Ceramics in Dentistry
simplified classification
which system for which case ?

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Ceramics in Dentistry

- Critical Material Properties relative to clinical failure- what really causes things to break?
- Simplified Classification system
- Ceramic system selection- which system for which case
  - Feldspathic? Glass Ceramics ? what type ? pressed or machined ?
- When to inlay vs. onlay, when to Veneer vs. when to Crown- What type of Crown
- Zirconia Issues

Ceramics in Dentistry

Classification of Dental Ceramics

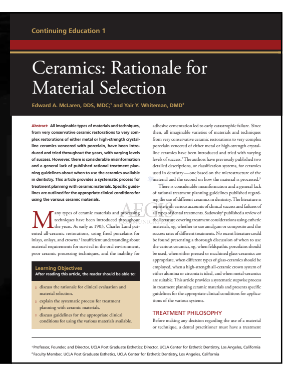
1. Inside dentistry 11/2009
2. Compendium Cont Ed 11/2010

Giordano and McLaren

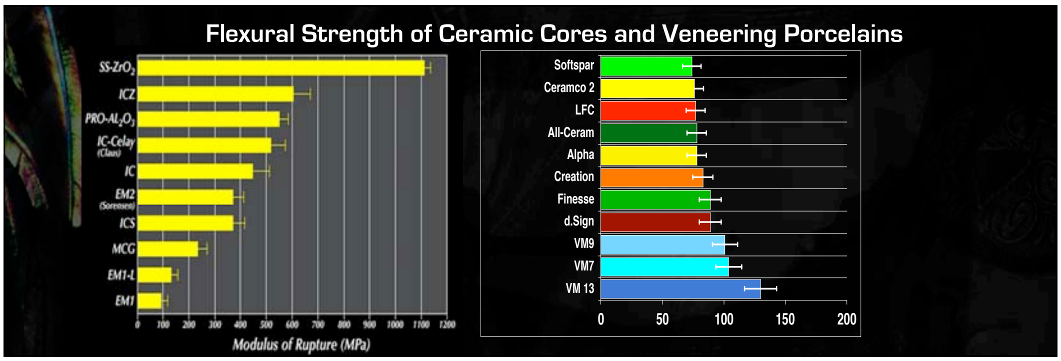
Ceramics in Dentistry

Rational for Ceramic Selection

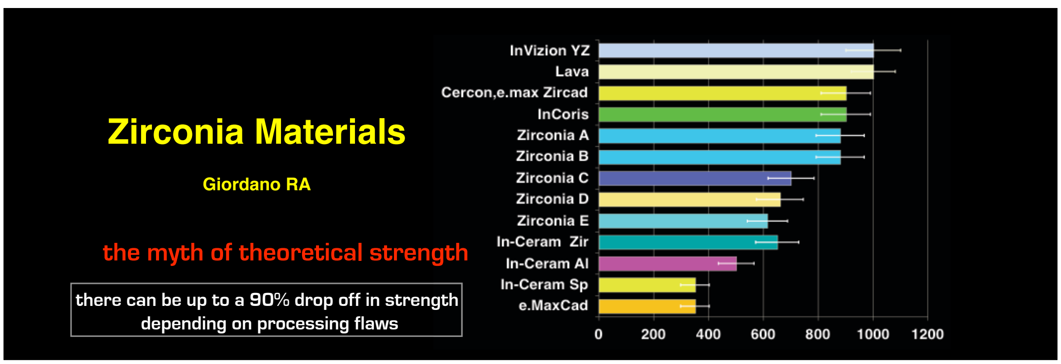
1. Compendium Cont Ed 11/2010
2. Inside Dentistry 2/2012



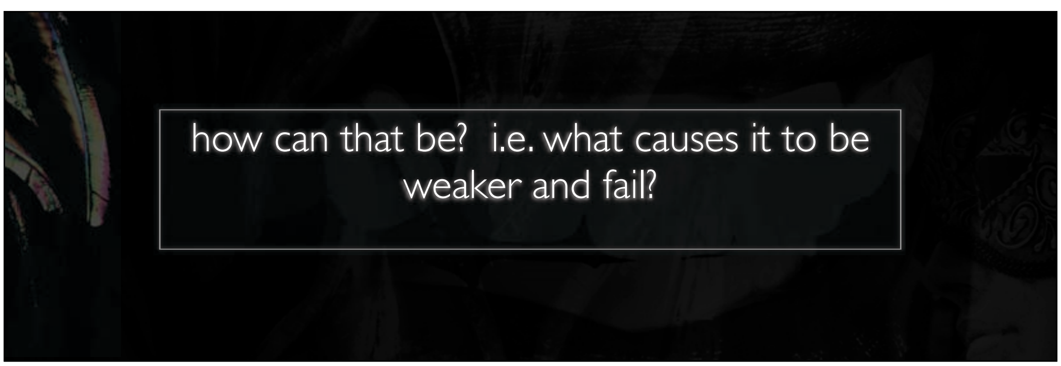
TREATMENT PLANNING
WHAT CERAMIC/material SHOULD I USE ?
I HEARD PRODUCT X WAS "STRONGER" SHOULD I USE IT?



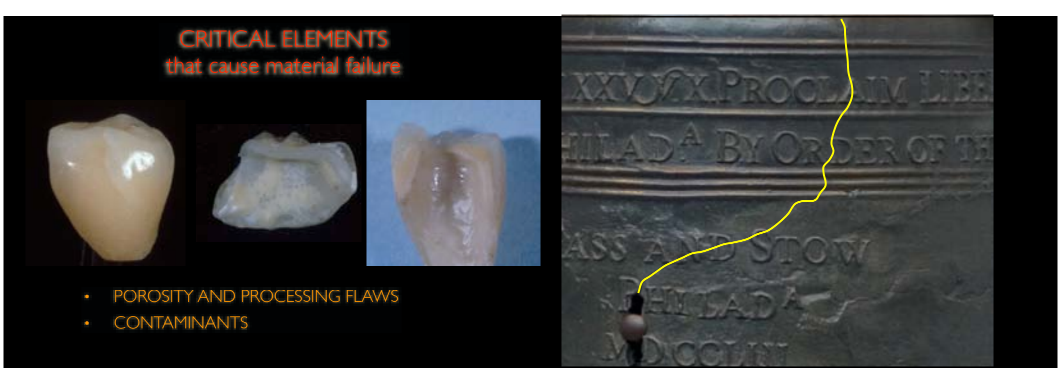
Flexural Strength of Ceramic Cores and Veneering Porcelains
SS-ZrO2
ICZ
PRO-AL2O3
IC-Celay (Claus)
IC
EM2 (Sorensen)
ICS
MCG
EM1-L
EM1
0 100 200 300 400 500 600 700 800 900 1000 1100 1200
Modulus of Rupture (MPa)
Softspar
Ceramco 2
LFC
All-Ceram
Alpha
Creation
Finesse
d.Sign
VM9
VM7
VM 13
0 50 100 150 200



Zirconia Materials
Giordano RA
the myth of theoretical strength
there can be up to a 90% drop off in strength depending on processing flaws
InVizion YZ
Lava
Cercon,e.max Zircad
InCoris
Zirconia A
Zirconia B
Zirconia C
Zirconia D
Zirconia E
In-Ceram Zir
In-Ceram Al
In-Ceram Sp
e.MaxCad
0 200 400 600 800 1000 1200

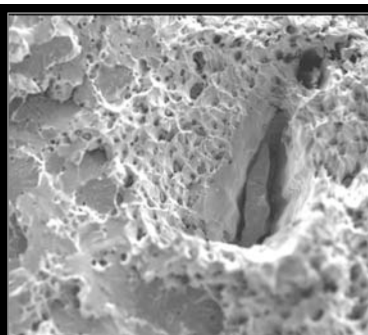


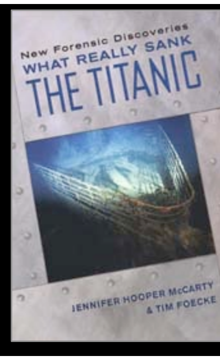
how can that be? i.e. what causes it to be weaker and fail?



