

# BONDING RESINS & LUTING CEMENTS



# INTRODUCTION

---

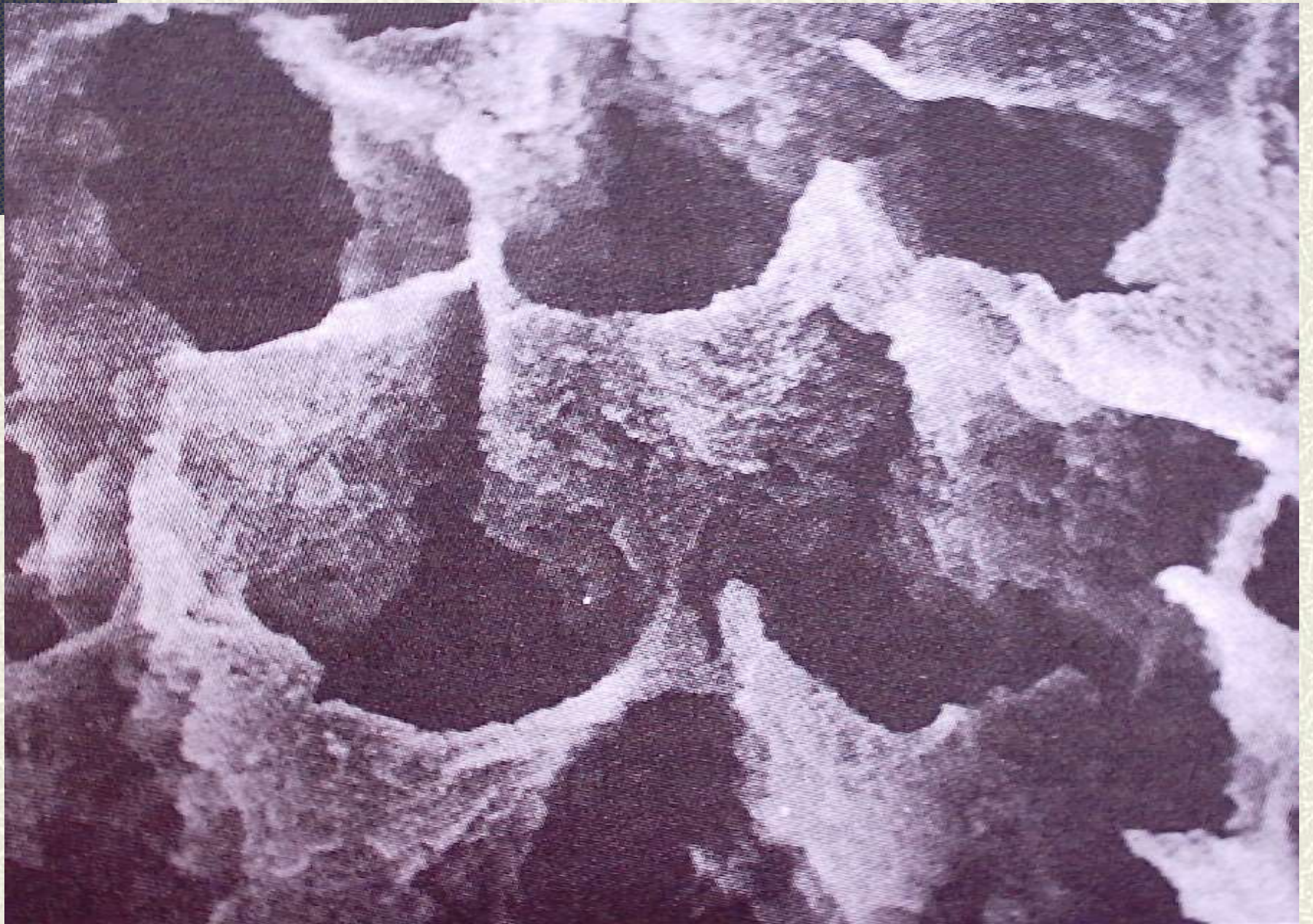
- # Composite Material:- it is defined as a compound of 2 or more distinctly different materials with properties that are superior or intermediate to those of the individual constituents.
  - # Eg.enamelin represents the enamel matrix, collagen represents dentin matrix.Both enamel & dentin have hydroxyapatite as filler particles in common.but differ in their matrix:filler ratios.
-

- # Development of the composite material started in 1950's & 1960's, when Bowen began experiments on combining advantages of epoxies & acrylates, which culminated in the development of bis-GMA (bisphenol-A glycidyl methacrylate) molecule.
  - # It soon replaced silicate cement & acrylic resins as aesthetic restorations.
  - # Modern composite materials contain 1) resin matrix, 2) inorganic filler particles, 3) silane (coupling agent), 4) an activator- initiator, 5) UV light absorbers, 6) hydroquinone (inhibitor), 7) pigments
-

# ENAMEL BONDING AGENTS

---

- # Enamel bonding agents were developed to enhance the wettability to etched enamel, because resin based composites were viscous.
  - # They have no potential of adhesion but tend to improve mechanical bonding by formation of resin tags within enamel.
  - # They have been made by combining different dimethacrylates such as bis-GMA & TEGDMA (tri-ethylene glycol dimethacrylate) to control viscosity.
-



# DENTIN BONDING AGENTS

---

- # Dentin is a living tissue
  - # It is heterogeneous – consists of 50% inorganic material –hydroxyapatite & 30% organic material –collagen & 20% fluid.
  - # Tubular nature through which dentinal fluid flows can affect adhesion.
  - # Presence of smear layer on the cut dentin surface.
  - # It can be a pathway through which the pulp can be affected by different chemicals of the adhesives.
-

# Eureka.....

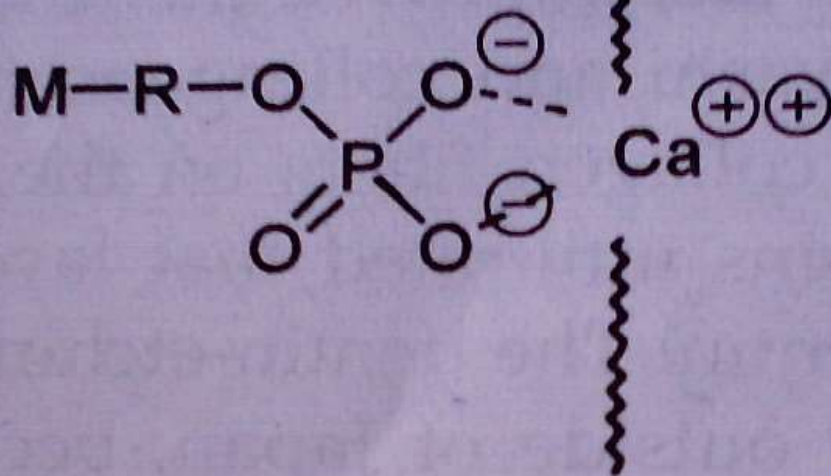
---

- # Important breakthrough of the dentin bonding agents ,when Fusayama started using 37% phosphoric acid to etch enamel & dentin.
  - # IDEALLY- dentin bonding agents should be both hydrophilic & hydrophobic.
  - # Hydrophilic to displace dentinal fluids and wet the surface, permitting penetration of porosities within dentin & eventually react with organic & inorganic particles.
  - # Hydrophobic to bond to the restorative resin.
-

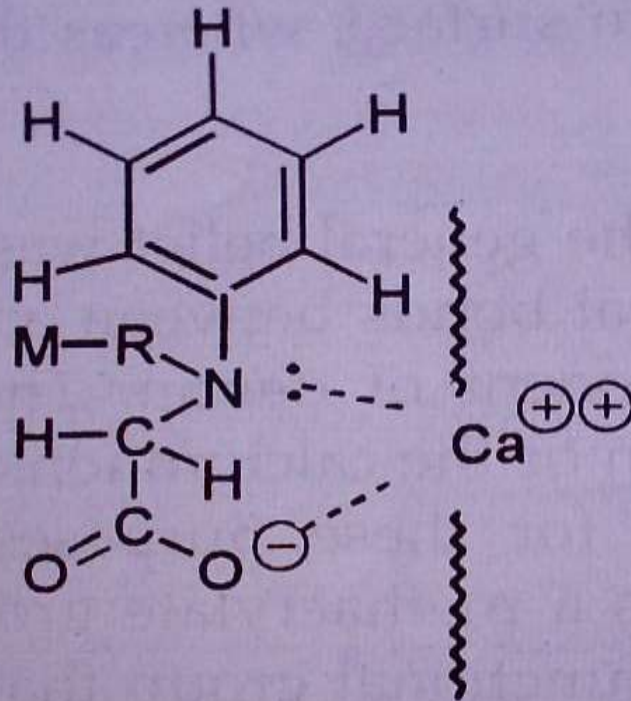
# Chemistry...

