composites and may enhance tooth decay. …………………………………………………………………….. There is strong evidence to suggest that biofilm formation contributes to the chemical and mechanical degradation of dental composites."

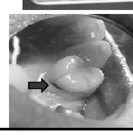
- Quote from 1. Research Objectives, Background: Increasing the Service Life of Dental Resin Composites; (R01); Announcement Type: New; Request for Applications (RFA) Number: RFA-DE-10-004

SRJ, 10-4-13

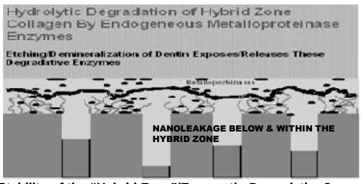
Is The Oral Environment Excessively "Corrosive" to Resins & Adhesives?

Long-Term Clinical Performance of Class II Posterior Composites
Demarco , et.al. Dent Mater. 2012
Roumanas ED. J Evid Based Dent Pract. 2010
Abt E. The Journal of Evidence-Based Dental Practice. 2008
Bernardo, et.al. J Am Dent Assoc. 2007
Soncini , et.al. J Am Dent Assoc. 2007





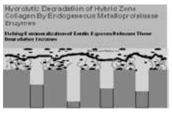
Questions About The Adhesive Resin Interface?



Stability of the "Hybrid Zone"/Enzymatic Degradation?

Brackett, et.al. J Dent. 2011; Pashley & Tay, et.al. Dent Mater. 2011; Neelakantan, et.al. J Clin Pediatr Dent. 2009;Hsu, et.al. Dent Mater. 2008; Reis, et.al. Dent Mater. 2007;Yuan, et.al. Dent Mater. 2007

BUT THERE ARE OTHER THREATS TO MARGINAL STABILITY!



- PLUS – OTHER DEGRADATIVE ENZYMES FROM MULTI-SPECIES OF BACTERIA
- PLUS – ACID DEMINERALIZATION & LOW pH

NANOLEAKAGE BELOW & WITHIN THE HYBRID ZONE NOW IS RECURRENT CARIES (I.E. – A GINGIVAL WALL LESION

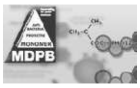
Growing Evidence of the Role of Enzymatic Degradation?

Carrera, et.al. Acta Biomater. 2013 ; Toledano, et.al. Caries Res. 2012; Zou, et.al. J Biomed Mater Res A. 2010

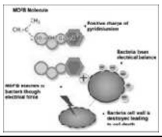
ANOTHER MAJOR CHALLENGE

- COMPOSITE RESINS MAY BE MORE PRONE TO BACTERIAL CHALLENGE /ENZYMATIC DEGRADATION.
- DENTIN BONDING IS STILL PROBLEMATIC.
- ANTIMICROBIAL RESINS AND COMPOSITES MIGHT BE USEFUL TO RESISTANCE SECONDARY/RECURRENT CARIES.

Clearfil Protect Bond



- MDBP ANTIMICROBIAL MONOMER



TOTAL ETCH/SELF ETCH?

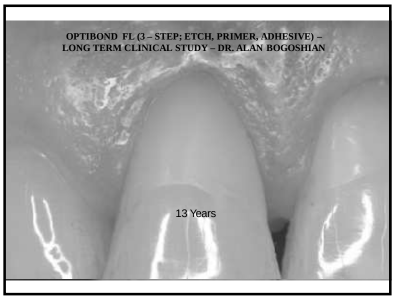
- WHAT'S THE DIFFERENCE?
- TWO BOTTLE VS ONE BOTTLE?
- ADDED "SELECTIVE" ETCH FOR ENAMEL

Self-Etch Components

Acidic monomers ⇨ MDP, Di-HEMA-Phosphate, MA 154, Phenyl-P, MAC-10, 4-MET(A)

Crosslinking monomers ⇨ BisGMA, UDMA, TEGDMA, GDMA, HEMA

Solvent ⇨ usually water based



NEW "UNIVERSAL" ADHESIVES

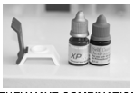
- ONE BOTTLE
- SELECTIVE ETCH;
- TOTAL ETCH
- SELF ETCH
- IS IT POSSIBLE???

NEW UNIVERSAL ADHESIVES

- SCOTCHBOND UNIVERSAL
- XP BOND – NOW PRIME & BOND XP
- PRIME & BOND ELECT

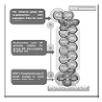
What Do These Three Adhesives Share in Common That May Enhance Their Performance?