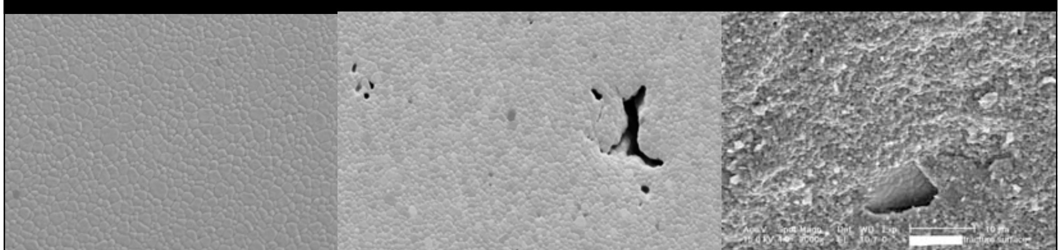
CRITICAL ELEMENTS
that cause material failure
POROSITY AND PROCESSING FLAWS
CONTAMINANTS

A SEM image of a broken wrought iron rivet. Note the very large piece of SLAG, and how much bigger is the hole it formed than those around the small pieces. the bigger the pieces are the ones causing the loss in strength.





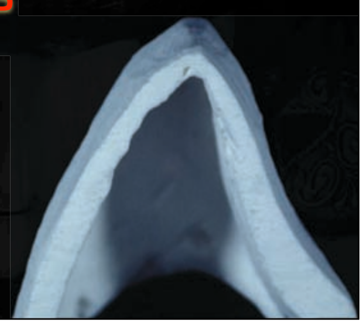
CRITICAL ELEMENTS that cause material failure



CRITICAL ELEMENTS

that cause material failure

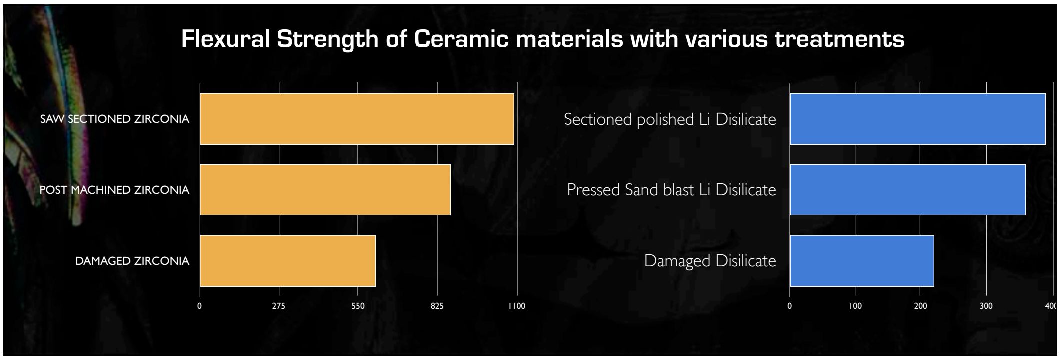
- POROSITY AND PROCESSING FLAWS
  - -CONTAMINANTS
  - -THERMAL INCOMPATIBILITY WITH VENEER MATERIAL
  - -COMPLEX STRESSES INTRODUCED DURING VENEERING
- STATIC FATIGUE OR STRESS CORROSION (CHEMICALLY ASSISTED CRACK GROWTH)



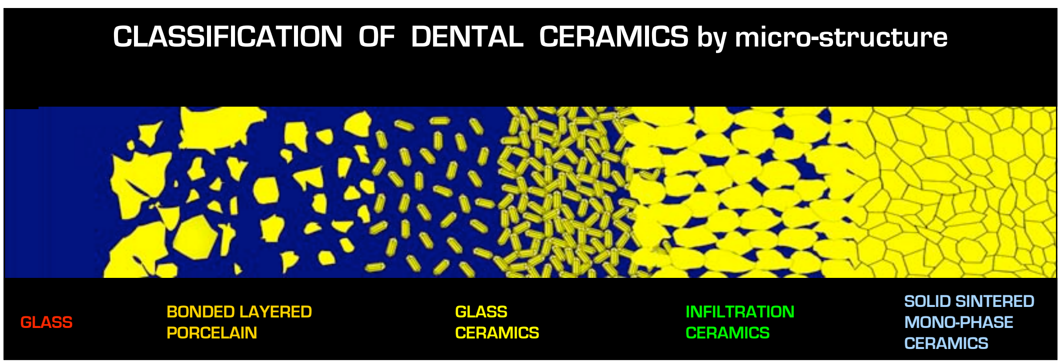
just because someone has the same material **it does not mean** they use the same processing technique:

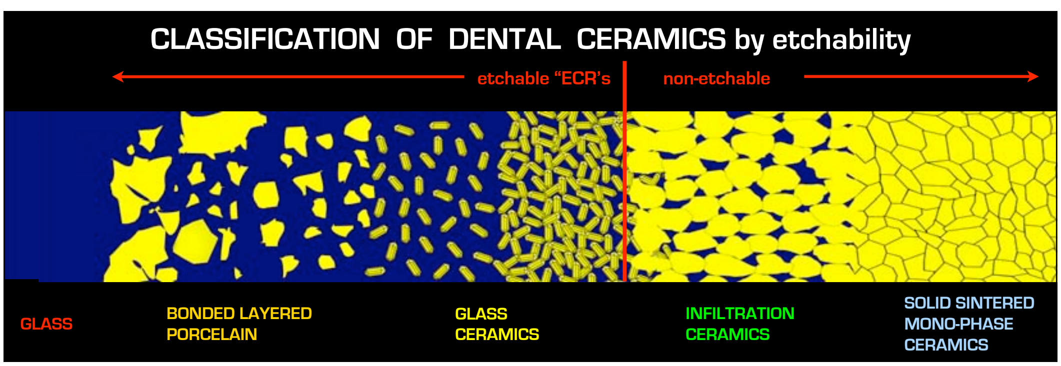
My Car

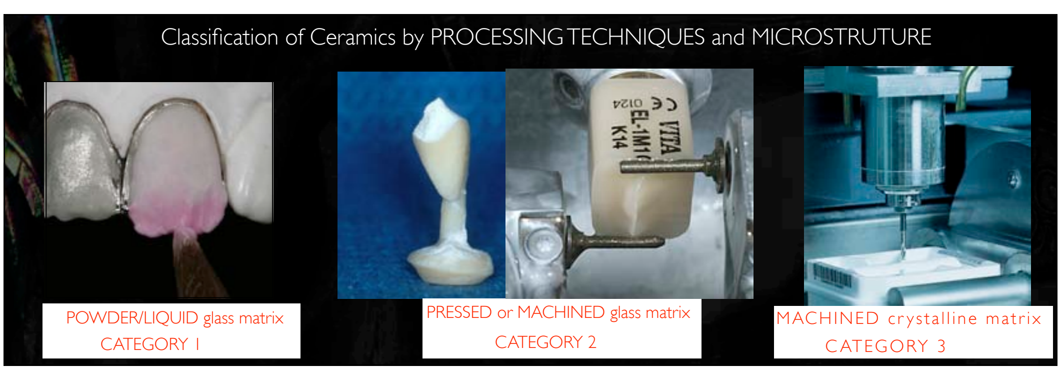
Jack's Car


Flexural Strength of Ceramic materials with various treatments
SAW SECTIONED ZIRCONIA
POST MACHINED ZIRCONIA
DAMAGED ZIRCONIA
0
275
550
825
1100
Sectioned polished Li Disilicate
Pressed Sand blast Li Disilicate
Damaged Disilicate
0
100
200
300


HOW ARE CERAMICS CLASSIFIED ?
HOW SHOULD THEY BE CLASSIFIED ?