---

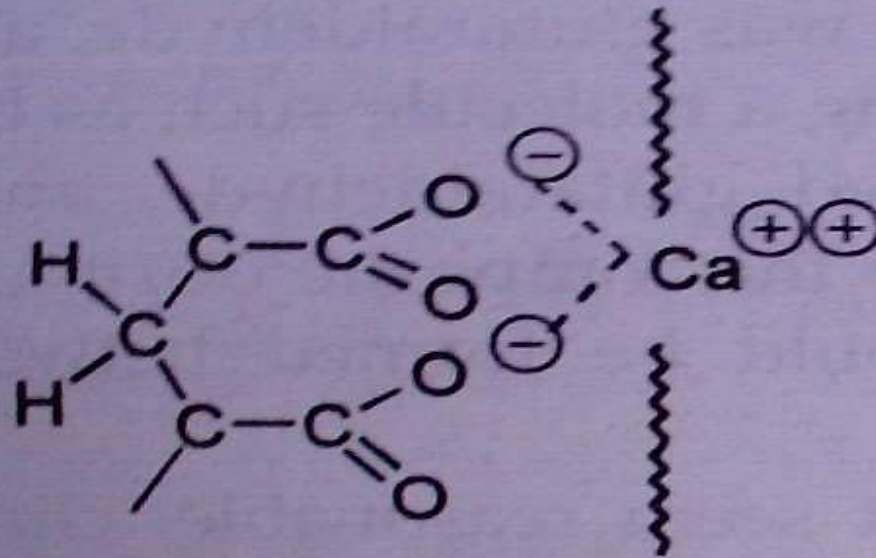
- # The basic structure is a M-R-X molecule.
  - # M –is a methacrylate spacer
  - # R –is a spacer such as hydrocarbon
  - # X –is a functional group that is targeted for adhesion to tooth tissue.
  - # Egs. NPG-GMA( N-phenylglycine –glycidyl methacrylate) , polyalkenoic acids & polymerizable phosphates.
-



**PHOSPHATE BASED BONDING AGENT**



**AMINO-CARBOXYLATE BASED BONDING AGENT  
(NPG-GMA)**



CARBOXYLATE BASED BONDING AGENT  
(PAA)

# Gluteraldehyde was known to bond with collagen by forming a bond with HEMA (hydroxymethacrylate)

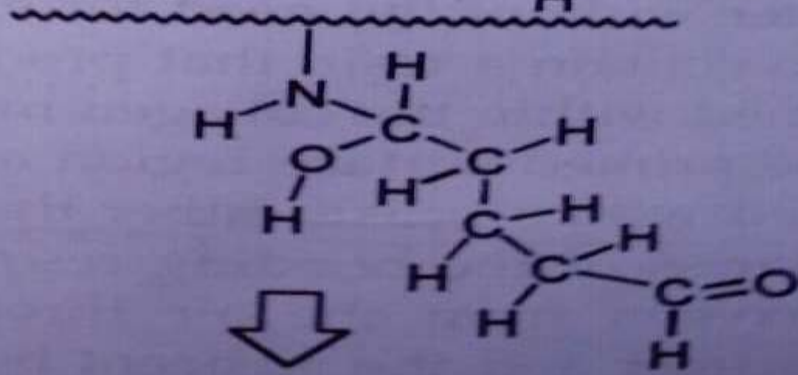
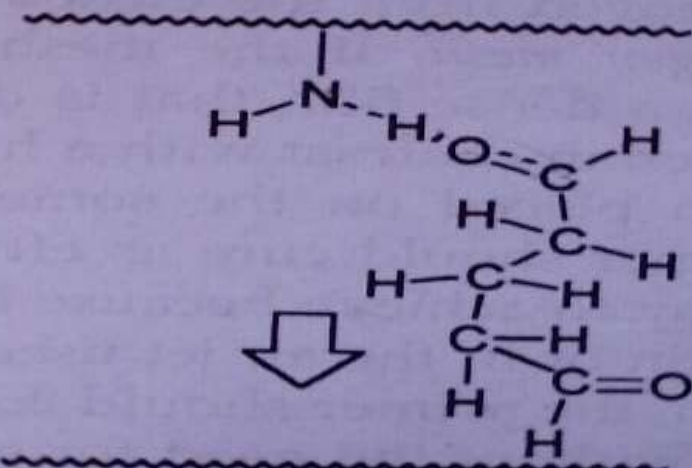
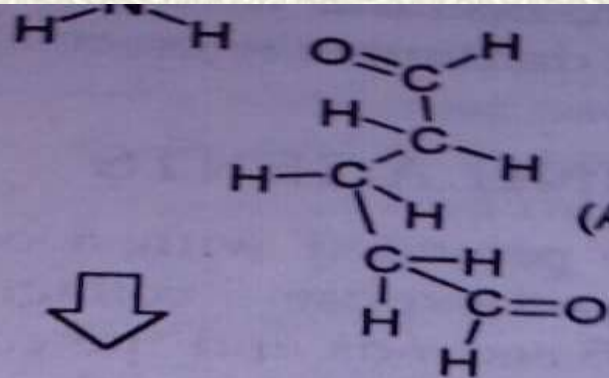
---

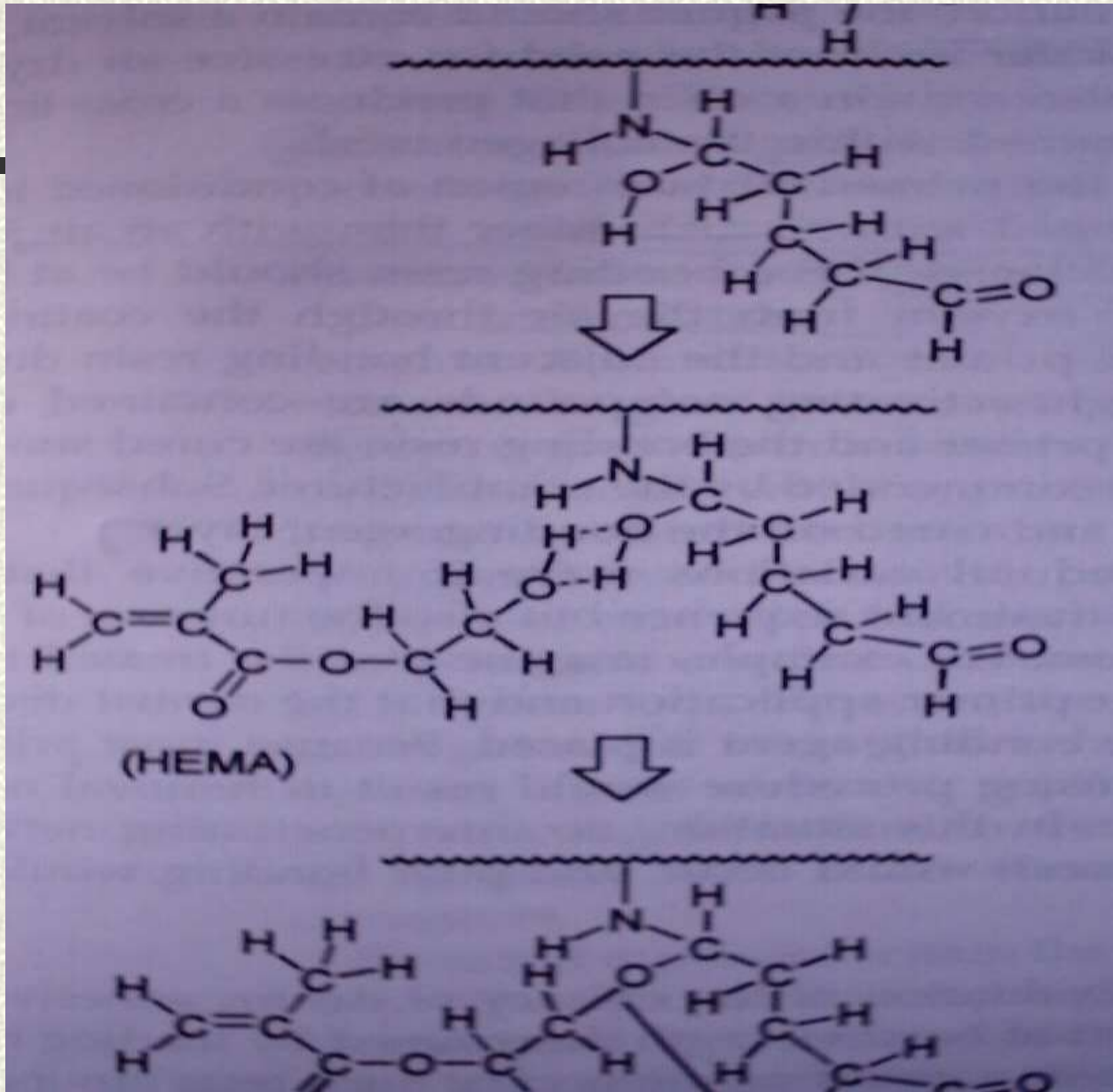
# This system had failures, but it was found that after conditioning procedures with EDTA (ethylene –diamine tetra –acetic acid) the bond was aggressive.

