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Lecture 8: Biomaterials (Cements)

By Dr Cheryl Fu

Learning Objectives

- Different permanent and temporary cements and their uses
- Bonding/luting mechanisms
- Clinical steps for cementing a permanent crown (glassy vs crystalline vs metallic)

Reading: Chapter 30 Contemporary fixed prosthodontics +

Dental Luting Cements: An Updated Comprehensive Review

Artak Heboyan,[1,*] Anna Vardanyan,[1] Mohmed Isaqali Karobari,[2,3] Anand Marya,[4,5] Tatevik Avagyan,[6] Hamid Tebyaniyan,[7] Mohammed Mustafa,[8] Dinesh Rokaya,[9,*] and Anna Avetisyan[10]

Cements

Divided into temporary and permanent cements

- Temporary cements such as zinc oxide eugenol/eugenol free cements covered in temporization

Permanent cements can then be classified in many ways:

- Composition:
  - Resin based vs Water based (GIC, zinc polycarboxylate and zinc phosphate)
- Bonding mechanism
  - Non adhesive luting vs micromechanical retention vs molecular adhesion

Luting

A Review of Dental Cements

Kipp Wingo, DVM, DAVDC[1]

"A term sometimes used to refer to final placement of a fixed prosthodontic restoration is to "lute" the restoration. It derives from the Latin lutum, which means mud or clay. A "luting agent" is the substance—such as cement, wax, or clay—that coats a joint area to make a tight seal. Historically, luting agents were used to mechanically link restorations to a prepared tooth."

- Luting cements work based of mechanical friction by
- Traditionally for cast restorations
- The luting cement powder sets into a hardened matrix
- However luting cements generally have solubility issues due to the matrix consisting of ionic salts

Micromechanical bonding

- Resin cements
- Etching dentin/enamel (Phosphoric acid)
- Etching glassy ceramics (hydrofluoric acid)
- Sand blasting metal/zirconia crowns

Molecular adhesion

- Physical forces such Van der Waals or chemical ionic bonding.
- 10-MDP
- At the moment cements still require other methods of retention (parallel walls)
- Can not rely solely on this.

Ideal Properties of Cements

- Low film thickness
- Suitable working time and setting time
- High compressive strength
- Similar elastic modulus as dentin
- Biocompatible
- Plaque/caries inhibition
- Low solubility
- Low microleakage
- Easy removal of excess
- High retention

Biocompatible and Antimicrobial Effects

- Cements should ideally not interact with bodily tissues, and not cause sensitivity or allergic reactions
- Antimicrobial effects to prevent marginal caries. However evidence in inconclusive whether low level fluoride or other antimicrobial agents can provide long term inhibition. (Will the fluoride etc still be there in 10 years?)

Suitable working and setting time

- Ideally enough time to mix the cement, seat and clean up excess in appropriate time
- Benefit of tack cure resin cement.
- However if excess resin cement is not fully removed before final cure, will be extremely hard to remove excess

Microleakage/Solubility

- Solubility of cements in the oral environment (water) can lead to microleakage at the marginal interface and possible loss of retention.
- Zinc phosphate and zinc polycarboxylate have high solubility
- Resin cements have low solubility

Microleakage/Solubility

Mean and standard deviation values of microleakage of the cements in restorations with open margins (mm)

Cement	N	Mean ± SD
Fleck [a,b,c]	15	3.32 ± 0.70
Fuji Plus [a,d]	15	0.92 ± 0.53
G-Cem [b,d,e]	15	2.08 ± 1.10
Panavia F2.0 [c,e]	15	0.64 ± 0.78
Total	60	1.74 ± 1.32

Mean and Standard Deviation Values of Microleakage of the Cements in Restorations With Closed Margins (mm)

Cement	N	Mean ± SD
Fleck [a,b]	15	1.92 ± 1.23
Fuji Plus [a,c]	15	0.77 ± 0.88
G-Cem [c,d]	15	1.25 ± 1.07
Panavia F2.0 [b,d]	15	0.18 ± 0.14
Total	60	1.03 ± 1.11

Fleck = zinc phosphate

HOWEVER ITS NOT APPROPRIATE TO SAY RESIN CEMENTS ARE PERFECT

Microleakage of Four Dental Cements in Metal Ceramic Restorations With Open Margins

Reza Eftekhar Ashtiani,[1] Babak Farzaneh,[2] Mohadese Azarsina,[3] Farzad Aghdashi,[4,*] Nima Dehghani,[4] Aisooda Afshari,[5] and Minu Mahshid[6]

Film thickness

- Low film thickness preferred
- ADA states a maximum film thickness of 25um for luting cements
- Associated with better seating of crown and possibly lower marginal discrepancies.

[Influence of types and surface treatment of dental alloy and film thickness of cements on bond strength of dental luting cements].

Hibino Y [1]

Table 4 Correlation coefficients between film thickness and tensile bond strength of dental luting cements

Alloy	Cement		
	DURELON	Fuji Ionomer TYPE I	PANAVIA EX
Au-Ag-Cu	−0.76	−0.87	−0.89
Ag-Pd	−0.78	−0.83	−0.92
Ag-Pd (hardened)	−0.78	−0.86	−0.86
Ni-Cr	−0.78	−0.85	−0.90

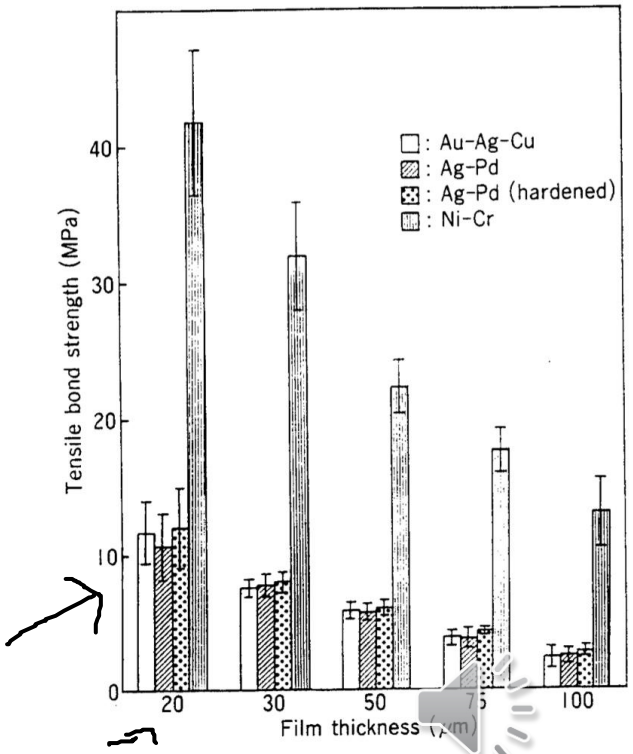
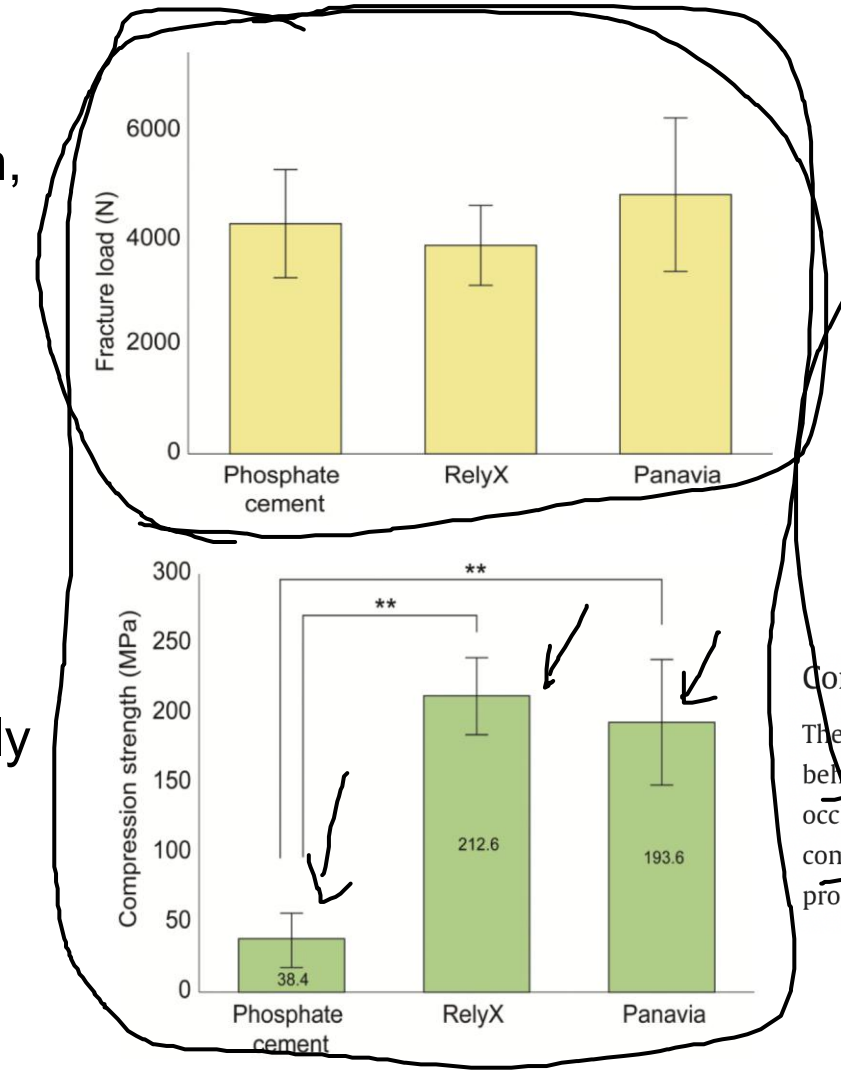