CLASSIFICATION OF DENTAL CERAMICS by micro-structure
GLASS
BONDED LAYERED PORCELAIN
GLASS CERAMICS
INFILTRATION CERAMICS
SOLID SINTERED MONO-PHASE CERAMICS


CLASSIFICATION OF DENTAL CERAMICS by etchability
etchable "ECR's
non-etchable
GLASS
BONDED LAYERED PORCELAIN
GLASS CERAMICS
INFILTRATION CERAMICS
SOLID SINTERED MONO-PHASE CERAMICS


Classification of Ceramics by PROCESSING TECHNIQUES and MICROSTRUTURE
POWDER/LIQUID glass matrix
CATEGORY 1
PRESSED or MACHINED glass matrix
CATEGORY 2
MACHINED crystalline matrix
CATEGORY 3

TREATMENT PLANNING goals/philosophy

1. Establish a patient appropriate ESTHETIC outcome that maintains the biologic health, and structural integrity of the teeth, gingiva and bone.
2. To do this as conservatively as possible with materials and techniques that maintain long-term durability.

TREATMENT PLANNING

to restore or not to restore ?

to grind or to move ?

Rule # 1: The teeth would have need restoration anyway

Rule #2: I will not cross the DEJ with a bur when another form of treatment could have satisfied the Esthetic Goals -

i.e. I move and then restore if necessary

consistent with the treatment goals this is how i select a ceramic system

- FIRST CHOICE: feldspathic ceramics or bonded porcelain (i.e. power/liquid) Category 1 ceramics
- SECOND CHOICE: glass ceramics (i.e. glass matrix materials that are pressed or machined) Category 2 ceramics
- THIRD CHOICE: densely sintered crystalline ceramics (i.e. alumina or zirconia core systems) Category 3 ceramics
- FORTH CHOICE: metal ceramics Category 4 ceramics

WHAT ARE THE THINGS WE SHOULD EVALUATE TO DETERMINE WHAT CERAMIC SYSTEM TO CHOOSE ?

WHAT TYPE OF CERAMIC TO USE IS BASED ON THE ANSWERS TO THESE 5 QUESTIONS ?

1) Space requirements for workability of the material and shade change?

2) Substrate Condition or What's Underneath?
enamel (how much) ? dentin ? (what type)

3) Flexure Risk Assessment or What's the potential for flexure?
low? medium? high?

4) Excessive Shear and Tensile Stress Risk Assessment?
low? medium? high?

5) Bond or Seal Maintenance Risk Assessment? low? medium? high?

What Caused This Fail?
Is it the material or the tooth"?

1. space requirements for material ?
2. substrate ?
3. potential for flexure ?
4. stresses ?
5. seal ?

guidelines for when to do bonded feldspathic porcelain (Category 1)

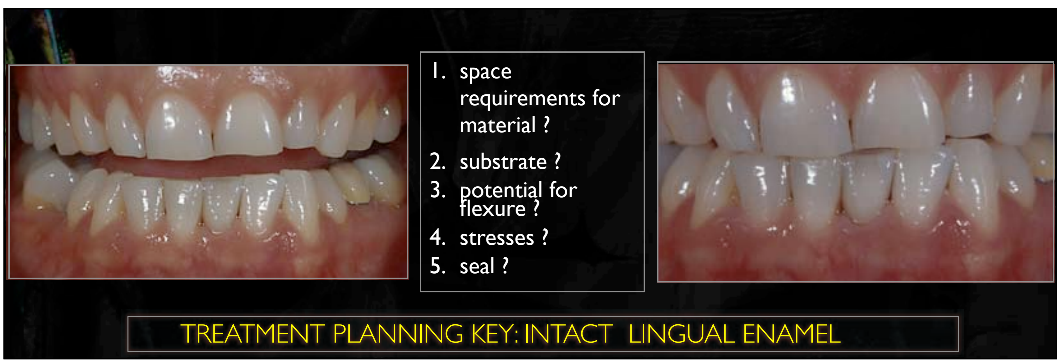
1) Space requirements for workability of the material and shade change?. 0.2 mm to 0.3 mm for each shade change and minimum thickness 0.3 mm

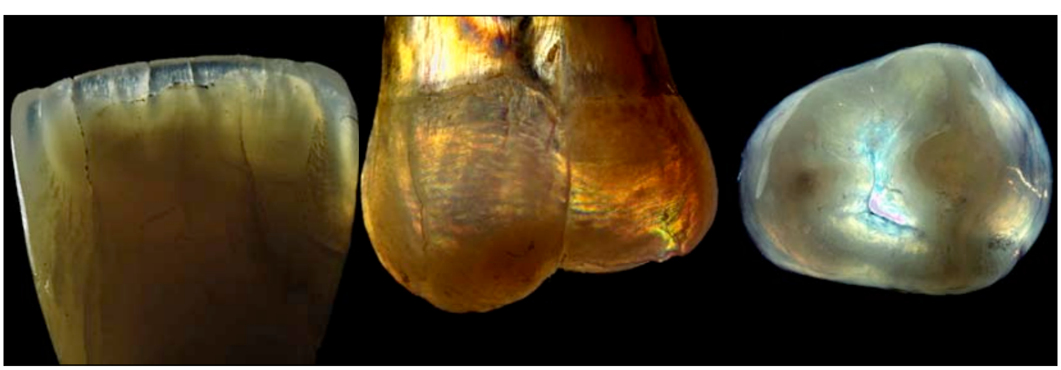
2) Substrate Condition or What's Underneath? . 50% or more remaining enamel on the tooth, 50% or more of the bonded substrate is enamel, 70 % or more of the margin is in enamel, If bonding to some dentin substrate the dentin is mostly unaffected and superficial dentin.

3) Flexure Risk Assessment or What's the potential for flexure? low to low/medium

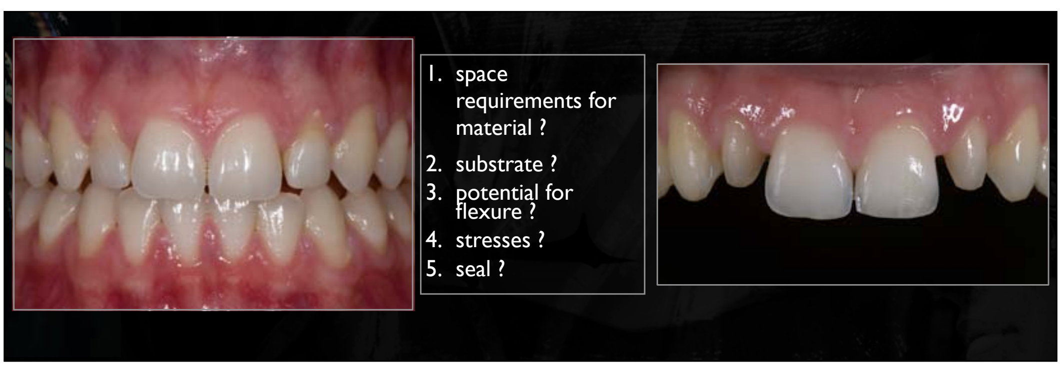
4) Excessive Shear and Tensile Stress Risk Assessment? low to low/medium