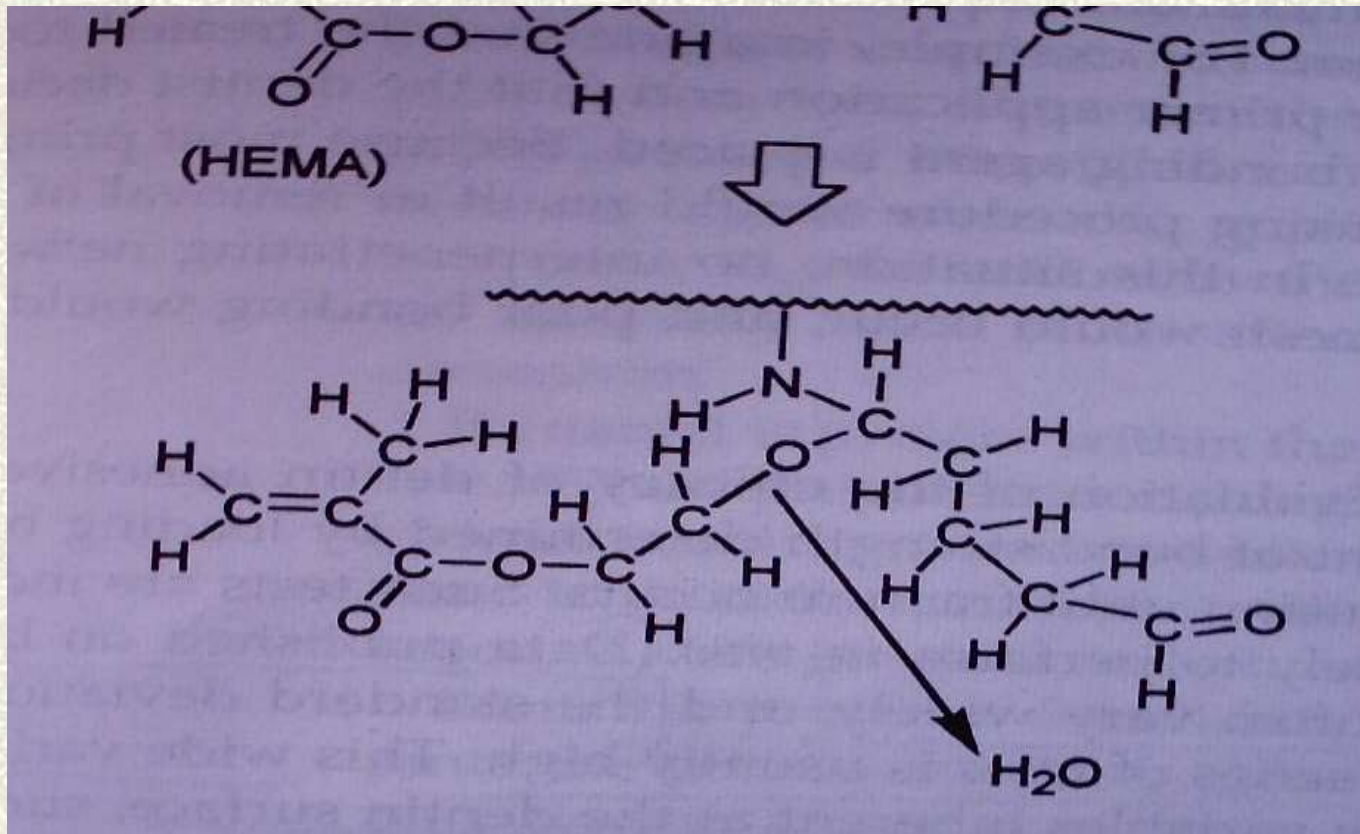
# The key to adhesion is –a hydrophilic monomer that can easily infiltrate the collagen mesh produced by the conditioning acid.

# Egs. HEMA, polyacrylic acid, NPG-GMA.

---







# Manipulation of dentin bonding agents

---

- # The dentin is conditioned for 15secs, then conditioner is rinsed away.
  - # Excess water is removed from the etched surface without dessicating the collagen mesh.
  - # If dessicated , the collagen network collapses, forming dense film, difficult to penetrate
  - # To optimize bonding ,primer should cure efficiently.
-

# Contd.....

- # This curing process, though difficult to achieve because both dentinal fluids & O<sub>2</sub> present either in dentin or in the air jet used for drying, inhibit polymerization.
  - # To avoid this ,primer should contain solvent that evaporates easily & removes water along with it without extra air-drying.
  - # Primer should contain resin that produces a cross linked polymer network that is retained within the collagen mesh.
  - # Bonding resin is placed with a brush of at least 50µm thickness to prevent O<sub>2</sub> diffusion.
  - # After curing of bonding agent,subsequent layers of composite are placed & cured.
-

# Bond strength & leakage

---

- # Bond strength depends on :-
    1. Water content
    2. Presence or absence of smear layer
    3. Dentin permeability & orientation of dentinal tubules.
  - # Minimal bond strength –20Mpa or higher.
  - # Newer systems are superior in inhibiting interfacial leakage.
-

# Luting cements

---

- # Many materials are available :-
  - # Zinc phosphate, zinc silico-phosphate, zinc polycarboxylate, glass ionomer, resin based cements.
  - # Their properties differ from each other, hence mandated to degree of functional & biologic demands of clinical situation
  - # Their physical & biologic props. & their handling characteristics, working & setting times, ease of removing excess material must be considered for a specific task.
-

## 1. Properties of Dental Cements for Bonding Applications

	Time of Setting (min)	Film Thickness ( $\mu\text{m}$ )	Compressive Strength—24 h (MPa)	Diametral Tensile Strength—24 h (MPa)	Modulus of Elasticity (GPa)	Solubility and Disintegration in Water (wt %)	Pulp Response
Specification No. 8 Type I	5 min 9 max	25 max	68.7	No specification	No specification	0.2 max	*
Silicate	5.5	20	104	5.5	13.5	0.06	Moderate
	4-10	25	6-28	—	—	0.04	Mild
Resin + EBA (Type II)	9.5	25	55	4.1	5.0	0.05	Mild
Resin (Type II)	6-10	32	48	4.1	2.5	0.08	Mild
Silicate	3.5-4	25	145	7.6	—	0.4	Moderate
Resin	2-4	<25	70-172	—	2.1-3.1	0.0-0.01	Moderate
Silicate	6	21	55	6.2	5.1	0.06	Mild
Resin	7	24	86	6.2	7.3	1.25	Mild to moderate

\*Comparison with silicate cement, a severe irritant.

\*American Dental Association; ZOE, zinc oxide-eugenol; EBA, ortho-ethoxybenzoic acid.

# Zinc phosphate cement

---

# Ingredients of powder- zinc oxide-90%  
magnesium oxide-10%

Liquid contains- phosphoric acid

water-  $33\% \pm 5\%$

aluminium phosphate

---

# Chemistry...

---

- # Water controls ionization of acid, which in turn controls rate of liq-powder reaction.
  - # Reaction –phosphoric acid attacks surface of particles and releases zinc ions into liq
  - # Aluminium, reacts with zinc & yields a zinc-alumino phosphate gel on the surface of the remaining portion of particles.
  - # Setting time-range- 5.5mins
-

# Factors influencing working & setting times

---

- # Powder : liquid ratio
- # Rate of powder incorporation
- # Spatulation time
- # Temperature of the mixing slab

## Physical & biologic props

- # Compressive strength- 104Mpa
- # Tensile strength- 5.5Mpa

Note:-primary bonding occurs by mechanical interlocking & not by chemical interactions.