Fig. 8 Effect of film thickness on tensile bond strength of adhesive resin cement to different dental alloys

Elastic modulus and compressive strength

- If cement has a similar elastic modulus as dentin, there will be less stress concentration at the interface
- Some studies claim that fracture of ceramic restoration begin at the cement layer.
- Fracture load of zirconia crowns may not be greatly affected by cement type
- However chemical adhesion may be more important for lithium disilicate crowns



Fracture resistance of monolithic zirconia crowns: The importance of the compressive strength of the dental cements used.

Weak adhesion between ceramic and resin cement impairs the load-bearing capacity under fatigue of lithium disilicate glass-ceramic crowns

Lucas Saldanha da Rosa [a], Helder Callegaro Velho [a], João Paulo Mendes Tribst [b], Luiz Felipe Valandro [a], Cornelis Johannes Kleverlaan [c], Gabriel Kalil Rocha Pereira [a]

Conclusion

The chemical adhesion between cement and ceramic is essential for better fatigue behavior of lithium disilicate crowns with a simplified anatomy, especially in the occlusal portion, but the restoration performance is impaired when such adhesion is compromised. There is an increase in crown and cement stress concentration with the progressive loss of chemical bonding of the crown's walls.

Compressive Strength

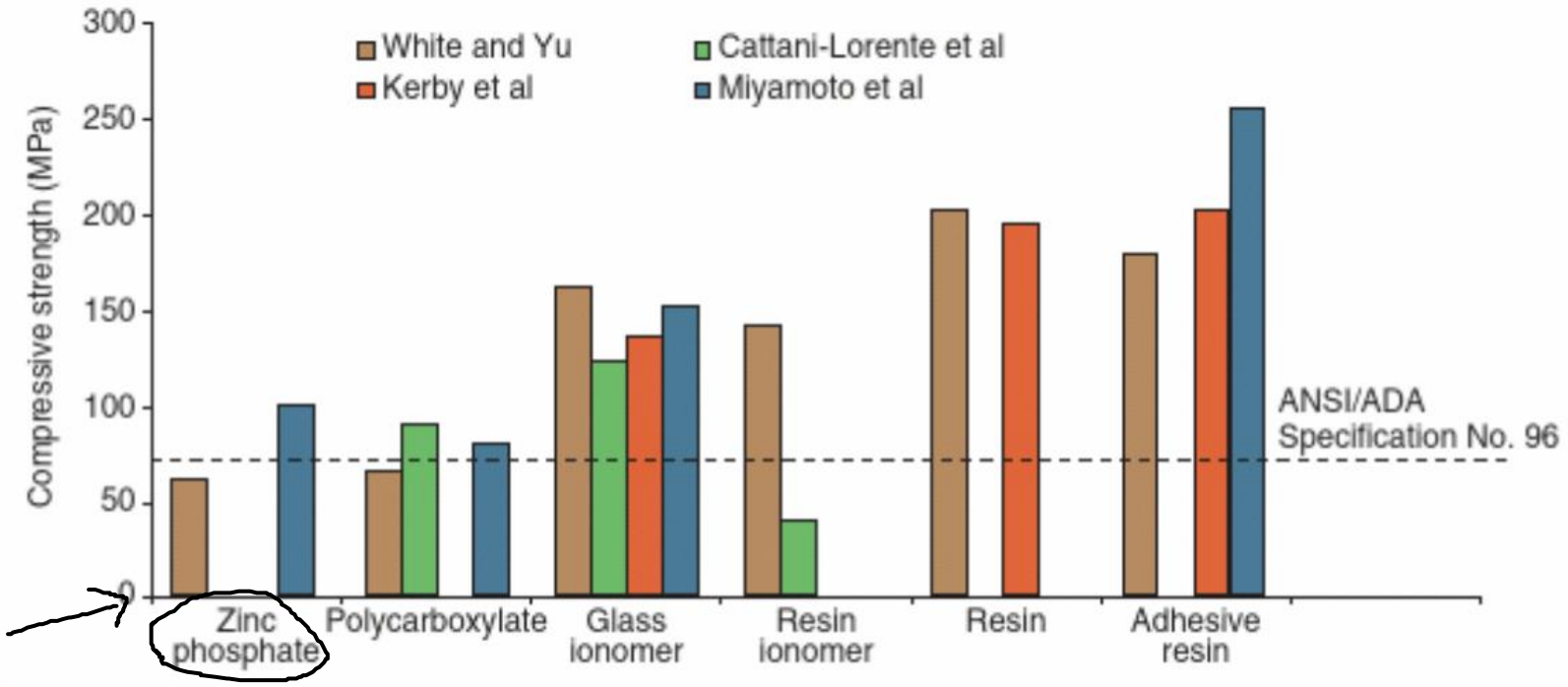


FIGURE 30-4 ■ Compressive strength of luting agents. In the studies cited, higher strength values were reported with the resin cements and glass ionomers than with zinc phosphate or polycarboxylate. Resin-modified glass ionomer exhibited greater variation than did other cements. *ANSI/ADA,* American Dental Association/American National Standards Institute. (From Rosenstiel SF, et al: Dental luting agents: a review of the current literature. J Prosthet Dent 80:280, 1998.)