- OPTIBOND FL
- XP BOND – NOW PRIME & BOND XP
- SCOTCHBOND UNIVERSAL

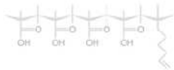


THEY HAVE COMBINATION ADHESION PROMOTERS!

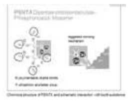
Scotchbond Universal



- **Phosphate – MDP**
- **Carboxylic Acid – Vitrebond Co-polymer**



XP Bond

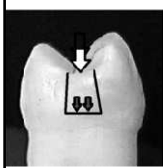


- Phosphate – PENTA
- Carboxylic Acid - TCB

BUT IS IT REALLY ALL ABOUT ADHESIVES AND ADHESION TO TOOTH STRUCTRE??

- OR ARE THERE OTHER FACTORS????

Occlusal forces on Proximal Box



AMALGAM	COMPOSITE
CS: 300 – 500 MPa	CS: 200 – 380 MPa
FS: 130 – 170 Mpa	FS: 90 – 150 MPa
Modulus: 15 – 55 GPa	Modulus: 2 – 12 GPa

MORE EVIDENCE – WHY MODULUS MATTERS!

"Fatigue resistance and crack propensity of large MOD composite resin restorations: direct versus CAD/CAM inlays."

Dent Mater. 2013 Mar;29(3):324-31.

Batalha-Silva S , de Andrada MA, Maia HP, Magne P.

Batalha-Silva, et al.

- "CAD/CAM MZ100 inlays increased the accelerated fatigue resistance and decreased the crack propensity of large MOD restorations when compared to direct restorations."
- "While both restorative techniques yielded excellent fatigue results at physiological masticatory loads, **CAD/CAM inlays seem more indicated for high-load patients**."

SO, WHAT DO WE DO ABOUT THE GINGIVAL WALL AREA IN TOOTH COLORED RESTORATIONS????

- PREPARATION & CASE SELECTION: AVAILABLE ENAMEL & CARIES RISK.
- ADHESIVE TECHNIQUE: SELF-ETCH W/ ENAMEL REBOND; OR SELCTIVE DENTIN ETCH ("BACK TO THE FUTURE")
- CONTROL OF AXIAL WALL LENGTH/DEPTH
- OPEN SANDWICH: BUT WITH WHAT MATERIAL???
- INDIRECT CERAMIC OR LAB-PROCESSED COMPOSITE: MAYBE? BUT TIME & EXPENSIVE!!
- OTHER OPTIONS??? STIFFER, HIGHER MODULUS CR

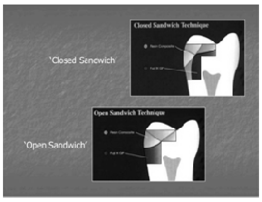
Open Sanwich/Closed Sandwich

Liner/Base

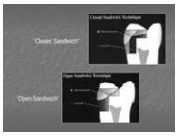
Vs

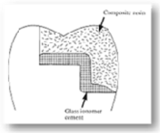
No Liner or Base

Closed vs Open Sandwich



Closed vs Open Sandwich





Do we know if an open sandwich technique works clinically?

- Clinical Research of Professor Jan van Dijken:
- Moderate to Long-term Clinical Studies with:

1) Glass Ionomer
2) Resin-modified Glass Ionomer
3) Compomer – Polyacid Modified Composite Resin

WHAT ABOUT SLOT PREPS?

WHAT'S THE EVIDENCE?

DOES IT WORK WITH LONGEVITY?

SOME IMPORTANT ANCILLARY PRODUCTS IN ADHESIVE DENTISTRY!! WHY THEY ARE IMPORTANT

PREVENTING DENTIN & ADHESIVE BOND DEGRADATION

MIMIMIZING TOOTH SENSITIVITY

Chlorhexidine & Gluma

Consepsis® - 2.0% chlorhexidine gluconate solution used to clean/disinfect before bonding (a disinfectant)

Gluma® - 5% Glutaraldheyde, 35% HEMA, 60 % Water (a collagen crosslinking agent)

Major Functions: Antimicrobial Activity & Inhibition of Metalloproteinases

- Reduces risk for recurrent caries?
- Reduces potential for post operative sensitivity caused by residual bacteria?
- Slightly higher bond strengths with many dentin bonding agents
- Lower risk of bond strength compromise (Chlorhexidine hand soaps can adversely affect bond strength with dentin bonding agents. Consepsis contains no surfactants or emolients that interfere with bond strength.)