- # pH – 5.5 at 24hrs-causes severe pulpal injury
  - # Modulus of elasticity- 13.5Mpa
-

# Manipulation

- # Maximal amount of powder possible for the operation ,should be used to ensure minimum solubility & max.strength.
- # Cool mixing slab should be used
- # Should not dispense liquid until mixing is initiated ,as there is loss of water when exposed to air.
- # Mixing initiated by adding small amount of powder.
- # Spatulate each increment for 15secs
- # Field of operation must be dry.
- # Excessive cement can be removed when set.
- # Apply varnish for resistance to oral dissolution

# Zinc silicophosphate cement

---

- # Contains mixture of silicate glass, small percentage of zinc oxide powder & phosphoric acid.
  - # Indications similar to zinc phosphate
  - # Strength is somewhat higher
  - # Aesthetically superior to zinc phosphate
  - # Use is declined ,replaced by resin & G.I.cements
-

# Zinc polycarboxylate cement

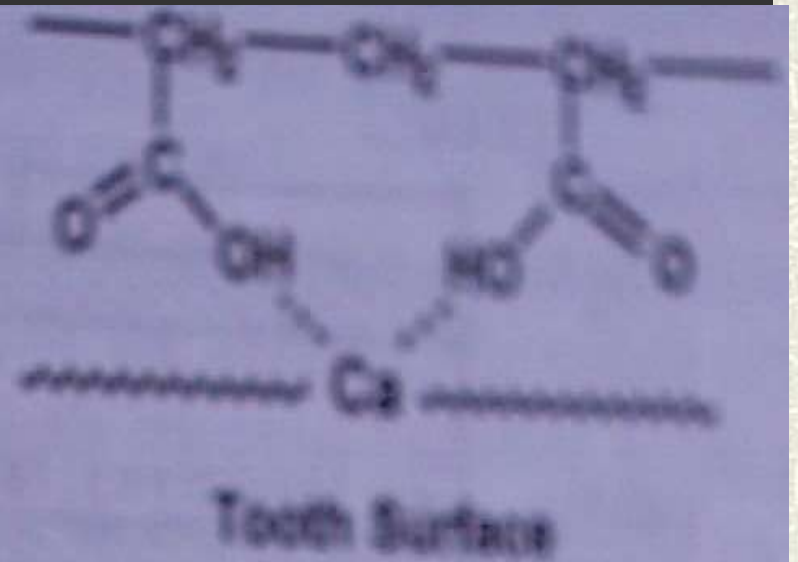
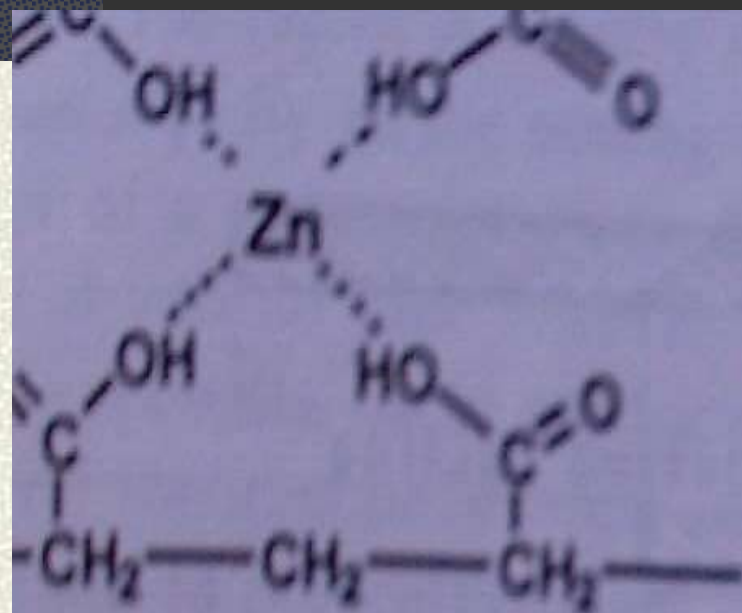
---

- # First cement system that developed an adhesive bond to tooth structure
  - # Liq contains- polyacrylic acid eg. itaconic acid 40%
  - # Powder contains- zinc oxide  
magnesium oxide/stannic oxide  
stannous flouride – it enhances the setting time and increases strength and enhances manipulative properties.but flouride released is less(15-20%)
-

# Chemistry....

---

- # Setting reaction of the cement involves particle surface dissolution by the acid
  - # First acid releases zinc, magnesium & tin ions which bind to the polymer chain via the carboxyl groups
  - # These ions react with carboxyl groups of polyacid chains so that a cross linked salt is formed as the cement sets.
-



5-12. The role of carboxylate functional groups in polycarboxylate  
 A. Yielding matrix through cross-linking by zinc ions. B. Bonding to  
 structure through calcium hydroxyapatite.

# General properties

---

- # Film thickness-21  $\mu$ m at occlusion
  - # Working time – 2.5mins
  - # Setting time – 6-9mins
  - # Compressive strength – 55Mpa
  - # Tensile strength – 6.2Mpa
  - # Modulus of elasticity is less –5.1Gpa, than half that of zinc phosphate
  - # It bonds chemically to tooth.highest bond strength to enamel than to dentin
-