Retention

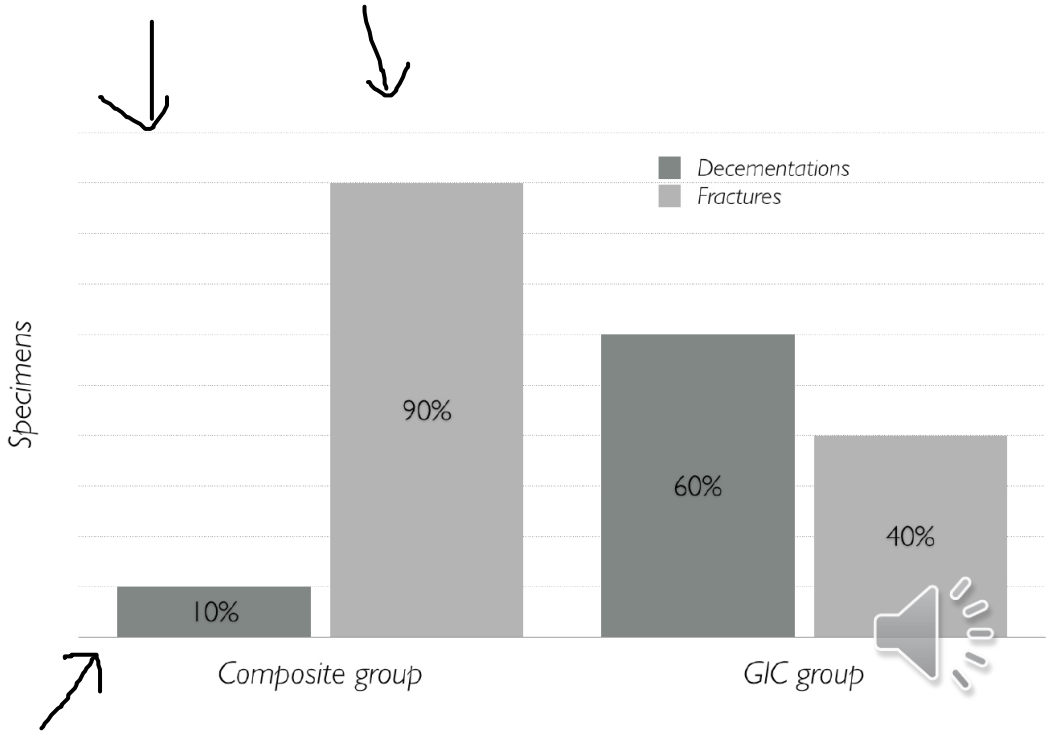
- Lithium disilicate crowns cemented adhesively with resin cement had a higher failure load compared to GIC. Additionally, fewer cases of debonding.

Effect of Different Luting Agents on the Retention of Lithium Disilicate Ceramic Crowns

Nicola Mobilio [1,*], Alberto Fasiol [1], Francesco Mollica [2] and Santo Catapano [1]

Table 1. Mean failure loads (standard deviation) in N.

Groups	Mean (sd)
Composite group	306.6 (193.8)
GIC group	94.7 (48.2)



Retention

- Mixed literature regarding zirconia crowns
- Some suggest MDP containing cements promoted better bond strength
- Some found no differences
- We will review zirconia bonding towards the end of this lecture

Bond strength and stability of 3 luting systems on a zirconia-dentin complex

Sebnem Begum Turker, DDS, PhD ▪ Mutlu Ozcan, PhD ▪ Gamze Mandali, DDS, PhD ▪ Isil Damla, DDS ▪ Burcu Bugurman, DDS
Luiz Felipe Valandro, PhD

Table 2. Median and mean values (±SD) of shear bond strength (MPa) failure before and after aging procedure. Based on the results of Kruskal-Wallis and Mann-Whitney U-tests ($\alpha < .05$).

	Immediate test		After aging		Mann-Whitney U-tests	*P* value
	Median ($P = 0.0001$; Kruskal-Wallis = 21.3)	Mean (±SD)	Median ($P = 0.016$; Kruskal-Wallis = 8.27)	Mean (±SD)		
GI	2.93	3.4 (1.23)	4.02	4.7 (3.4)	44	0.650
RMGI	8.37	9.2 (3.80)	4.66	6.2 (3.7)	24	0.049
MDP	17.65	16.9 (6.40)	9.79	11.3 (6.4)	24	0.049

Abbreviations: GI, glass ionomer; RMGI, resin-modified glass ionomer; MDP, resin cement containing 10-methacryloyloxydecyl dihydrogen phosphate.

Retention

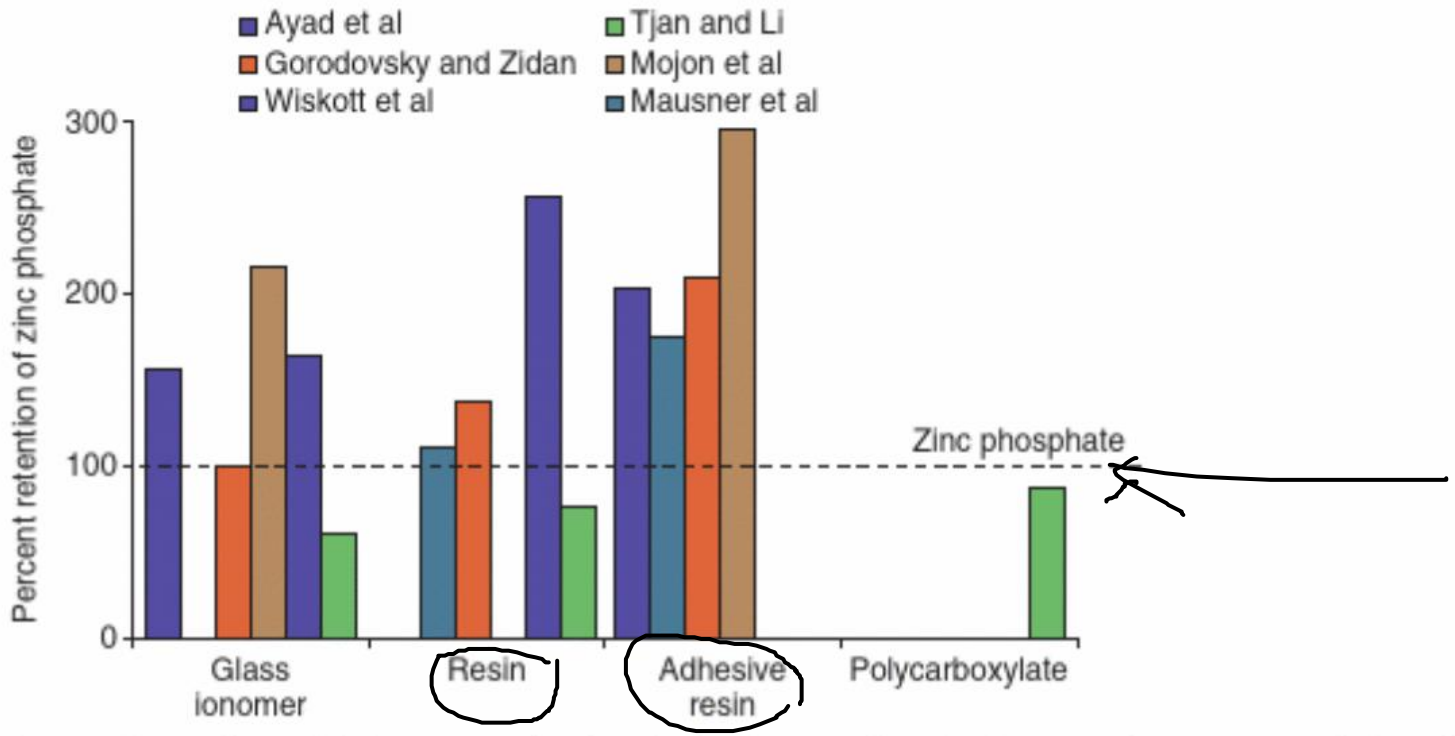


FIGURE 30-3 ■ Crown retention studies: effect of luting agent. In the six in vitro studies cited, researchers evaluated the effect of luting agent on crown retention. The data were normalized as percentages of the retention value with zinc phosphate cement. Adhesive resins had consistently greater retention than did zinc phosphate. Conventional resins and glass ionomers yielded less consistent results. (From Rosenstiel SF, et al: Dental luting agents: a review of the current literature. J Prosthet Dent 80:280, 1998.)