ALDEHYDES & "CHX"

Final Thoughts – Adhesives/Dentin Bonding

- CHEMICALLY STABILIZING DENTIN WITH CROSSLINKING AGENTS (ALDEHYDES), ENZYME INHIBITORS, ANTIMICROBIALS;
- USE AN ADHESIVE THAT COMBINES A PHOSPHATE **AND** CARBOXYLIC ACID MONOMER;
- USE OF SELECTIVE ETCH OR "**LIMITED"** TOTAL ETCH MAY BE THE PREFERRED TECHNIQUE.

ALTERNATIVE METHODS TO FORM A BOND TO TOOTH STRUCTURE?

INTEGRATION TO TOOTH STRUCTURE WITHOUT USE OF ADHESIVE MONOMERS

NECESSITY?
FEASIBILITY?
BENEFIT?

Reducing New Bioactive – "Interactive" Materials to Practice

- New variations on the "classical" theme of the acid-base reaction cement may yield "unanticipated" benefits.
- Interactive materials, which are structurally more "analogous" to native mineralized tissue; may present new opportunities for restorative and prosthetic treatment in dentistry.

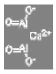
EXAMPLES OF CERAMIC BIOMATERIALS

Ceramic Classification		Examples of Bioceramic
Traditional Ceramics	→	Dental Porcelain, Leucite
Special Ceramics	→	Al-, Zr, and Ti- Oxides
Glass	→	Bioglasses
Glass-ceramic	→	Apatite-Wollastonite
Chemically Bonded Ceramics	→	Ca-Phosphates Ca-Silicates, Ca-Aluminates

PORTLAND CEMENT

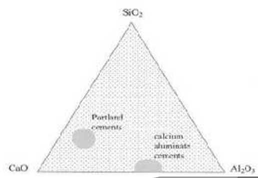
CALCIUM SILICATE

CALCIUM ALUMINATE



CALCIUM ALUMINATE – GLASS IONOMER

Compositions of Portland & calcium aluminate cements



CURRENTLY AVAILABLE BIOACTIVE MATERIALS

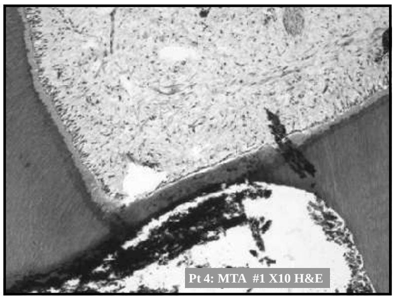
Calcium-Based, Bioactive Cements: The Potential

- Bioactivity via apatite formation at the cavity interface leading to true microstructural integration with the tooth substrate
- If above property is proven, potential to eliminate need for adhesive bonding agents.

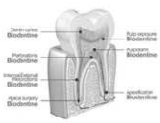
Mineral Trioxide Aggregate (MTA) Composition

- **Calcium Oxide**
- **Silicate Oxide**
- **Tricalcium Silicate**
- **Tricalcium Aluminate**
- **Bismuth Oxide**

Torabinejad M, Hong CU, McDonald F and Pitt Ford TR. J Endod 1995; 21(7): 349-53



Biodentine



WHAT MAKES THESE CALCIUM- CONTAINING MATERIALS UNIQUE?

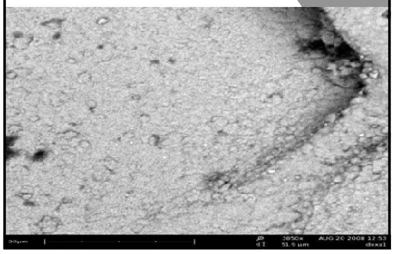
BIOACTIVITY

BIOACTIVITY & NANOSTRUCTURAL INTEGRATION

Bioactivity materials, when immersed in physiologic phosphate buffered saline solution, form calcium phosphate and hydroxyapatite.

In-vivo, interaction with tooth structure is manifested through the precipitation of nanocrystals (<0.2 microns/200 nanometers) at the interface of the prepared tooth resulting in mechanical interlocking, and surface energy-based attachment of the hydrated cement nanocrystals with the tooth structure.