# Contd....

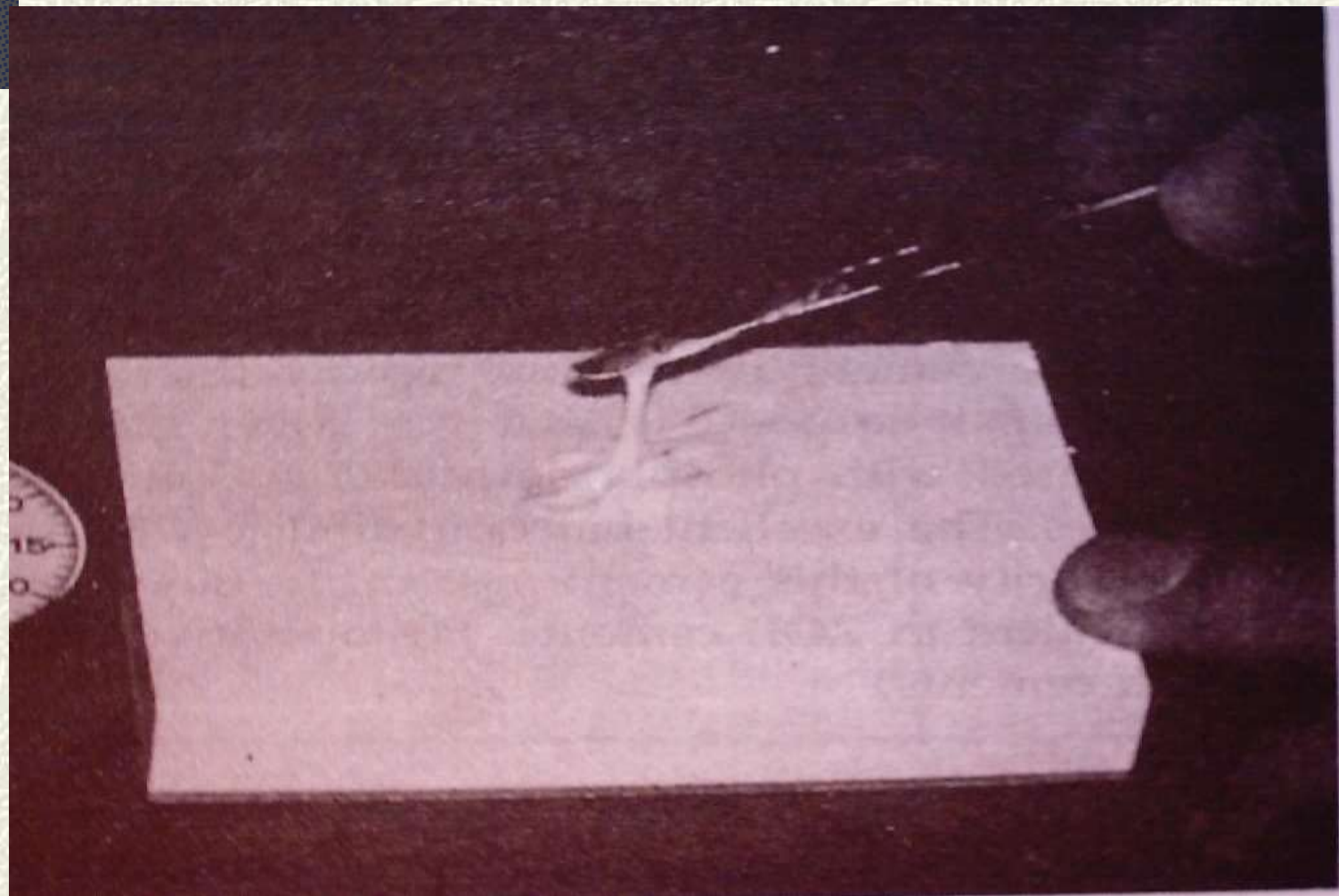
---

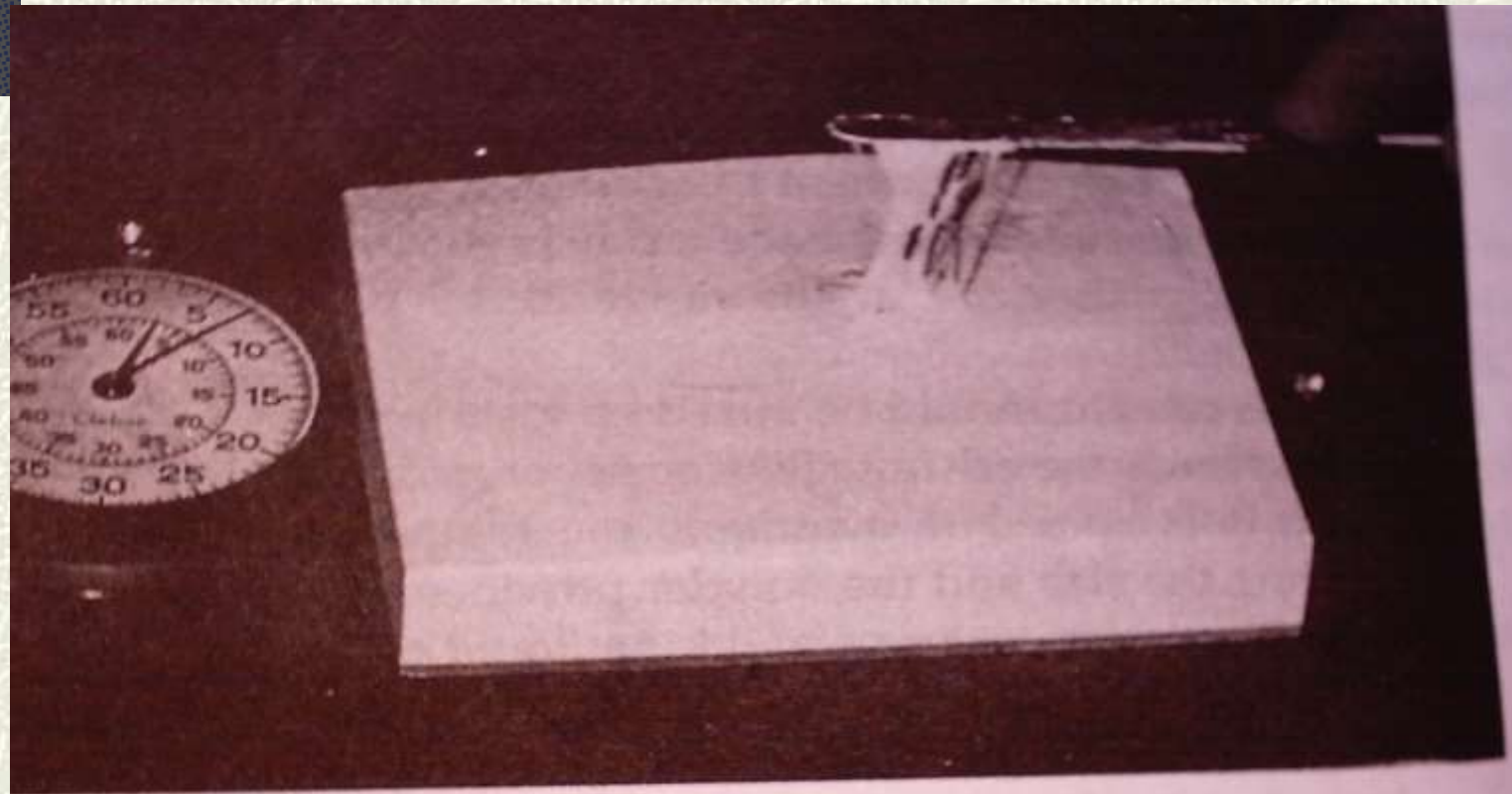
- # Not as brittle as zinc phosphate, it is more difficult to remove excess after it has set.
  - # Solubility in water is low, but when exposed to organic acids of pH 4.5, solubility increases.
  - # The powder : liquid ratio also determines solubility.
  - # pH-5.94 –they produce minimal irritation to the pulp
-

# Manipulation..

---

- # 30 second mix is ideal for luting.
  - # Use glass slab as it doesn't absorb the liq.
  - # Cool the slab, but don't cool the liquid in fridge.
  - # Liq. should not be dispensed before start of mix as it loses water to atmosphere rapidly.
  - # For good bonding, cement must be placed on tooth surface before it loses glossy appearance
  - # Glossy appearance indicates significant no. of free carboxylic acid groups on the surface of the mixture, which are vital for bonding to tooth.
-





25-15. A, Consistency of polycarboxylate cement on completion of a 30-  
d mix. B, If mixing time is prolonged or the mix is allowed to remain on the  
he cement becomes dull in appearance and the consistency becomes tacky. (A  
courtesy of M. Jendresen.)

# Contd....

---

- # Dull looking mixture- means insufficient no. of free carboxylic acids groups.
  - # Removal of cement should be done when the it becomes hard.
  - # Or it can be done immediately after seating is completed.
  - # Preferable to apply a separating media to prevent excess cement from adhering to tooth .
-

# Glass Ionomer cement

---

- # Introduced in 1972 as luting agents & direct restorative material.
  - # Has unique properties of bonding chemically to enamel & dentin, as well as stainless steel.
  - # It releases fluoride for caries protection.
  - # They are available in 2 forms-1)conventional polyacid liquid-powder system 2)water added systems
  - # They bond via reaction of carboxyl groups with calcium in tooth.
-

# General properties


---

- # Thickness of film-24  $\mu$ malocclusion
  - # Working time – 3-5mins
  - # Setting time- 7mins, water added have a rapid set .
  - # Compressive strength- 86Mpa
  - # Tensile strength – 6.2Mpa
  - # Modulus of elasticity-  $\frac{1}{2}$  of zinc phosphate
-

# Contd...

---

- # Solubility in water is high in first 24hrs.
  - # Once it has matured fully it becomes one of the most resistant of the non resin cements to solubility & disintegration in oral cavity.
  - # Bonds adhesively to tooth structure and prevents infiltration of oral fluids at cement tooth interface.
  - # Less irritating nature of acid.
  - # Occasionally there are reports of postoperative sensitivity. mostly seen in water settable cements and in thin mixes.
-

- 
- 
- # Regardless to type of G.I cement ,when postoperative sensitivity does occur, it could be due to 1 or more conditions:
1. Pre-existing pulpitis
  2. Deep cavity preparation
  3. Associated minimal dentin thickness
  4. Bacterial invasion along the tooth-cement interface.
-

# Precautions taken....

---

- # Smear layer on the cut surface of cavity preparation should not be removed & left as a barrier to prevent penetration of tubules by acid component of cement
  - # All deep areas should be protected by calcium hydroxide.
-

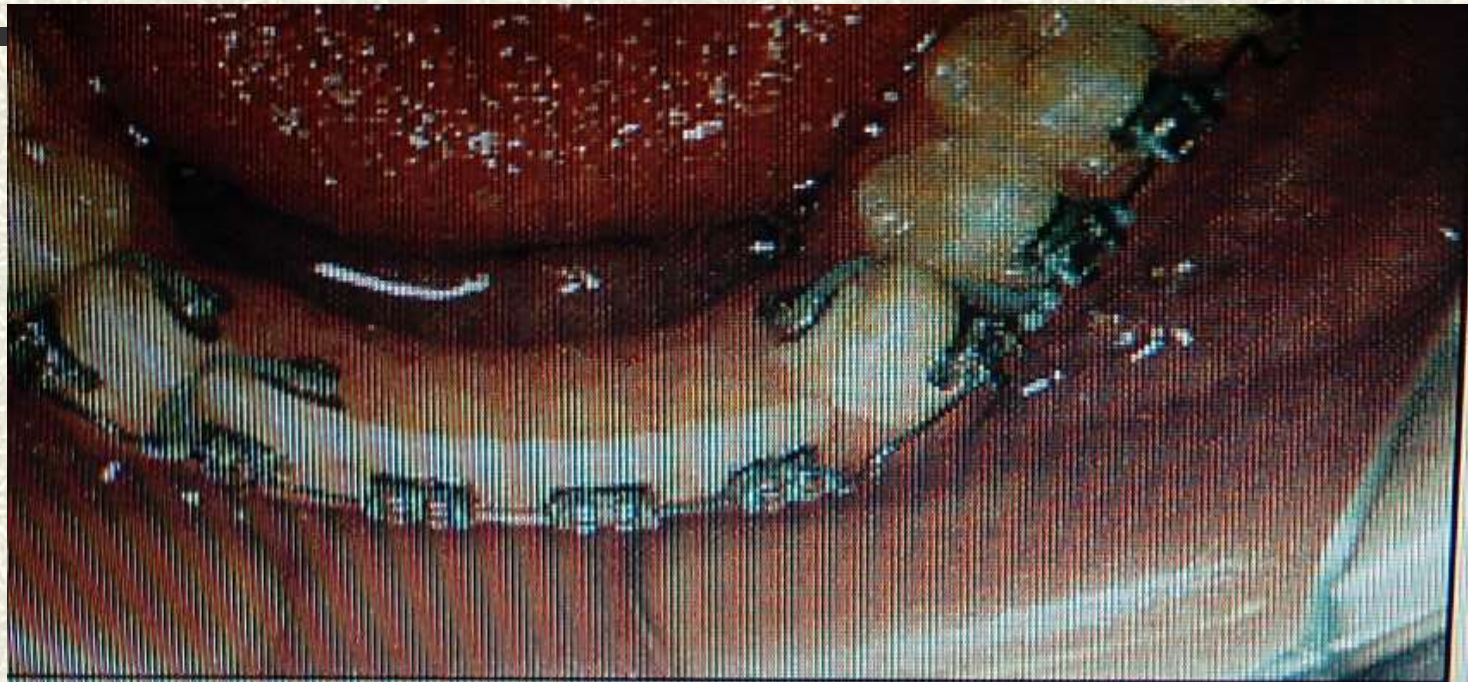
# Manipulation..