Zinc Oxide Eugenol

- Basic composition:
  - Zinc oxide + Eugenol +Rosin + Zinc Acetate
- Low strength + high solubility in oral environment
- A potential “sedative” effect for the pulp and otherwise biocompatible
- Issues with eugenol inhibiting resin polymerization
- Temporary cement

Zinc Phosphate

- Basic composition:
  - Zinc oxide + magnesium oxide + phosphoric acid + water +buffers
- Popular cement for use in traditional cast restorations, (has been around since 1800s)
- Acceptable film thickness of 25um
- Ease of removal of the excess material after setting
- Potential issues with biocompatibility due to the inclusion of phosphoric acid (pH 2 at time of cementing). However generally well tolerated if preparation is not too close to the pulp
- Acceptable working time of about 5 minutes

Zinc Polycarboxylate

- Basic composition
  - Zinc oxide + polyacrylic acid
- Attempts to address some biocompatibility issues from zinc phosphate by changing to polyacrylic acid
- Also exhibits some adhesion to the tooth surface through chelation of calcium (but not to cast metal surfaces)
- Potentially technique sensitive due to mixing of viscosus powder and liquid (mitigated via capsules)
- Additionally very short working time of under 3 minutes
- Indicated for high retention preps, or close to pulp horns

Glass ionomer cement (GIC)

- Basic composition
  - Polycarboxylate + fluorialuminosilicate glass + water + tartaric acid
- Good biocompatibility + theoretically anticariogenic
- Aesthetic due to translucency of the cement
- Potential for water absorption during early setting which would lead to erosion of the weakened material
- Ionic bonding to tooth structure
- Concerns regarding possible post-op sensitivity not supported by literature when manufacturer followed

Resin modified glass ionomer

- Basic composition
  - GIC + resin
- Due to the inclusion of resin and corresponding photoactivators, some of the issues of GIC cement were improved
- Resin matrix improves the mechanical properties such as compressive and fracture strength compared to unmodified GIC
- Also suggest improvement in retention and bond strength
- Could be harder to remove excess. (Remember to tack cure)
- Some studies say it is contraindicated for all ceramic crowns (risk of fracture after water absorption)

- Latest generation of resin-modified glass ionomer cement
- Excellent handling, consistency and bond strength
- Easy clean-up and one-step application, saving chair time
- Ideal for cementation of zirconia, PFM and lithium disilicate restorations
- High fluoride release
- Moisture tolerant, no isolation required

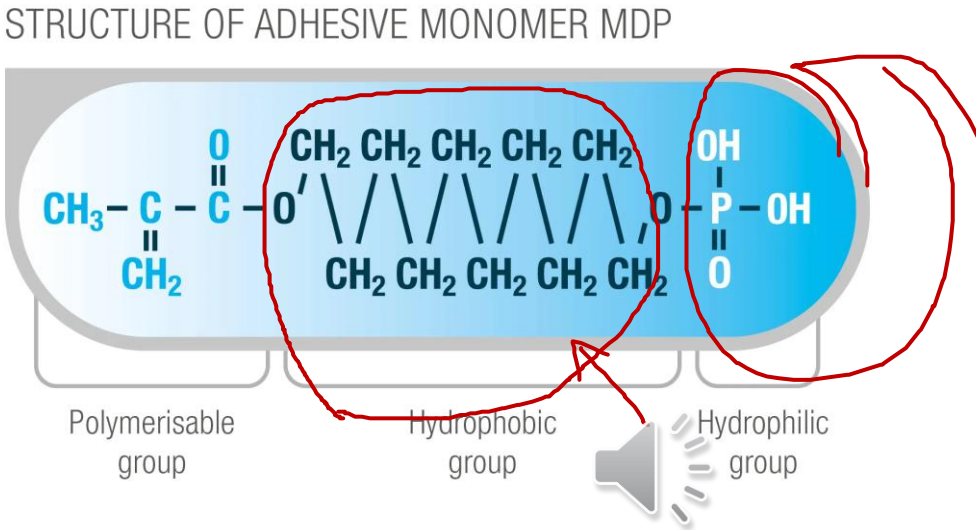
Resin based cements

- Basic composition
  - Resin + filler (lower filler ratio for lower film thickness)
- Similar to restorative composite (exactly the same steps required)
- Offers micromechanical retention
- Very high compressive strength
- Least soluble
- Technique sensitive (moisture control)
- May be more expensive
- Self cure, dual cure or light cure options
- Removal of excess may be difficult if not removed at tack cure stage

Special mention: Panavia

Panavia

- Resin cement with bifunctional monomer, 10-methacryloyloxydecyldi-hydrogen-phosphate (MDP)
- 10-MDP is able to interact with metal oxides via the hydrophilic phosphoric acid end group
- 10-MDP also facilitate a chemical bond with dentin through the formation of MDP-Ca insoluble salts



Summary

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TABLE 30-2 Indications for and Contraindications to Luting Agent Types

Restoration	Indication	Contraindication
Cast crown, metal-ceramic crown, partial FDP	1, 2, 3, 4, 5, 6, 7	—
Crown or partial FDP with poor retention	1, 2	3, 4, 5, 6, 7
MCC with porcelain margin	1, 2, 3, 4, 5, 6, 7	—
Casting on patient with history of post-treatment sensitivity	Consider 4 or 7	2
Pressed, high-leucite, ceramic crown	1, 2	3, 4, 5, 6, 7
Slip-cast alumina crown	1, 2, 3, 4, 6, 7	5
Ceramic inlay	1, 2	3, 4, 5, 6, 7
Ceramic veneer	1, 2	3, 4, 5, 6, 7
Resin-retained partial FDP	1, 2	3, 4, 5, 6, 7
Cast post-and-core	1, 2, 3, 5, 6	4, 7

Key

LUTING AGENT TYPE	CHIEF ADVANTAGES	CHIEF CONCERNS	PRECAUTIONS
1. Adhesive resin	Adhesive, low solubility	Film thickness, history of use	Moisture control
2. Self-etch adhesive resin	Low solubility, ease of use, bonding to dentin	Film thickness	Moisture control
3. Glass ionomer	Translucency	Solubility, leakage	Avoid early moisture exposure
4. Reinforced ZOE	Biocompatible	Low strength	Only for very retentive restorations
5. Resin ionomer	Low solubility, low microleakage	Water sorption, history of use	Avoid with ceramic restorations
6. Zinc phosphate	History of use	Solubility, leakage	Use for "traditional" cast restorations
7. Zinc polycarboxylate	Biocompatible	Low strength, solubility	Do not reduce powder-to-liquid ratio

FDP, Fixed dental prosthesis; *MCC*, metal-ceramic crown; *ZOE*, zinc oxide–eugenol.

Cementation

- After ensuring permanent crown seats fully (covered in other lecture, and consent from patient to cement.
- Zirconia vs Lithium Disilicate crowns

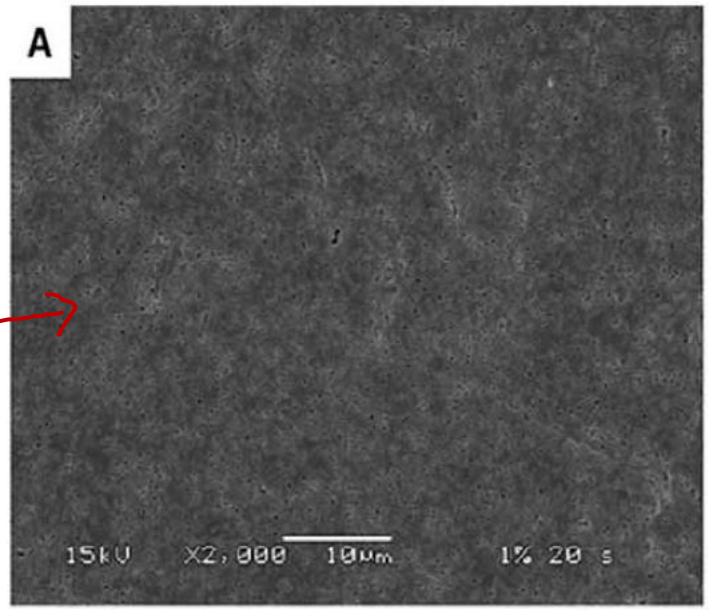
Glassy ceramic crowns

$$SiO_2(s) + 4\,HF(aq) \rightarrow SiF_4(g) + 2\,H_2O(l) \quad (2)$$

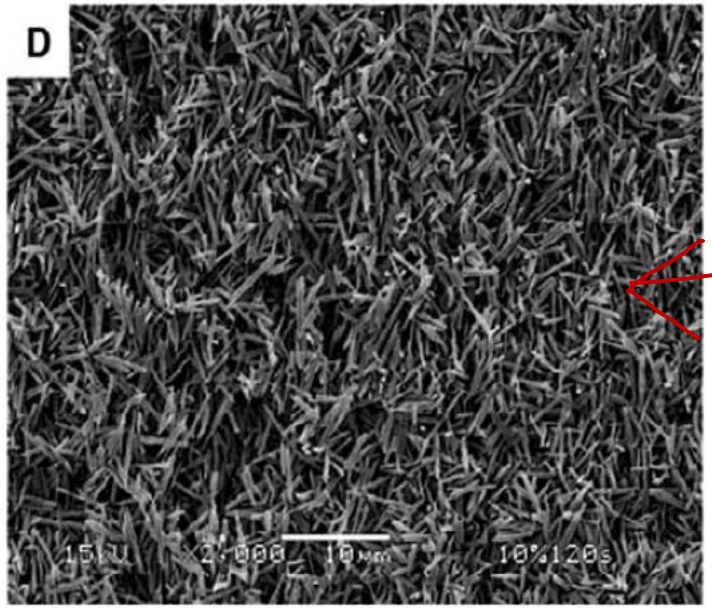
$$4\,SiF_4(g) + 3\,H_2O(l) + 2\,HF(aq) \rightarrow 3\,H_2SiF_6(aq) + H_2SiO_3(aq) \quad (3)$$

Lithium disilicate, etc.