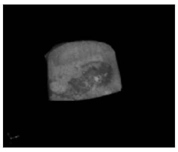
Bioactivity: Hydroxyapatite crystals (HA) on the cement surface

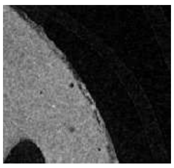


Ceramir® Crown & Bridge

- Ceramir® C&B is a material that combines Glass ionomer technology with Calcium Aluminate Chemistry.
- The GI contributes to:
  - Low initial pH, short duration
  - Flow and Setting characteristics
  - Early strength
- The CA contributes to:
  - Increased strength and retention
  - Biocompatibility
  - Sealing of tooth material interface
  - Apatite formation
  - Sustained long term properties, no degradation
  - Basic end pH

MICRO CT ANALYSIS – SURFACE APATITE LAYER





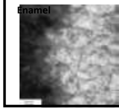
Nano structural integration ?

- Inherent properties of Bioactive Reactions
  - Crystallites precipitates from solution, wetting and penetrating tooth surface;
  - As nano-sized crystallites and the gibbsite gel precipitates on the tooth interface and within the cement matrix, the cement integrates within the dentin and enamel matrix;
  - The material is constituted of nano-sized katoite crystals in a gibbsite gel matrix bonded together by means of surface energy and mechanical interlocking.

INTEGRATION VS ADHESION

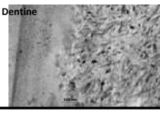
- A "seamless" interface, which could reseal itself over time – less risk of secondary caries?
- Basic pH (biocompatibility), chemical stability, and no shrinkage (unlike resin-based materials) gives a stable interface

Enamel



Ceramir TEMs

Dentine



Intended Use

- Ceramir® Crown & Bridge is intended for permanent cementation of:
  - Porcelain Fused to Metal Crowns and Bridges
  - Metal (gold etc.) crowns and bridges
  - Gold inlays and onlays
  - Cast or prefabricated metal posts
  - Strengthened core All-Zirconia, All-Alumina, and Lithium Disilicate (eMax) ceramic crowns and bridges

Test program

- The material is tested according to:
  - ISO 9917:2007, both internal and external tests, NIOM Norway
  - FDA guidelines
  - Biocompatibility testing ISO 7405
  - External testing at Temple University , Prof Steven Jefferies
  - External testing with Prof C. H. Pameijer
  - Additional internal tests

Net setting time, compressive strength, and film thickness all conform to the International Standards Organization (ISO) values for water-based luting agents.

Shear Bond Strength

- Shear Bond strength to different substrates

Substrate	Calcium Aluminate/Glass Ionomer (MPa) Manufacturer's Data*	Calcium Aluminate/Glass Ionomer (MPa) Independent Testing Lab	Glass Ionomer Luting Cement (MPa) Manufacturer's Data*
Dentine	11	8.6 (range 5.3-11.9)	4.7
Enamel	8.4	Not Tested	8.4
Gold Alloy	10.2	16.2 (1.4)	2.8
Alumina	7.5	12.0 (2.9)	6.6
Zirkonia	8.2	10.4 (3.0)	3.7

In all tests the standard deviation was about 2 MPa

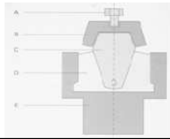
CERAMIR MAY FILL A CRITICAL NEED FOR ALL-CERAMIC CROWNS/BRIDGES

BOND STRENGTH LEVELS TO ALUMINIA AND ZIRCONIA SUGGEST:

A POSSIBLE UNIQUE & NEW BONDING MECHANISM FOR CERTAIN BIOACTIVE, CHEMICALLY-BONDED CERAMIC CEMENTS (LIKE CERAMIR) TO HIGH-STRENGTH, POLYCRYSTALLINE SINTERED CERAMICS

Crown retention

- Tests conducted by Professors Pameijer & Jefferies
  - Gold or Zirconia crowns , 3mm prep height with 32 degree taper.



Crown Retention Vs. Type of Cement
(all values in Kgs tensile force to displacement, using gold crown copings)

- Polycarboxylate: ~ 9 Kgs
- Zinc Phosphate: ~14 Kgs
- Glass Ionomer: ~24 Kgs
- RMGI: ~25 – 45 Kgs
- Resin Cement(w/DBA): ~30 – 60 Kgs
- Self Adhesive RC: ~16 – 45 Kgs
- ZOE or Non-ZOE Temp Cements:< ~9 Kgs