- # Prepared tooth surface should be cleaned with pumice, rinsed, dried but not dessicated.
- # Powder incorporated rapidly into liq in large increments & spatulated rapidly for 30-45secs
- # Cementation should be carried out before it loses its glossy appearance.
- # Like zinc phosphate, it becomes brittle once set. excess can be flicked away.
- # It should be protected from susceptible attack from water during setting, by applying separating media.
- # More recently they have been modified to produce dual cure or hybrid cements( eg. Fuji Ortho LC)

# Article from AJO-light cured glass ionomer cement

---

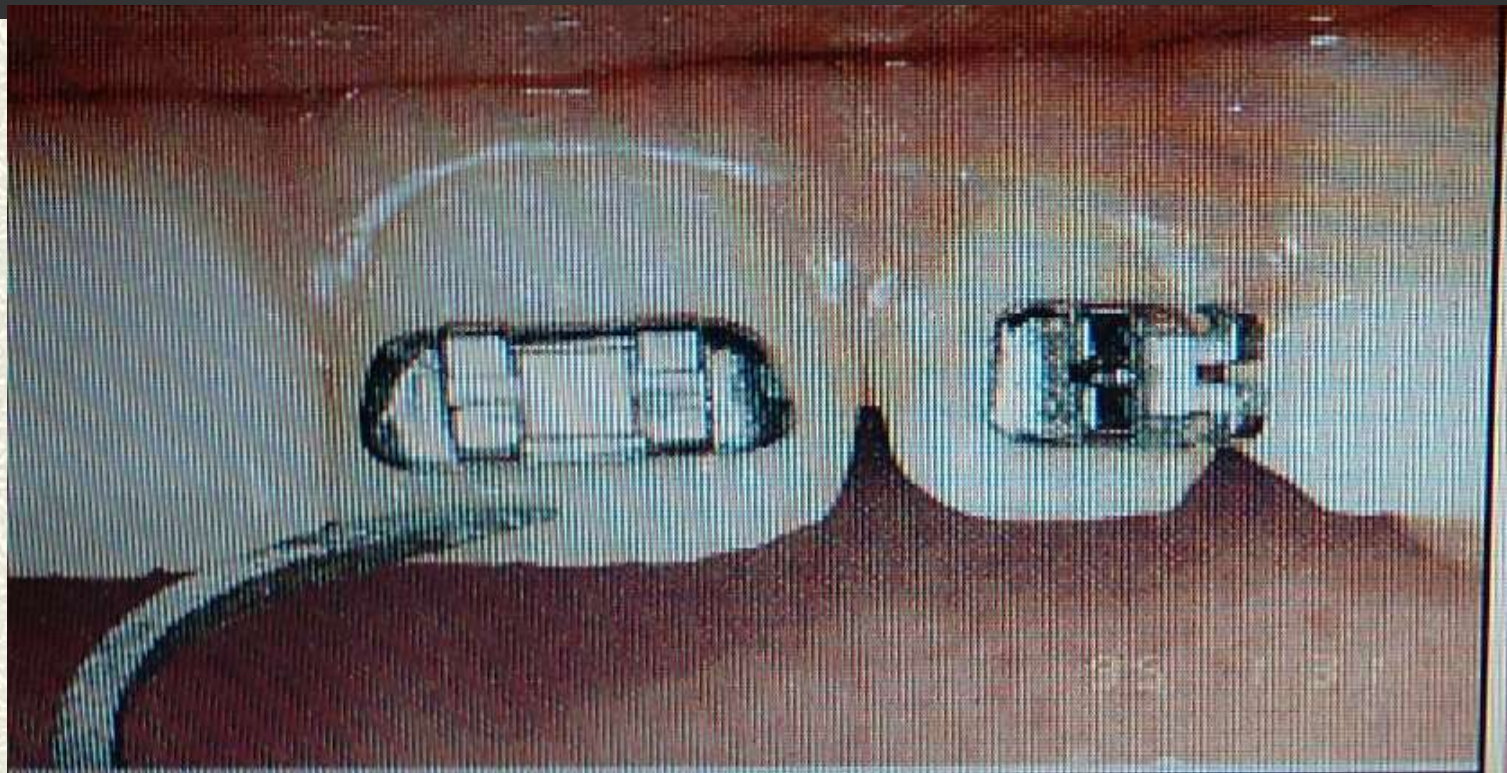
- # Characteristics :- 1)no etching reqd.
  - 2)can be bonded in presence of saliva
  - 3)tensile strength was exhibited to resist forces to move teeth.
  - 4)debonding procedures were undamaging to enamel
  - 5)releases flouride- decalcification noticed
  - 6)repairs are quick & easy
  - 7)saves chair side time ,increased pt.& dentist comfort.
-



Occlusal view of case, showing lingual buttons used for rotations. All buttons were cemented with Fuji Ortho LC cement with no need to etch or dry teeth.



anding of molar tubes to their respective  
this new cement. Presence of moisture  
onsequence.



Excess Fuji Ortho LC is removed with  
immediately after bracket placement.



cket is light cured for 30 seconds.





# It showed 96.8% success rate. failures were  
a) due to occlusal interferences or pt.  
Cooperation

---

b) due to technique-disturbance of bracket  
while cement is setting.

# Composition:- powder- fluoro-alumino-  
silicate glass

liq- copolymer of acrylic acid & maleic acid  
HEMA, water,

camphorquinone (photoinitiator) , activator

# P:L ratio- 3gm:1gm

---

# Resin based cement

---

- # Composition:-resin matrix with silane treated inorganic fillers.

monomers like HEMA, organophosphates

- # Bonding is achieved by acid-etch technique

- # Polymerization can be achieved by 1)peroxide amine induction system

2)light activation system

Some systems use both-referred to as dual-cure systems.

---

# General props...

---

- # Solubility:-They are insoluble in oral fluids
  - # Film thickness:-25  $\mu\text{m}$  or less
  - # Anticariogenic potential- none
  - # Setting time- 2-4mins
  - # Compressive strength- 70-172Mpa
  - # Pulpal response- very irritating,so place a layer of calcium hydroxide for pulp protection.
-

# Manipulation...

---

- # Peroxide amine initiator system- they are combined by mixing on a pad for 20-30secs.
  - # It is best to remove the excess just after seating the bracket.
  - # Don't remove excess when it is in its rubbery stage lest a void be created leading to plaque buildup.
-

# Contd....

---

- # No-mix adhesives-these materials set when 1 paste under light pressure is brought together with a primer fluid on the etched enamel and bracket backing
  - # 1 adhesive is applied to bracket backing while another to dried etched tooth.
  - # After precise positioning ,the bracket is pressed firmly into place & curing occurs in 30-60secs.
  - # The liq.activators are toxic,allergic reactions reported in patients, dental assistants & doctors when these were used.
-

- # Light cured cements-single component systems,widely used for bonding orthodontic brackets.
- # Time of exposure –never less than 40secs
- # Argon laser may be used for polymerization
- # Useful when quick set is required such as when placing an attachment on a palatally impacted canine after surgical uncovering with the risk of bleeding
- # Also desirable when extra long working time is required eg.difficult premolar bracket positioning

- # Dual cure systems – 2 component systems incorporating light initiators as well as a chemical catalyst
- # Chemical activation is slow & provides extended working time until cement is exposed to curing light, at which point the cement solidifies rapidly.
- # It continues to gain strength over an extended period because of chemically activated polymerization.