- Lab steps:
  - Prior to returning the crown, the lab may have already etched the internal fitting surface with hydrofluoric acid (eg ceram etch 9% hydrofluoric gel)



1% HF 20 s

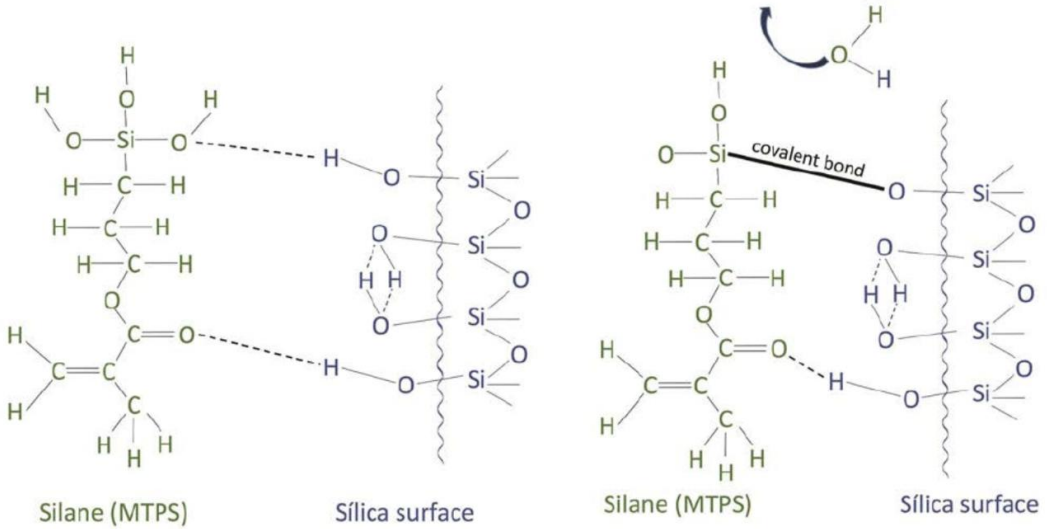


1% HF 120 s

Glassy ceramic crowns

Lithium disilicate, etc.

- Lab steps:
  - Prior to returning the crown, the lab may have already etched the internal fitting surface with hydrofluoric acid (eg ceram etch 9% hydrofluoric gel)
  - Silane coupling agent eg 3-methacryloxypropyltri-methoxysilane (MPS) forms bridge between the organic compounds in resin cements and inorganic ceramic molecules, hence improving the bond strength. Also increase surface energy and contact angle decreased for better resin/adhesive contact.



Influence of the Multiple Layers Application and the Heating of Silane on the Bond Strength between Lithium Disilicate Ceramics and Resinous Cement

Uriel Paulo Coelho Silva[1] Andréa Peixoto Maia[2] Isaias Donizeti Silva[3] Milton Edson Miranda[2] William Cunha Brandt[3,*]

Glassy ceramic crowns

Lithium disilicate, etc.

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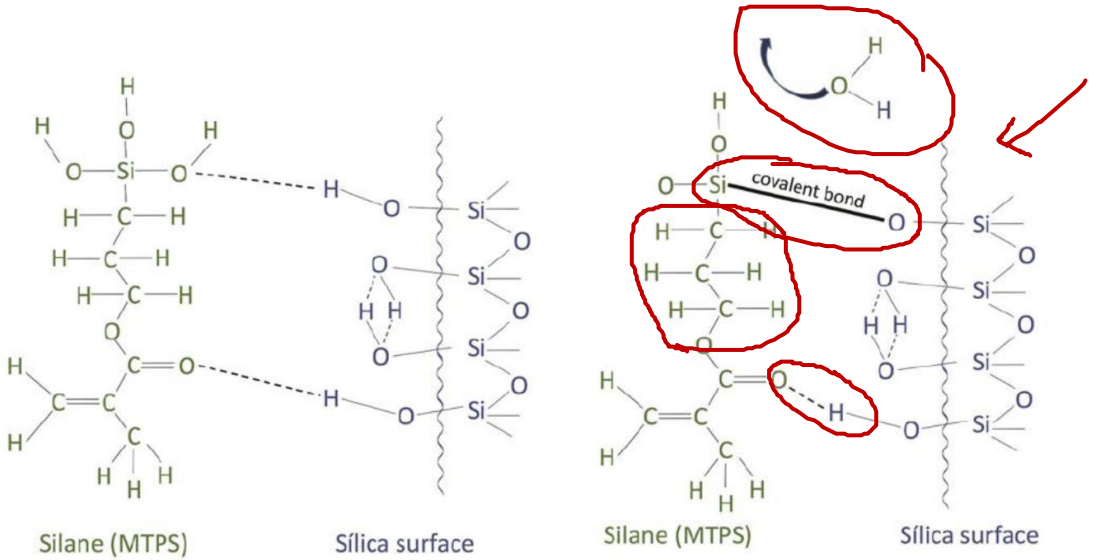

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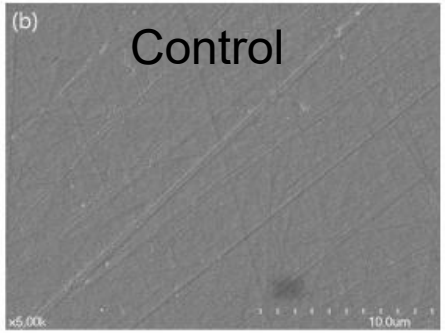
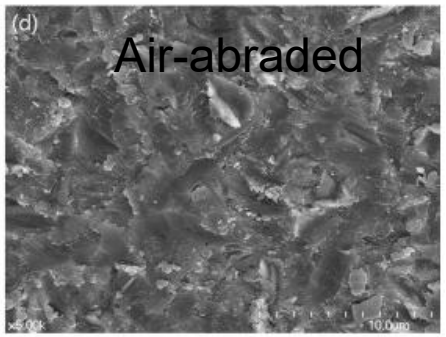
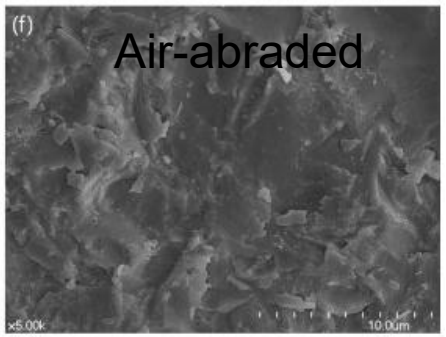
Zirconia crowns

Zirconia:

- Lab steps:
  - Not able to be etched
  - Micromechanical surface treatments
    - Airborne particle abrasion to increase surface roughness (Pressure ~1 bar)
  - Chemical surface treatments
    - Hot acid treatment (eg sulfuric acid and hydrogen peroxide)
    - Silica coating (aluminum oxide particle coated with silica)







Effects of airborne-particle abrasion protocol choice on the surface characteristics of monolithic zirconia materials and the shear bond strength of resin cement

Ji-Eun Moon [a], Sung-Hun Kim [a] ✉, Jai-Bong Lee [a], Jung-Suk Han [a], In-Sung Yeo [a], Seung-Ryong Ha [b] ✉

Glassy ceramics

- After try in completed
- Fitting surface cleanser: Katana or Ivoclean
- Otherwise can use phosphoric acid to remove saliva contaminants

Glassy ceramics

Protocol for Removal of Clinically Relevant Contaminants from Glass Ceramic-based Restorations

Thorsten Bock[a] / Mutlu Özcan[b]

IAAD WORKING INSTRUCTIONS

Question: What is the best cleaning method to remove saliva, blood, and silicone disclosing medium contaminants from etched and silanized bonding surfaces of glass ceramic restorations?