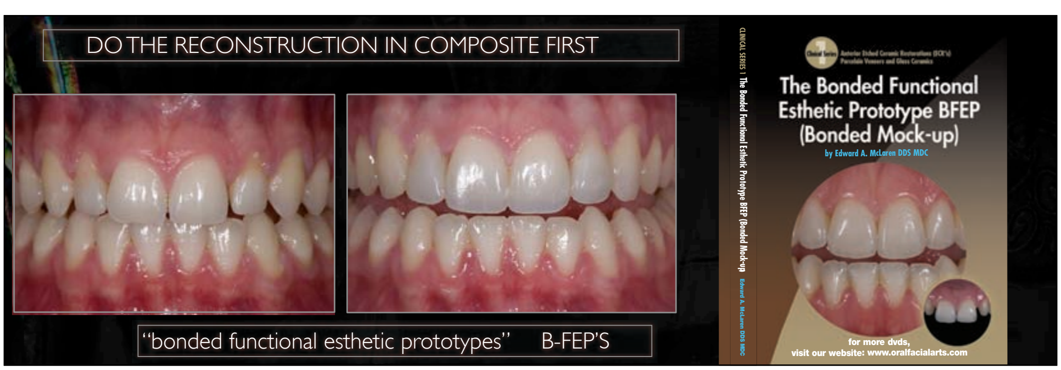
5) Bond or Seal Maintenance Risk Assessment? Absolute low risk of bond/ seal failure





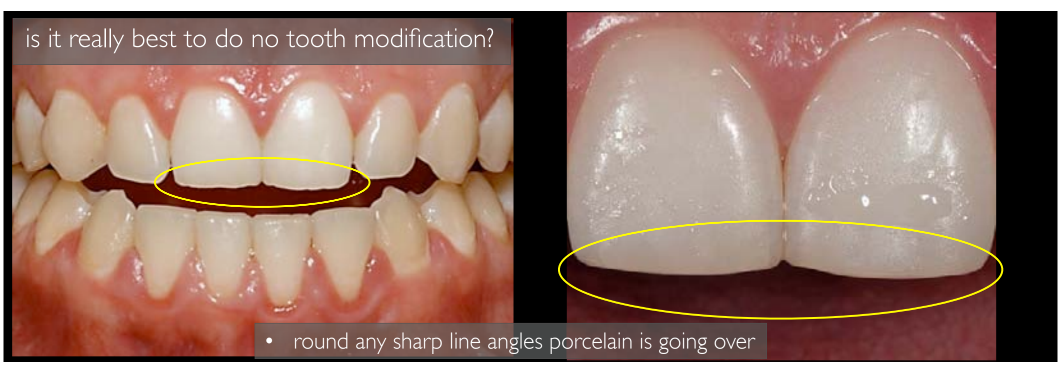

Tooth issues that lead to failure


1. space requirements for material ?
2. substrate ?
3. potential for flexure ?
4. stresses ?
5. seal ?

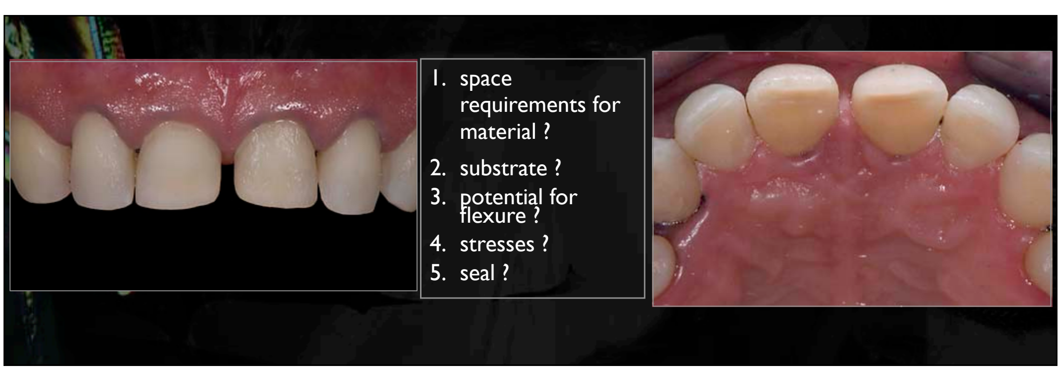

DO THE RECONSTRUCTION IN COMPOSITE FIRST
"bonded functional esthetic prototypes" B-FEP'S
CLINICAL SERIES 1 The Bonded Functional Esthetic Prototype BFEP (Bonded Mock-up
Edward A. McLaren DDS MDC
The Bonded Functional Esthetic Prototype BFEP (Bonded Mock-up)
by Edward A. McLaren DDS MDC
for more dvds,
visit our website: www.oralfacialarts.com


ECR'S
1. To Prepare or not to Prepare?
you have to decide do I grind on teeth or do I grind on the porcelain and then
2. If We are going to Prepare-
then how much ?
LAB taLk
Laboratory perspectives from the inside out
Porcelain Veneer Preparations:
To Prep or Not to Prep


Lipton
Ice Tea
Limón
PONCELEON
photography


is it really best to do no tooth modification?
• round any sharp line angles porcelain is going over


PRE-OP
FIRST SET - BFP
MODIFICATIONS


1. space requirements for material ?
2. substrate ?
3. potential for flexure ?
4. stresses ?
5. seal ?

Summary for Category 1 material use: (1) Generally indicated for anterior teeth. (2) Occasional bicuspid use, and rare molar use would be acceptable only with all parameters at the least risk level.

Category 1 materials are ideal with significant enamel remaining on the tooth, and generally with low flexure and stress risk assessment. Category 1 use absolutely requires long-term bond maintenance for success.

consistent with the treatment goals this is how i select a ceramic system

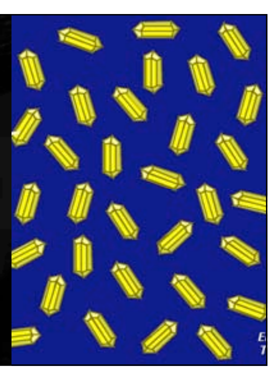
- FIRST CHOICE: feldspathic ceramics or bonded porcelain (i.e. power/liquid) Category 1 ceramics
- SECOND CHOICE: glass ceramics (i.e. glass matrix materials that are pressed or pressed or machined) Category 2 ceramics
- THIRD CHOICE: densely sintered crystalline ceramics (i.e. alumina or zirconia core systems) Category 3 ceramics
- FORTH CHOICE: metal ceramics Category 4 ceramics

GLASS CERAMICS

CONTROLLED CRYSTALLIZATION OF GLASS

- PRESSING PROCESSED (LOST WAX)
- MACHINED (CAD-CAM)
  - CEREC IN-LAB
    1. MARK II VITA
    2. IVOCLAR Empress CAD
    3. IVOCLAR E.MAX CAD

- TETRA SILICA FLOURO MICA
- LEUCITE
- LITHIUM DISILICATE



guidelines for when to do glass ceramics (Category 2) vs. feldspathic porcelain (Category 1)

1) Space requirements for workability of the material and shade change?. 0.8 mm minimum working thickness facial and incisal- can thin to margin to 0.3 mm, and 0.2 to 0.3 mm for each shade change.

2) Substrate Condition or What's Underneath? . Less than 50% enamel remaining on the tooth, less than 50% of the bonded substrate is enamel, and 30 % or more of the margin is in dentin.