# Article from AJO-comparison of conventional & dual cure system

- # Modified direct technique- developed by Peter Brenn
- # Major requisite-it should have filled bis-GMA resin onto the retentive bracket bases as part of manufacturers fabrication of brackets.
- # Differences b/w the 2 systems:-
  - 1) use of unfilled resin sealant around the periphery of the bracket, after bonding, in modified technique
  - 2) there was fairly no excess composite flash
  - 3) reduces the risk of clinical # because of premature loading ,since a smaller vol. of material is used
  - 4) reduction of porosity & ample working time

# Indirect bonding

---

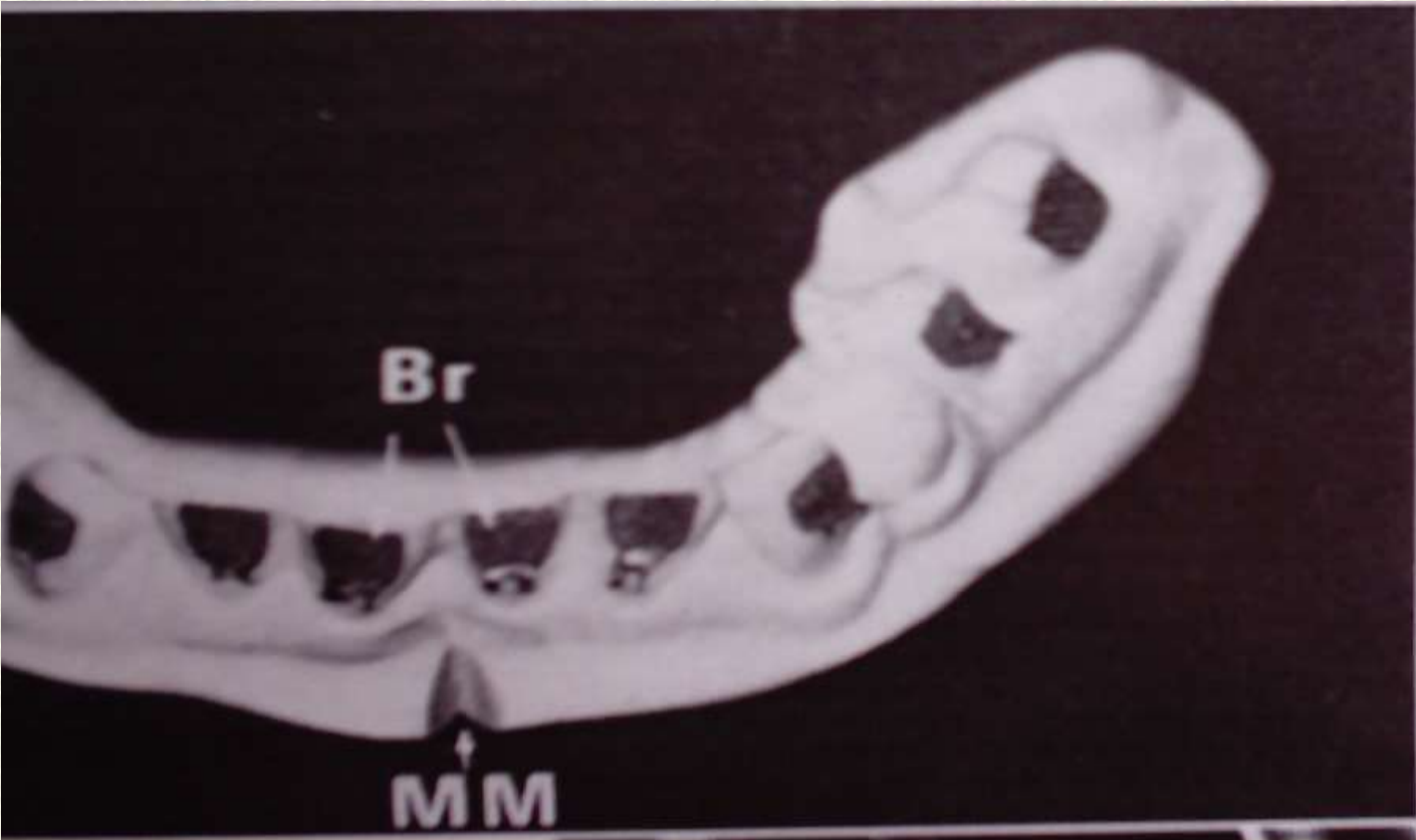
- # Silverman & Cohen
  - # 2 most popular techniques:- 1)with silicone impression material 2)double sealant technique
  - # They differ in the way brackets are attached temporarily to the model, type of transfer tray, adhesive used and way transfer is removed so as not to exert excess force on a still maturing bond.
-

# Indirect bonding with silicone tray

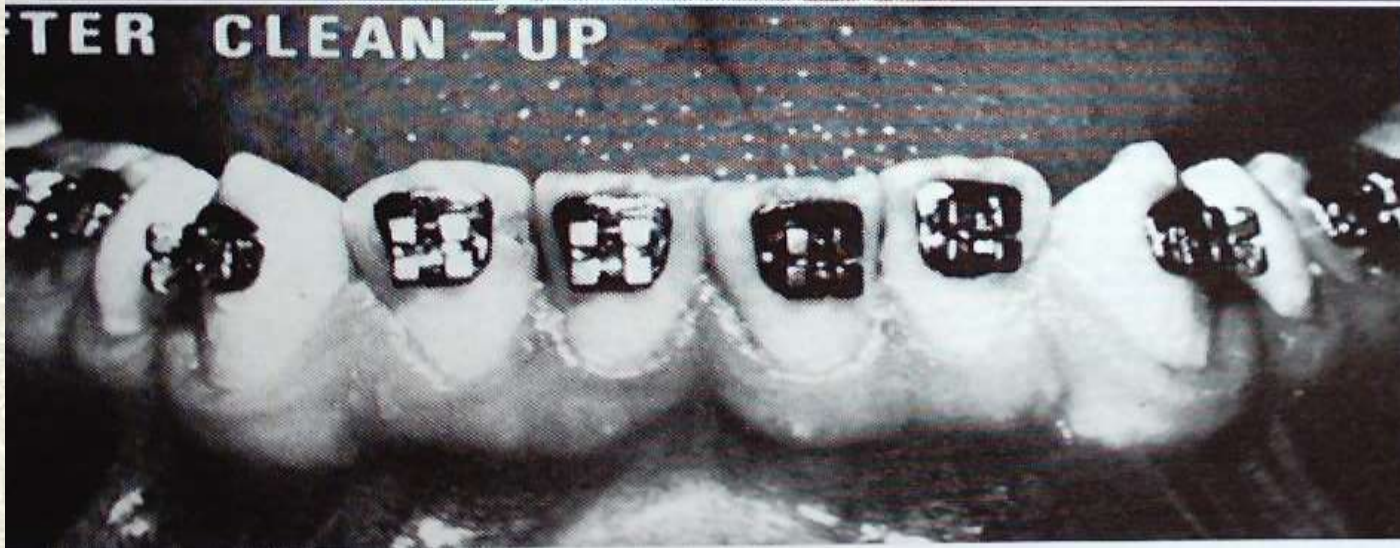
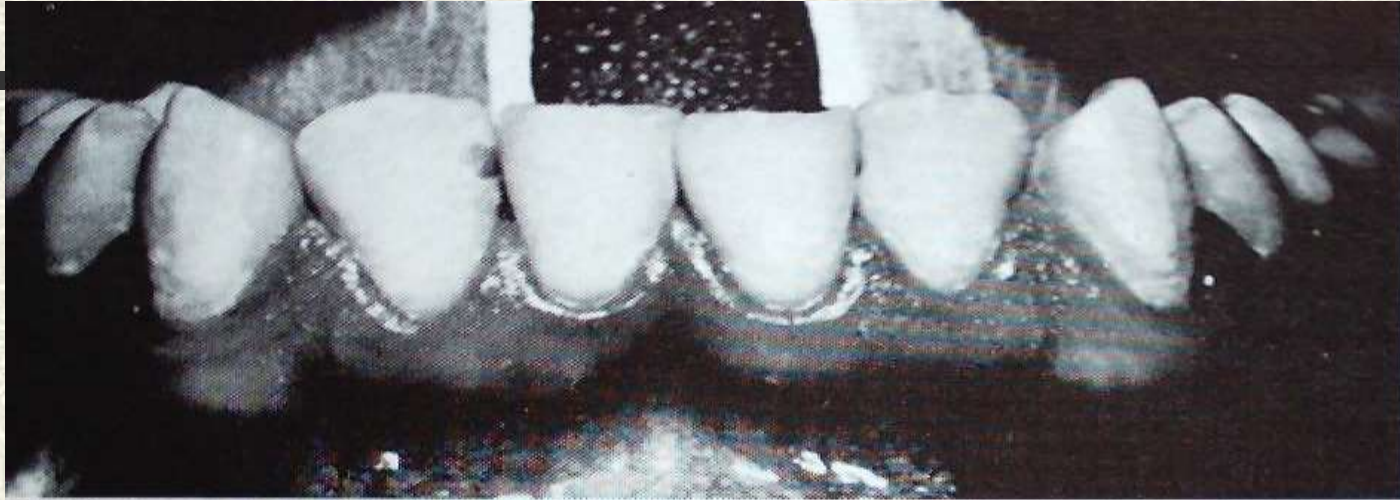
---