Answer: During intraoral try-in of ceramic restorations, the bonding surfaces may come in contact with saliva or occasionally blood.[1,5] The resulting persistent protein contamination from saliva in particular was shown to hinder adhesion of resin cements to glass ceramics.[1,5-7,9] Similarly, the use of silicone-based materials during checking the fit of indirect glass ceramic restorations contaminates the bonding surfaces with silicone residues, also impeding adhesion of resin cements.[5,10,11] Water spray, alcohol, and acetone do not seem effective in removing saliva residues from glass ceramics,[1,5,7] but 35% to 37% phosphoric acid gel application presented effective cleaning.[1,3-5] Several studies also demonstrated that cleaning pastes with particles (eg, Ivoclean) could also remove saliva contaminants from both glass and oxide-based ceramic surfaces.[2-4] Since durable adhesion of glass-ceramic restorations is crucial, especially in minimally invasive restorations, the following surface cleaning sequence can be recommended to eliminate contaminants from ceramic surfaces, based on the available scientific reports.

What about zirconia?

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Cleaning Zirconia Surface Prior To Bonding: A Comparative Study of Different Methods and Solutions

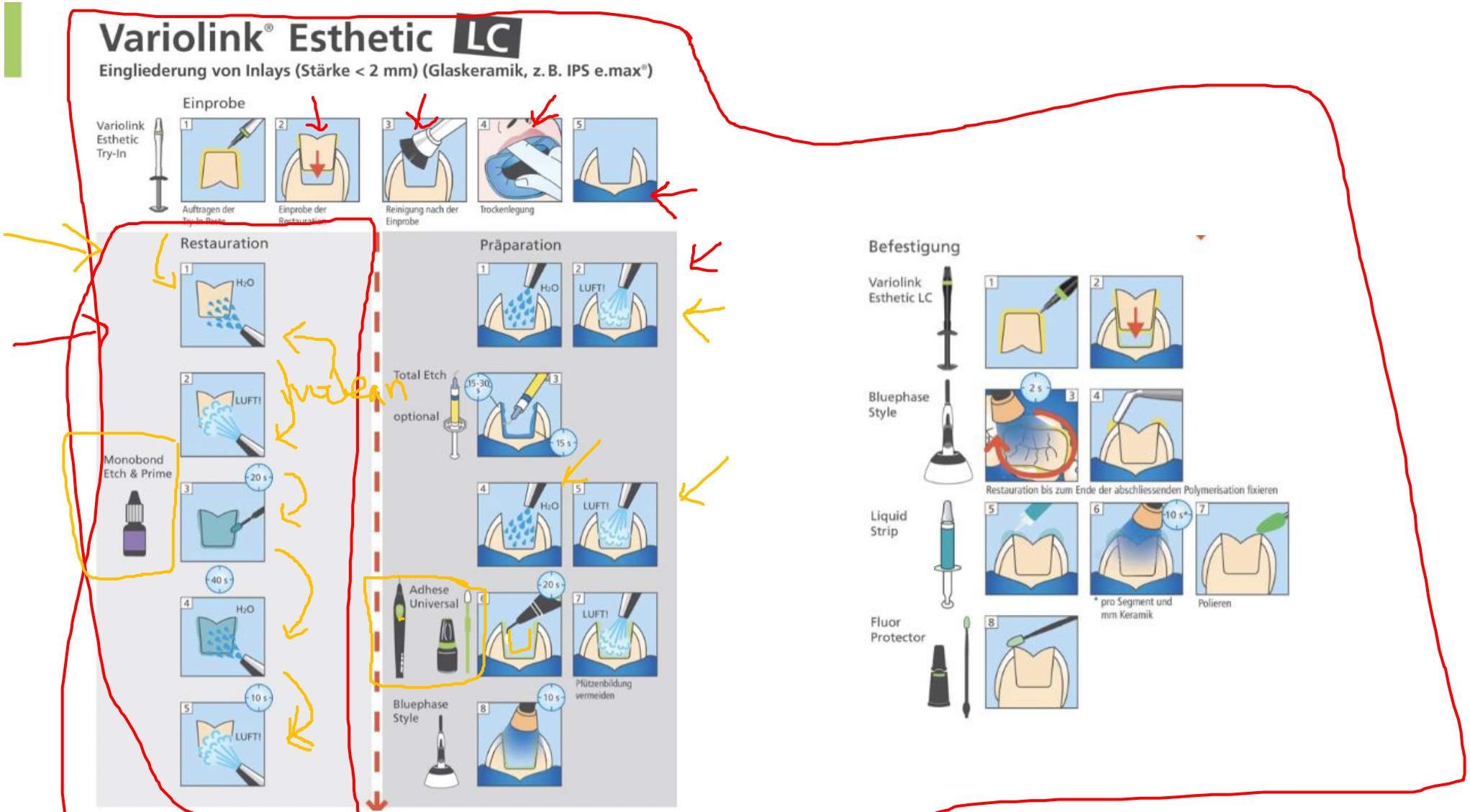
Taiseer A. Sulaiman, DDS, PhD [1], Ali Altak, DDS,[1] Awab Abdulmajeed, DDS, MS [2], Brandon Rodgers, BS,[1] & Nathaniel Lawson, DMD, PhD [3]

[1]Division of Comprehensive Oral Health, Adams School of Dentistry, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina
[2]Department of General Practice, School of Dentistry, Virginia Commonwealth University, Richmond, Virginia
[3]Division of Biomaterials, University of Alabama School of Dentistry, Birmingham, Alabama

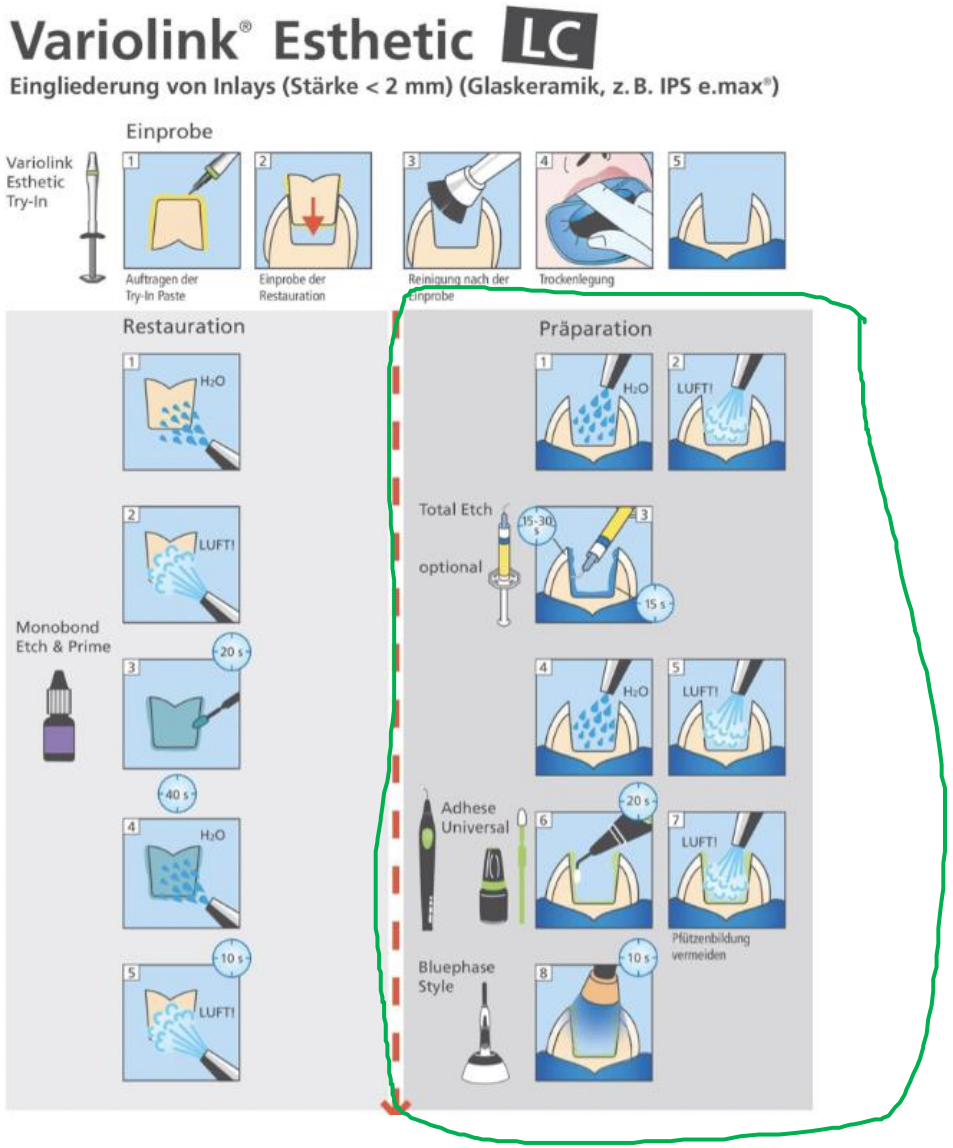
Conclusion: Air-borne particle, zirconia cleaning solutions and hydrofluoric acid are feasible to decontaminate the zirconia surface from saliva prior to bonding the restoration.