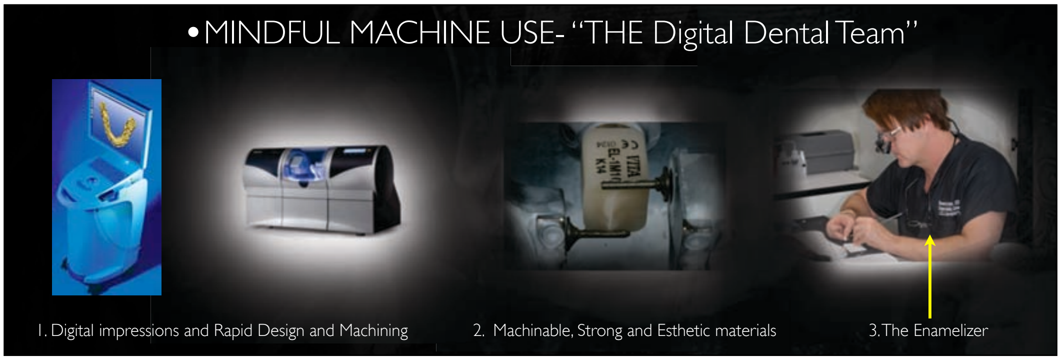
3) Flexure Risk Assessment or What's the potential for flexure? **Medium or less:** Empress, Vita Mark 2, and Authentic type glass ceramics or Layered E.Max indicated. **Medium to Medium/ high**-- Monolithic E.max indicated (only early data)

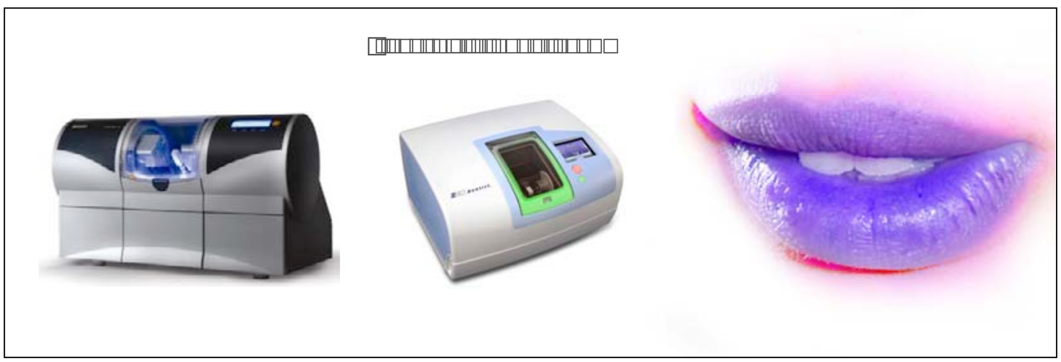
4) Excessive Shear and Tensile Stress Risk Assessment? **Medium or less:** Empress, Vita Mark 2, and Authentic type glass ceramics or Layered E.Max indicated. **Medium to Medium/ high**-- Monolithic E.max indicated (only early data)

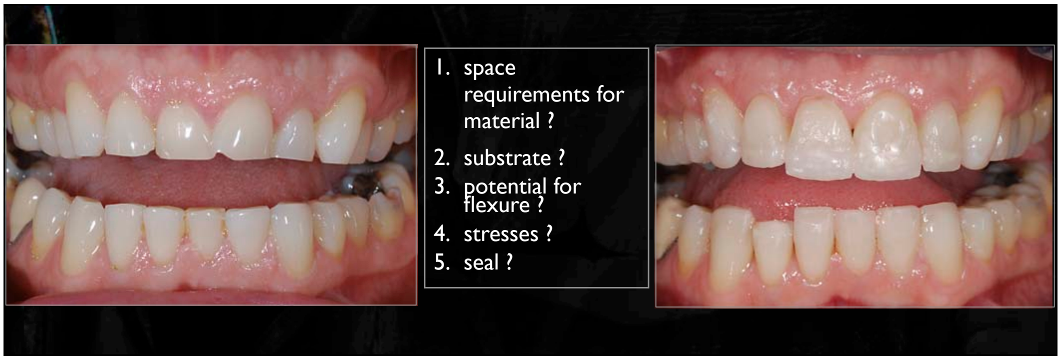
5) Bond or Seal Maintenance Risk Assessment? **Low risk** of bond/ seal failure for Empress, Vita Mark 2, and Authentic type glass ceramics or Layered E.Max. **Medium** for monolithic E.Max

1. space requirements for material ?
2. substrate ?
3. potential for flexure ?
4. stresses ?
5. seal ?

- VITA MARK II/ VM9
- IVOCLAR Empress CAD- EMPRESS ESTHETICS
  - E.Max Cad (lithium Disilicate)


• MINDFUL MACHINE USE- "THE Digital Dental Team"
1. Digital impressions and Rapid Design and Machining
2. Machinable, Strong and Esthetic materials
3. The Enamelizer




1. space requirements for material ?
2. substrate ?
3. potential for flexure ?
4. stresses ?
5. seal ?

E.MAX ? EMPRESS CAD ? VITABLOCKS ?

1. if you are pressing: E.Max for max strength Empress or Authentic for max esthetics (this will change with new porcelain
2. if you are machining: all 3 have shown similar clinical success bonded in monolithic form
3. if you are going to layer machined: then E.MAX (high stress) for any single tooth anterior or posterior: Vitablocks and Empress for anterior layering only (highest esthetics).

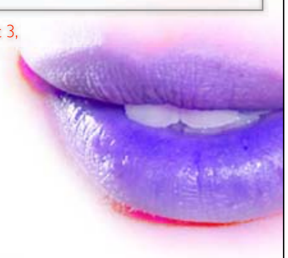
WHERE TO USE E.MAX ?- SITUATIONS WHERE YOU DON'T WANT TO ETCH

WHERE TO USE E.MAX ?- SITUATIONS WHERE YOU DON'T WANT TO ETCH

1. space requirements for material ?
2. substrate ?
3. potential for flexure ?
4. stresses ?
5. seal ?

<u>Summary for Category 2 material use:</u> Pressed or Machined glass ceramic material like Empress, Mark 2, and Authentic are indicated for thicker veneers, anterior crowns, and posterior inlay and onlays where medium or less flexure and shear and tensile stress risk is documented.

Also, they are only indicated in clinical situations where long term bond and seal can be maintained. E.Max which is a different type of glass ceramic (that has higher toughness) is also indicated for the same clinical situations as the other glass ceramics but can be extended for single teeth use in higher stress situations (as in molar crowns) as long as it is used in a full contour monolithic form and cemented with a resin cement.



Guidelines for when to do a Crown vs. Onlay (Category 3 or 4)

1) Space requirements for workability of the material and shade change?. 1.2 mm minimum Cat 3, 1.5 mm minimum CAT 4. need 1.5 mm to mask for CAT 3

2) Substrate Condition or What's Underneath? . Most of the enamel is gone on the tooth. most of the margin is in dentin, dentin substrate is compromised, very little tooth structure would need to be removed to create a crown preparation, large composite or post and core

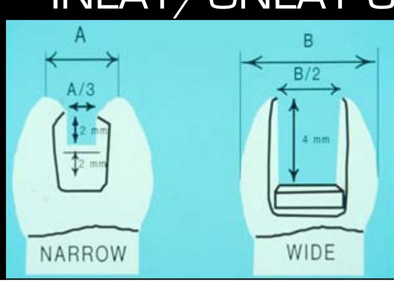
3) Flexure Risk Assessment or What's the potential for flexure? High or less:

4) Excessive Shear and Tensile Stress Risk Assessment? High or less:

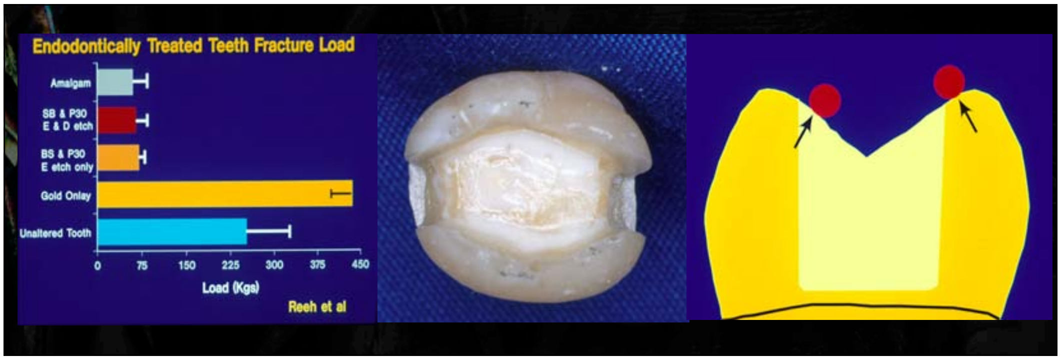
5) Bond or Seal Maintenance Risk Assessment? High or less: MOST IMPORTANT QUESTION FOR CHOOSING A CROWN

W H E N ?