CROWN RETENTION DATA			
Cement	Results: Gold crowns (in Kg f)	Results: Zirconia crowns (in Kg f)	Results: eMax crowns (lithium disilicate) (in Kg f)
Ceramir Crown & Bridge (Doxa)	38.3 ± 8.5	32.1 ± 6.3	29.48 ± 9.99 (Cr-Co Die)
Rely X Unicem (3M ESPE)	39.8 ± 15.3	27.8 ± 11.3	Not tested
Glass Ionomer	26.6 ± 4.4 (Ketac Cem , 3M ESPE)	Not Tested	27.7 ± 12.73 (Cr-Co Die) (Vivaglas, Ivoclar)
Zinc Phosphate (Flecks Cement, Mizzy)	13.9 ± 4.5	Not Tested	Not Tested

Clinical study

- The study is performed at Temple University Philadelphia by Prof Steven. R. Jefferies
- A total of 38 crowns and bridges were cemented in 17 patients of which 31 were on vital and 7 on non-vital teeth. There were 6 bridges cemented in the study, consisting of 13 prepared abutment teeth (12 vital/1 non-vital).
- The clinical handling was part of the evaluation
- The study was made with a hand mixed version of the cement

Measurement Parameters for Clinical Study

CEMENT MEASUREMENT DATA	CLINICAL MEASUREMENT DATA
Dispensing	Sensitivity (Categorical - Patient Perception)
Mixing	Retention
Working Time	Gingival Inflammation Index (GI)
Complete Seating	Marginal Integrity
Adverse Taste	Marginal Discoloration
Ease of Cement Removal	Caries
	Visual Analogue Scale (VAS) - Sensitivity

Clinical study

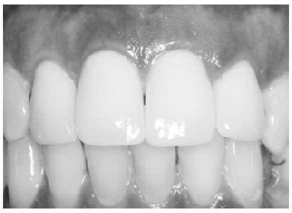
- Results of the clinical handling

Result clinical handling parameters	
Dispensing	Material now available in capsules
Mixing	Easy
Working-time	2 minutes
Setting-time	4 minutes
Seating characteristics	Very good
Ease of cement removal	Very easy

Cement Removal & Clean-up

Clean-up and removal of Ceramir® was deemed to be very easy. The cement reached a "crispy" state at the end of work-time at the marginal areas of the restoration(s), which facilitated easy and straightforward excess cement removal.

Porcelain Fused to Metal (PFM) Crowns on Right and Left Lateral and Central Incisors; Ceramir® C&B Cement; ONE YEAR RECALL PHOTO



Clinical digital photograph of maxillary anterior, ceramo -metal restorations (right and left lateral and central incisors) cemented with Ceramir® at two year clinical evaluation.

CEMENTATION OF LITHIUM DISILICATE ALL-CERAMIC CROWN

Clinical study

➢ Results

Clinical parameters followed in the study were:

Sensitivity (Categorical)
Retention
Soft Tissue Reaction
Marginal Integrity
Marginal Discoloration
Caries
Visual Analogue Scale (VAS) - Sensitivity
Gingival Inflammation Index (GI)

Results of cement performance up to three years recall have been excellent and quite clinically acceptable.

1 Year results published in: Jefferies SR, Pameijer CH, Appleby D, Boston D, Lööf J, Glantz P-O. "One year clinical performance and post-operative sensitivity of a bioactive dental luting cement – A prospective clinical study. Swed Dent J. 2009;33:193-199.

2 Year results published in: Jefferies SR, Pameijer CH, Appleby D, Boston D, Galbraith C, Lööf J and Glantz P-O. Prospective Observation of a New Bioactive Luting Cement: 2-Year Follow-Up. Journal of Prosthodontics 21 (2012) 33–41

EVERYDAY ISSUES

What constitutes good handling in a luting cement?

Summary Data & Conclusions from a field trial

1. Easy to use.
2. Robust seating procedure.
3. Low viscosity – easy seating.
4. Easy to clean up.

SO WHAT DOES BIOACTIVITY DO FOR ME CLINICALLY??

UNIQUE PULPAL BIOCOMPATIBILITY & CAPACITY FOR REGENERATION

UNIQUE CAPACITY FOR REGENERATION OF PERIODONTAL/PERAPICAL TISSUE FOR ROOT REPLACEMENT

OK WHAT ELSE – ESPECIALLY FOR THE RESTORATIVE DENTIST???

DISCLOSURE

In the interest of full disclosure, this research was supported, in part, by Doxa Dental AB

Physical & Clinical Properties of an Experimental Bioactive Luting Cement

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WHAT ARE THE NEW PARADIGMS?

- Bioactive vs. Inert
- Molecular Integration vs. "Physical – Chemical" Adhesion
- Nanomolecular Structure
  vs.
  Traditional, "Filler-Matrix" Composite Structure