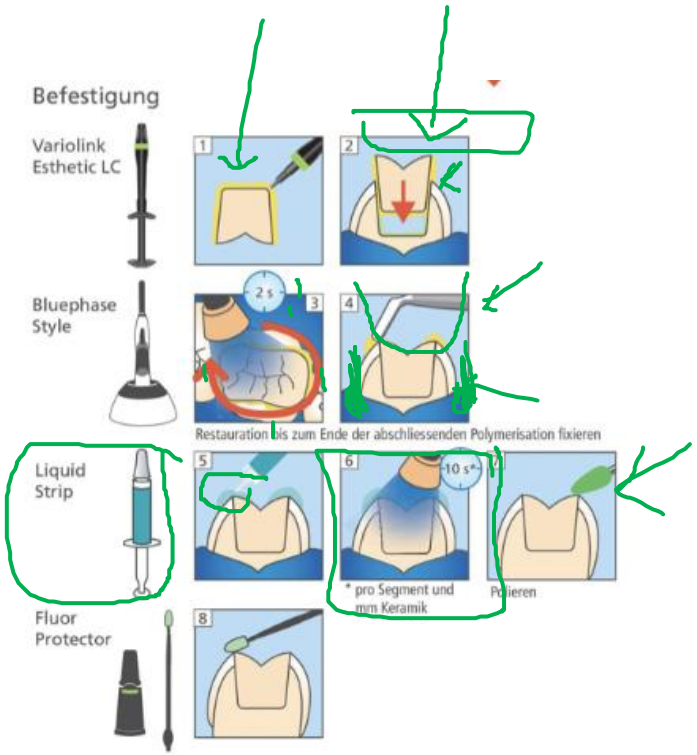
Air-borne particle abrasion: best outcome to restore previous uncontaminated surface bond strengths.
Followed by HF acid or intaglio cleaners

Glassy ceramics



Glassy ceramics





Erstellungsdatum: 2015-07-06
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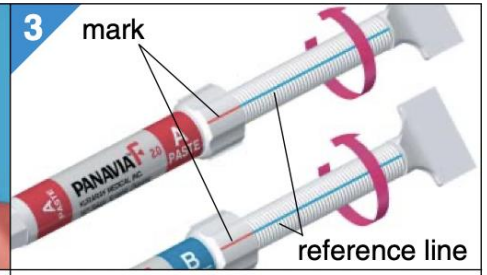
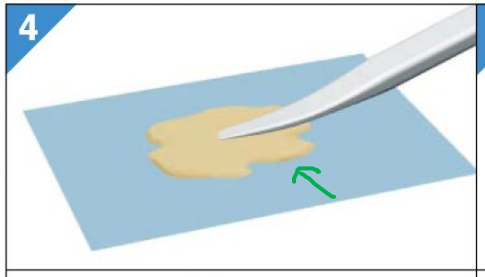
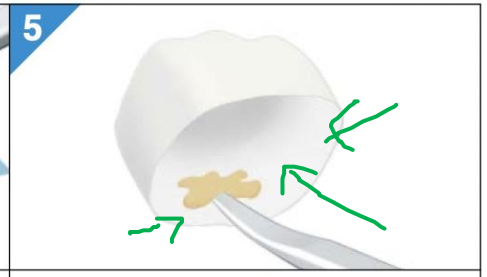
Zirconia

DUAL CURE DENTAL ADHESIVE SYSTEM
PANAVIA F 2.0

Cementation of ceramic oxide restorations: PROCERA™, IN-CERAM™, CERCON™ and other zirconia prostheses.

1	2	3
		
Mix equal amounts of ED PRIMER Ⅱ A&B and apply to the tooth. Then, wait 30 sec. *ED PRIMER Ⅱ initiates set of cement.	Gently air dry.	Dispence equal amounts of paste A&B.

4	5
	
Mix paste A&B for 20 sec.	Apply the mixture of the paste to the sandblasted crown.

3

Cementation of ceramic oxide restorations: PROCERA™, IN-CERAM™, CERCON™ and other zirconia prostheses.

Zirconia

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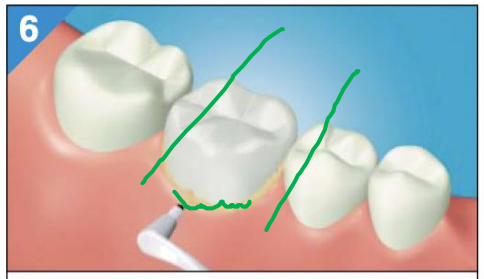
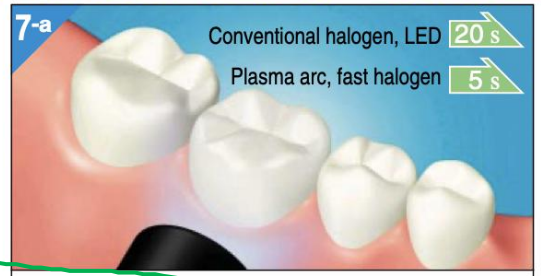
3 Cementation of ceramic oxide restorations: PROCERA™, IN-CERAM™, CERCON™ and other zirconia prostheses.

DUAL CURE DENTAL ADHESIVE SYSTEM PANAVIA™ F 2.0

Cementation of ceramic oxide restorations: PROCERA™, IN-CERAM™, CERCON™ and other zirconia prostheses.



Remove excess cement.
(For easy clean up, partialy light-cure the excess cement for 2-3 sec. with conventional halogen or LED light, then remove the excess.)



Light cure the margins.
20sec. per surface
(Conventional halogen or LED light)
5sec. per surface
(Plasma arc or fast halogen light)

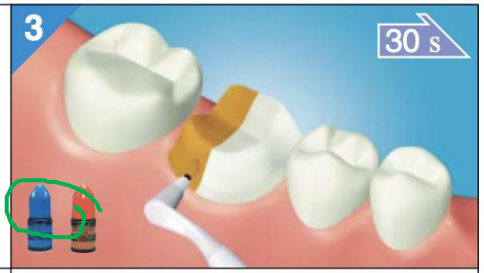
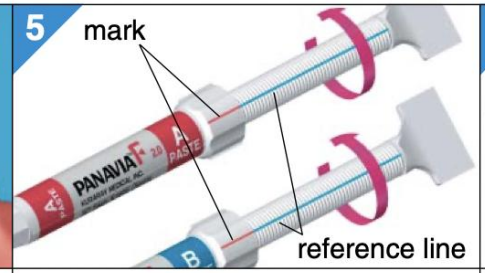
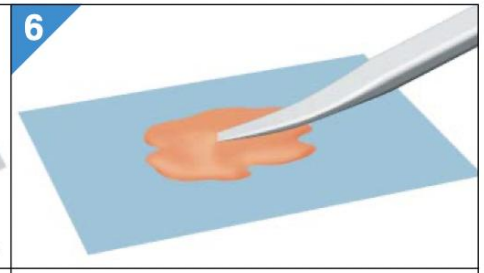
OR

Self cure material by applying OXYGUARD Ⅱ to the margins. Then, wait 3 min.