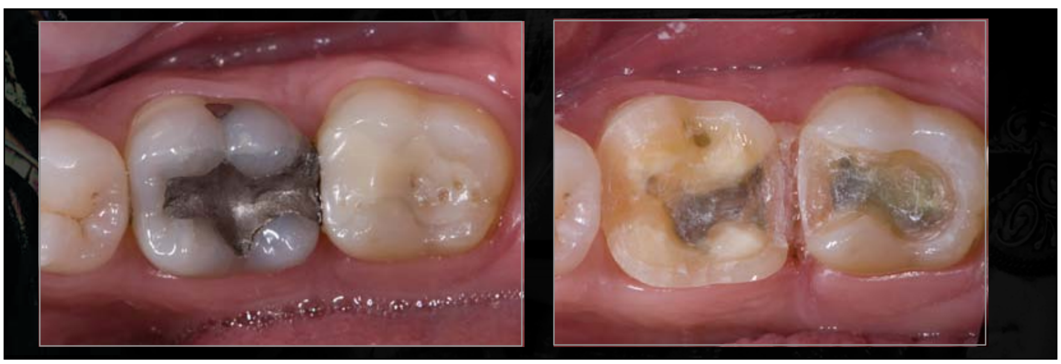
INLAY/ONLAY CONSIDERATIONS

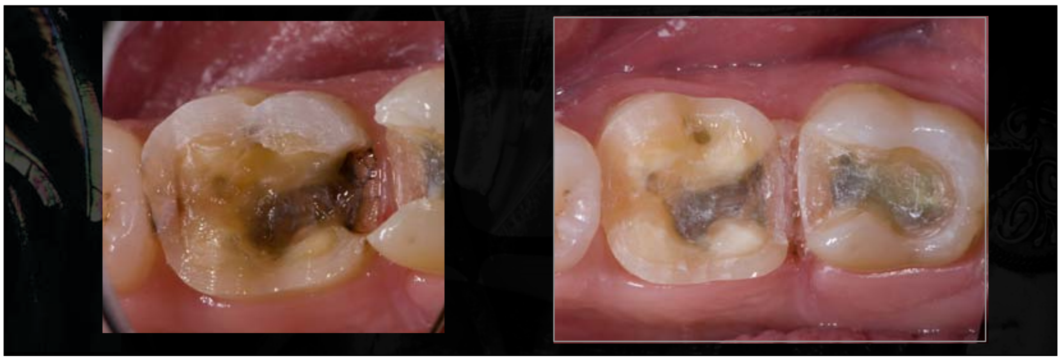


- LOAD TO FAILURE TESTS
  - MORIN- J DENT RES 1981
  - SHETH- JPD 1988
  - JOYNT- JPD 1987
  - DONLY, JENSEN- J PED 1988
  - JENSEN- COMP 1987
  - LOPES- QUINT INT 1991


Endodontically Treated Teeth Fracture Load
Amalgam
SB & P30 E & D etch
BS & P30 E etch only
Gold Onlay
Unaltered Tooth
0 75 150 225 300 375 450
Load (Kgs)
Reeh et al


COMPOSITE is a poor support for ceramic or enamel
• REMOVE UNSUPPORTED ENAMEL





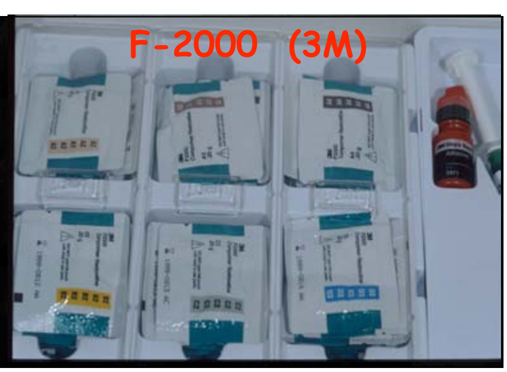
~~BUILD- UP or FOUNDATION RESTORATIONS ????~~

INDICATIONS

- BLOCK OUT UNDERCUTS
- SMOOTH WALLS

CONTRAINDICATIONS

- SUPPORT



CERAMIC ONLAY FRACTURE

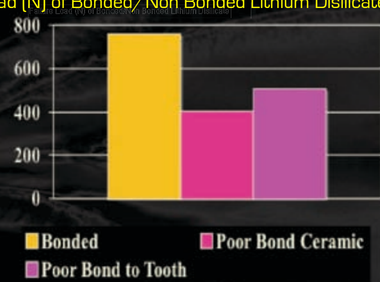
1. Moderate to large composite foundation restoration under the ceramic onlay
2. all-in-one cements without a separate adhesive step

material / technique	no storage control- total etch- AB 3	MULTI-LINK AUTOMIX separate primer	UNICEM no primer	UNICEM separate primer	MAXCEM ELITE no primer	MAXCEM ELITE separate primer
shear bond strength	24.49 Mpa	22.81 Mpa	10.97 Mpa	21.81 Mpa	7.51 Mpa	24.45 Mpa
ST. DEV.	5.19	5.82	5.88	5.12	5.45	6.40

Lithium Disilicates/ (empress 2/ eris

CLINICAL IMPLICATIONS
Material selection and the quality of the bonding technique influence the load-bearing capabilities of bonded ceramic restorations. Poor initial bond quality or degradation of the bond quality over time may contribute to the potential for restoration failure in service.

Failure Load (N) of Bonded/Non Bonded Lithium Disilicate



Clelland et. al., JPD, 1/2007

WHAT CERAMIC/material SHOULD I USE ?

- FIRST CHOICE: feldspathic ceramics or bonded porcelain (i.e. power/liquid) Category 1 ceramics
- SECOND CHOICE: glass ceramics (i.e. glass matrix materials that are pressed or machined) Category 2 ceramics
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- FORTH CHOICE: metal ceramics Category 4 ceramics

what type of crown system ?

question 5) CAN I PROTECT THE INTERNAL INTERFACE?