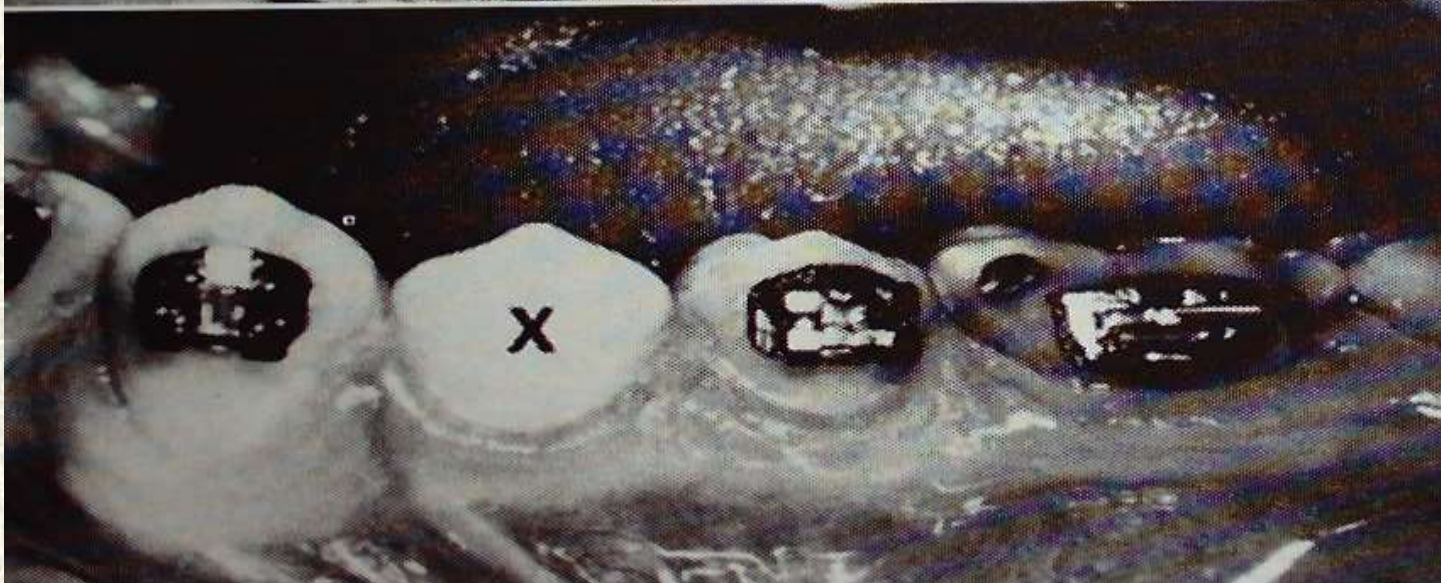
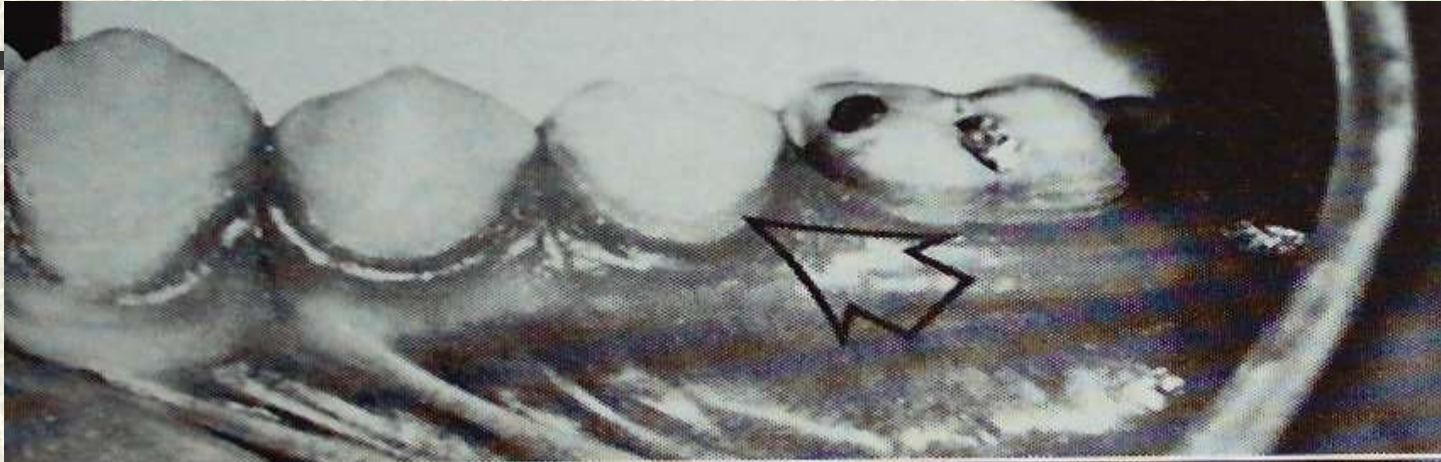
- # Take impression & fabricate stone model
  - # Select brackets for each tooth.
  - # Apply small portion of water soluble adhesive on each base or tooth.
  - # Position the brackets on model. check all measurements. reposition if necessary.
  - # Following manufacturers instructions press putty onto the cemented brackets.
  - # Form the tray allowing sufficient thickness for strength.
-





- # After silicone putty is set,immerse model and tray in water to release brackets from stone.remove remaining adhesive with running water.
  - # Trim silicone tray and mark midline
  - # Prepare patient s teeth as for a direct application
  - # Mix adhesive, load it in a syringe & apply a sufficient portion to bonding bases.
  - # Seat the tray after 10mins.tray can be cut longitudinally /transversely.
  - # Using oval or tapered T C bur clean the area properly around each bracket.
  - # Inspect for voids,fill with small mix of adhesive if needed.
-





# Indirect bonding with double sealant technique.

---

- # Adhesive pastes are used instead of a temporary adhesive to attach the brackets to the stone model.
  - # Small portions of catalyst & universal adhesive pastes are mixed & applied to back of bonding bases of all brackets, until all are attached to model
  - # After 10mins a placement tray is vacuum formed for each arch.
  - # They are placed in water until thoroughly saturated.
  - # Then trays are separated & trimmed-within 2mm of the brackets.
-

- # Midline is marked, the embedded bonding bases are lightly abraded with a mounted stone point
  - # Preparation of the patients teeth. the etched teeth are painted with universal sealant resin (part A)
  - # Lingual sides of bonding bases are painted with catalyst sealant resin (part B)
  - # Tray is inserted into patients mouth, held in place for 3mins.
  - # It is removed by peeling from lingual
  - # Excess flash of sealant is carefully removed from gingival & contact areas of tooth.
  - # Advantage- the cleanup is simple because little flash is present and consists of unfilled sealant only.
-

# Summary.....

---

- # Zinc phosphate is universal cementation agent. it has disadvantages of being pulp irritant, lacks adhesiveness & has no anticariogenic property.
- # Polycarboxylate-adv: -blandness to pulp, adhesiveness to tooth  
disadv: -short working time, sensitivity of cement to disintegration & lack of fluoride release.
- # Glass ionomer- adv: -bond to tooth, releases fluoride, shows greater resistance to disintegration in oral fluids & good mechanical props  
disadv: -slow development of ultimate props (24hrs), slight pulpal sensitivity postoperatively.

# Resin based cements-adv:-insoluble, high # toughness, good bonding to dentin & enamel via dentin bonding agent & acid-etching respectively.

---

disadv:-poor handling, critical to remove excess before onset or just after seating the brackets & irritant to pulp.

# Indirect bonding-adv:-brackets can be accurately positioned in lab, clinical chairside time reduced.

disadv:-chairside procedure more crucial for inexperienced clinicians, removal of excess adhesive difficult & time consuming, risk for adhesive deficiencies under brackets, failure rates are slightly higher.

---

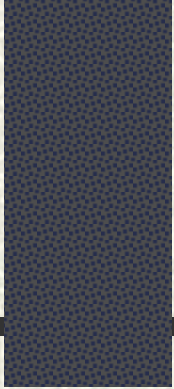
# Conclusion.

- # At present, individual practitioner may use either method based on practice routine, auxiliary personnel & clinical ability.
  - # For instance, indirect bonding is more likely to be used when all brackets are placed at one time at the start of orthodontic treatment rather than with a progressive strap up over several months.
  - # In lingual orthodontics, the indirect technique is a prerequisite for good bracket alignment because direct visualization has evident difficulties.
  - # So also it is apparent that no single type of cement satisfies all the ideal characteristics desired.
-

# References:-

---

- # Philip's science of dental materials 10<sup>th</sup>edn.  
by Kenneth J. Anusavice
  - # Orthodontics-Current Principles & Technique  
by Graber & Vanarsdall Jr.
  - # American journal of Orthodontics  
Article 1993 Dec & 1995 Sept
-



Thank You