Metal crowns/PFM crowns

DUAL CURE DENTAL ADHESIVE SYSTEM
PANAVIA F 2.0

Cementation of precious & semi-precious metal crowns, PFM crowns, bridges, inlays and onlays.

1 	2 	3 
Sandblast, wash & dry.	Apply ALLOY PRIMER to internal surface of precious metal restoration.	Mix equal amounts of ED PRIMER Ⅱ A&B. Apply to the tooth. Then, wait 30 sec. *ED PRIMER Ⅱ initiates set of cement.
4 	5 	6 
Gently air dry.	Dispense equal amounts of paste A&B.	Mix paste A&B for 20 sec.

1

Cementation of precious & semi-precious metal crowns, PFM crowns, bridges, inlays and onlays.

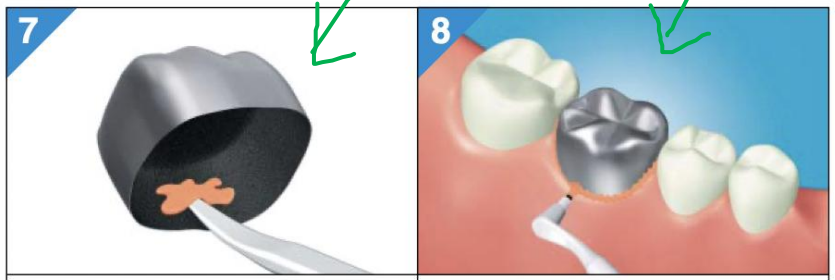
Metal crowns/PFM crowns

THE UNIVERSITY OF WESTERN AUSTRALIA

1 Cementation of precious & semi-precious metal crowns, PFM crowns, bridges, inlays and onlays.

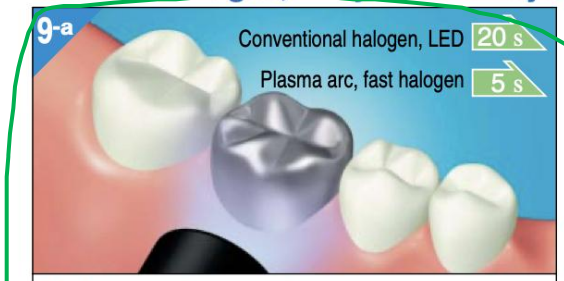
DUAL CURE DENTAL ADHESIVE SYSTEM PANAVIA F 2.0

Cementation of precious & semi-precious metal crowns, PFM crowns, bridges, inlays and onlays.



Apply mixture of the paste.

Remove excess cement.
(For easy clean up, partialy light-cure the excess cement for 2-3 sec. with conventional halogen or LED light, then remove the excess.)



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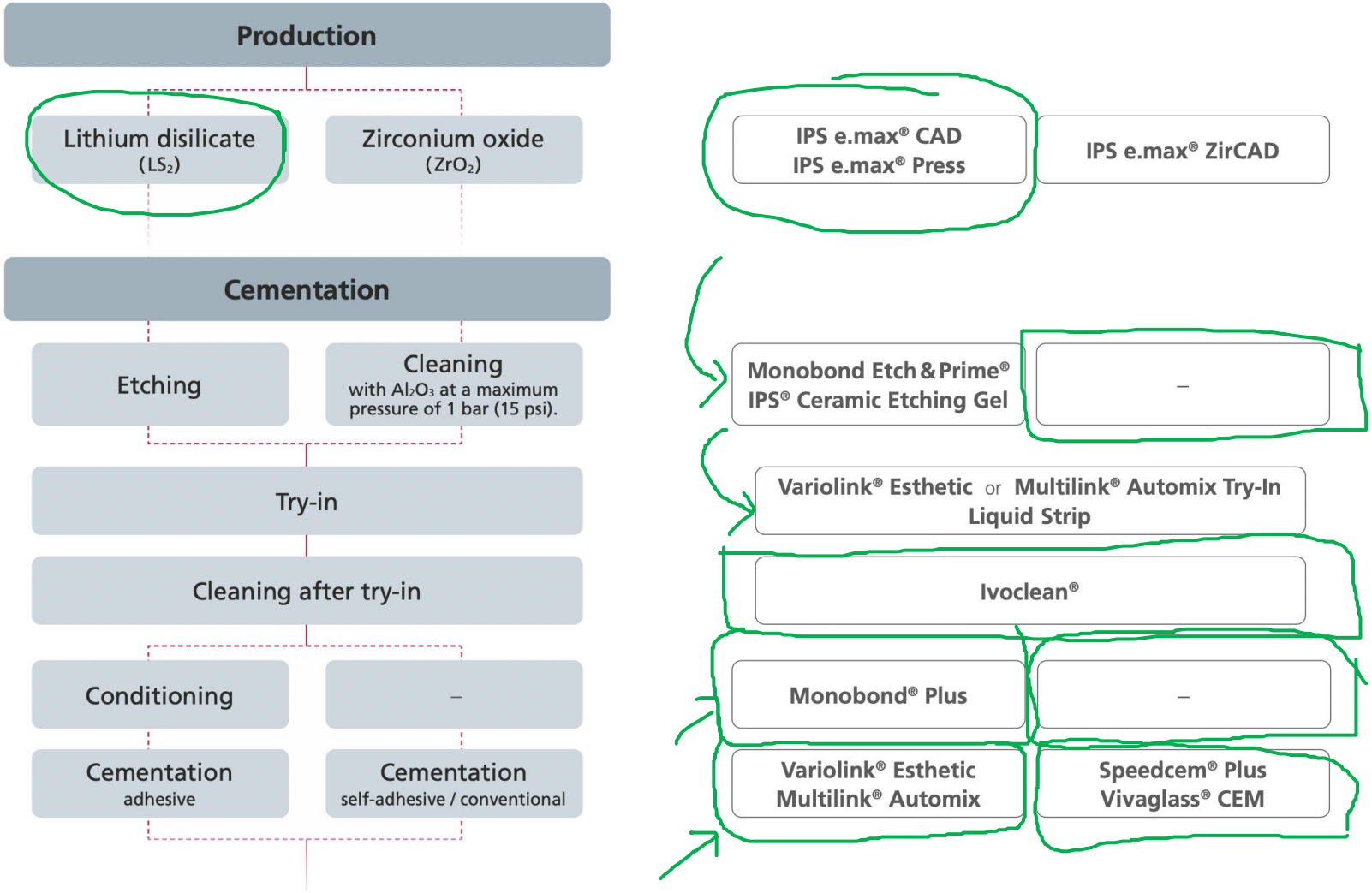
Guidelines


Production
Lithium disilicate
(LS_2)
Zirconium oxide
(ZrO_2)
IPS e.max® CAD
IPS e.max® Press
IPS e.max® ZirCAD
Cementation
Etching
Cleaning
with Al_2O_3 at a maximum pressure of 1 bar (15 psi).
Monobond Etch & Prime®
IPS® Ceramic Etching Gel
–
Try-in
Variolink® Esthetic or Multilink® Automix Try-In Liquid Strip
Cleaning after try-in
Ivoclean®
Conditioning
–
Monobond® Plus
–
Cementation
adhesive
Cementation
self-adhesive / conventional
Variolink® Esthetic
Multilink® Automix
Speedcem® Plus
Vivaglass® CEM

Thanks for listening

Anything you want to recap?