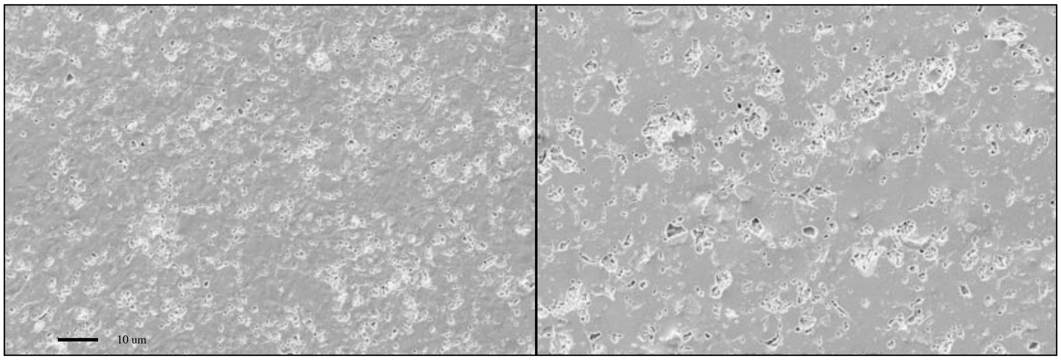
- METAL-CERAMICS any where / any cement
- PARTIALLY STABILIZED ZIRCONIA (properly thermally treated) anywhere / data looks good for conventional cement i.e. any cement
- Alumina IN-Ceram or Procera up to the first molar i.e resin cement
- Spinell anterior teeth i.e resin cement
- Lithium Disilicate- E.Max (long term data not available) bonding strongly recommended I.E. RESIN

BELIEF: There is a specific chemical or manufacturing problem with the porcelains for Zirconia because of the chipping and pitting problem

- since 2004 over 1200 single units YZ, Lava, and others over 7 years (average approx. 5 years)
  - 2 documented core fractures
- over 30 3-unit posterior FPD's
  - 1 documented framework fracture
- approx. 6 % restorations replaced for porcelain fracture
- minor chipping noted on approx. 15% of the samples- not requiring replacement

- since 2007 slightly over 300 single units of YZ, Lava, and Procera all Done with VM9 with new firing parameter (average 2.5 years)
  - no documented core fractures
- 1 restoration replaced for porcelain fracture
- 2 minor marginal ridge fractures noted

Least Problems seen with
VM9 Vita
CZR Noritake



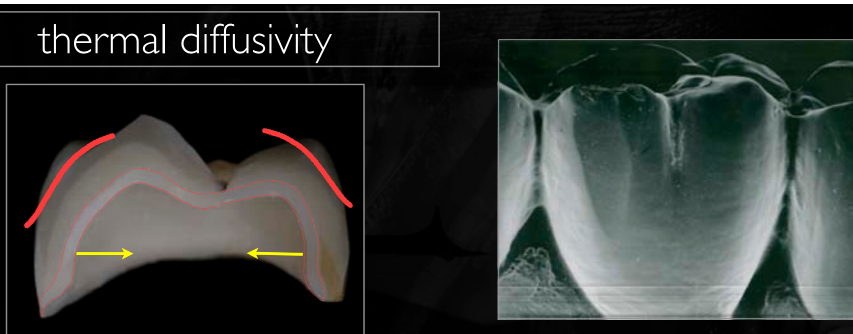
over 200 veneers (VM9) at 2 years- virtually no porcelain chipping especially when bonded to enamel

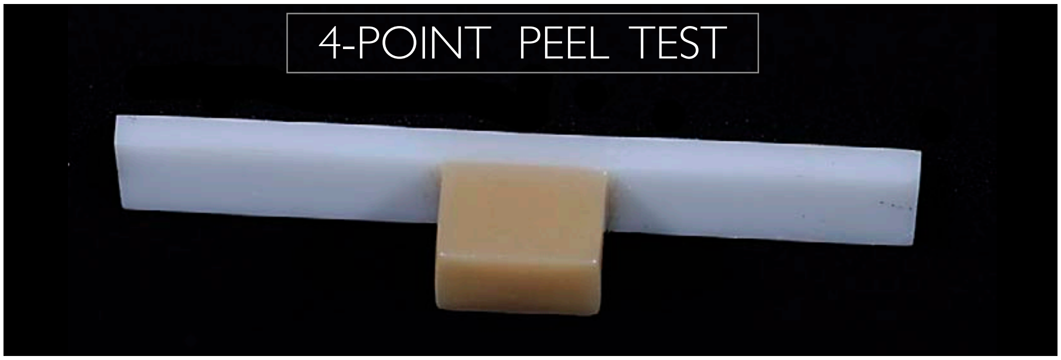
RESEARCH- CRITICAL ELEMENTS that cause Zirconia VENEER failure

- THERMAL INCOMPATIBILITY WITH CORE MATERIAL i.e. CTE (the amount of expansion over a temperature range)
- BONDING INTERFACE ceramic/core
- STRUCTURAL SUPPORT FOR THE VENEER CERAMIC
- UNDER-FIRING OF PORCELAIN
- DIFFERENCES IN THERMAL DIFFUSIVITY BETWEEN VENEER AND CORE MATERIAL-(the rate materials take up and give off heat)

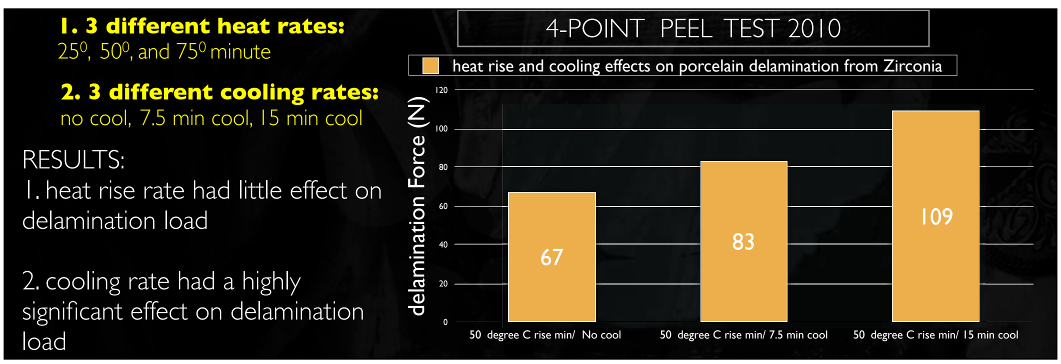
PROPERTY	Y-TZP	Glass/ Porcelain	ALUMINA
Hardness (HV_{30})	1350	700	1600
Flexural Str. (MPa)	800-1200	80-100	400-600
Young's Modulus (GPa)	205	70-80	380
Fracture Toughness (MPa. $m^{1/2}$)	9.5	.8-1.5	4-5
CTE ($x10^{-6}\,{}^{0}c^{-1}$)	10	7-14	8
Thermal Conductivity ($W.m^{-1}.K^{-1}$)	.5 to 2	1.5-5	20-35

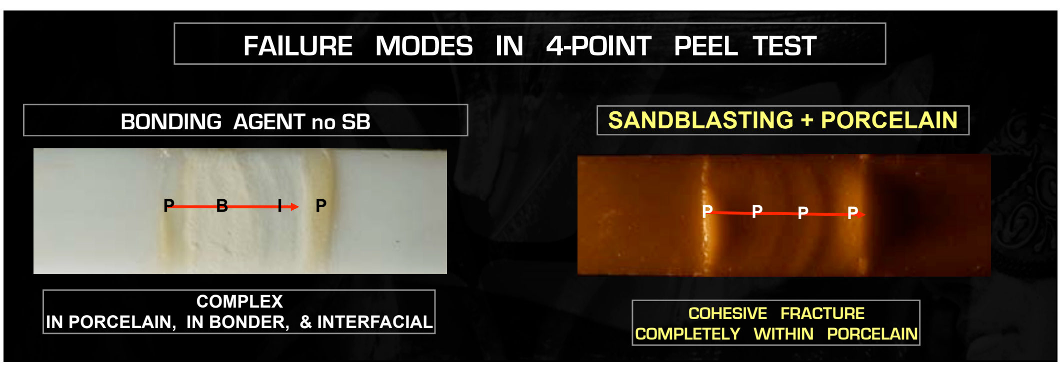
thermal diffusivity




4-POINT PEEL TEST


4-POINT PEEL TEST


1. 3 different heat rates:
25⁰, 50⁰, and 75⁰ minute
2. 3 different cooling rates:
no cool, 7.5 min cool, 15 min cool
RESULTS:
1. heat rise rate had little effect on delamination load
2. cooling rate had a highly significant effect on delamination load
4-POINT PEEL TEST 2010
heat rise and cooling effects on porcelain delamination from Zirconia
delamination Force (N)
120
100
80
60
40
20
0
67
83
109
50 degree C rise min/ No cool
50 degree C rise min/ 7.5 min cool
50 degree C rise min/ 15 min cool

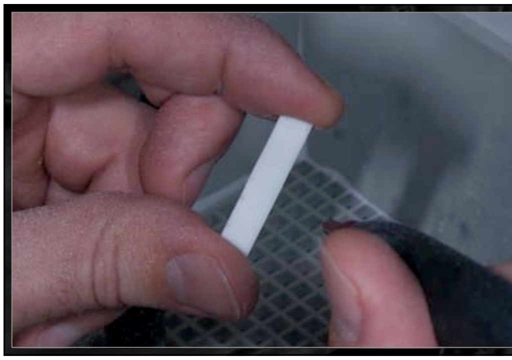

FAILURE MODES IN 4-POINT PEEL TEST
BONDING AGENT no SB
P B I P
COMPLEX
IN PORCELAIN, IN BONDER, & INTERFACIAL
SANDBLASTING + PORCELAIN
P P P P
COHESIVE FRACTURE
COMPLETELY WITHIN PORCELAIN


• slow cool main bakes 3 minutes leave on muffle for 4 mins (7 minutes)
• SLOW COOL-ON THE GLAZE CYCLE- high temp to 500 degrees- 6 min
• leave on muffle for 10 minutes until about 200 degrees C on glaze cycle
thus a total slow cool is 16 min ON THE LAST BAKE

MYTH #3 : You should not SAND BLAST Zirconia

question: what surface are you talking about ?

- SUZANNE SHERRERER, SHANE WHITE, OTHER OTHERS HAVE ALL SHOWED THAT MILD SAND BLASTING OF ALREADY MACHINED PIECES DOES NOT WEAKEN THE ZIRCONIA
- GIORDANO, WHITE & MCLAREN- LIGHT SANDBLASTING INCREASED BOND STRENGTH OF PORCELAIN
- KERN, BLATZ HAVE SHOWN INCREASED BOND STRENGTH AND BETTER SEAL WITH SAND BLASTING THE INTERNAL (cementing surface)



- POST LAVA MACHINED ZIRCONIA BARS
- 50 um AL_2O_3 at 20 psi for 10 seconds- at 1 inch
- statistically no difference in 3 point flexure test

BONDING INTERFACE ceramic/core

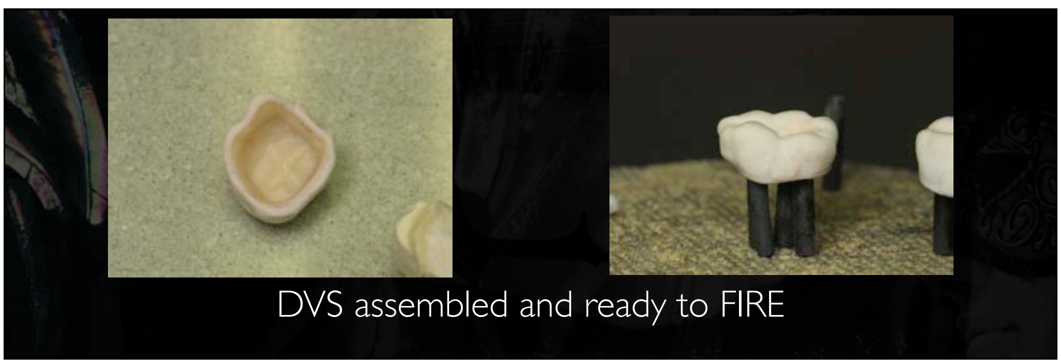
- LIGHTLY SAND BLAST SURFACE OF CORE BEFORE BONDING LAYER PORCELAIN APPLICATION
  - 50 um AL_2O_3 at 30 psi

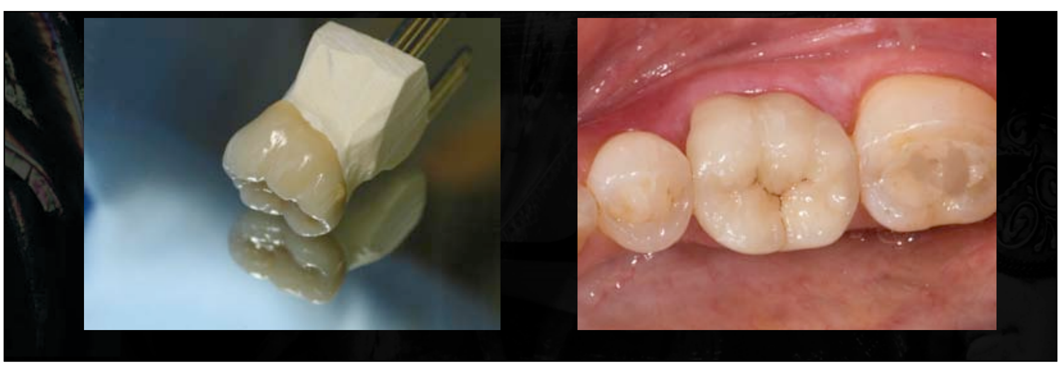
STRATEGIES TO TREAT DISCOLORATIONS

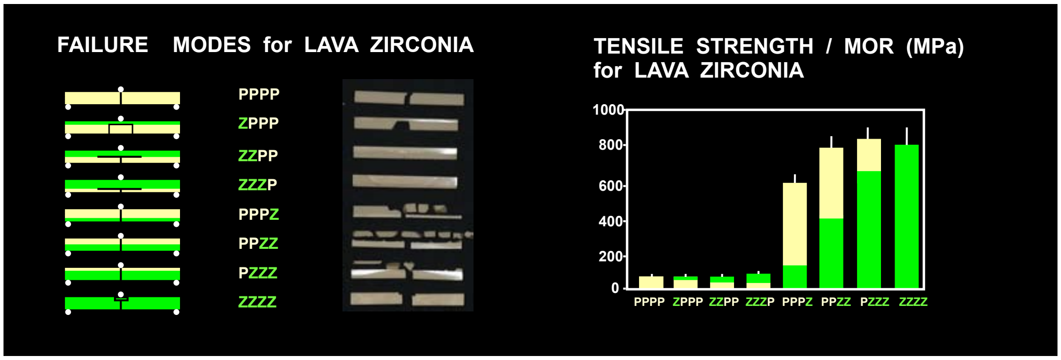
- METAL-CERAMICS
- PARTIALLY STABILIZED ZIRCONIA
  - must have 1.0 mm for porcelain
  - 0.6 mm core
  - one shade brighter core

ONE SHADE BRIGHTER CORE FOR DISCOLORED TEETH


DVS and Coping and Fusion

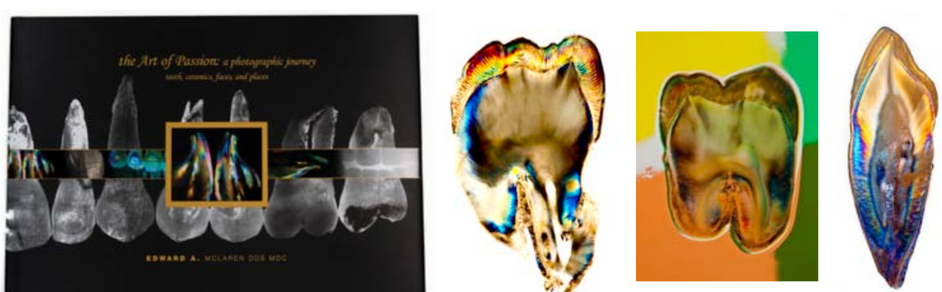

DVS assembled and ready to FIRE





- 3mm or ideally 4mm distal connector
- No Porcelain on Gingival Aspect of Embrasure

best bond to zirconia was Z Prime + : Bisco



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