New Dental Products

Kraig S. Vandewalle, DDS, MS
Col, USAF, DC
Director, Materials Evaluation Dental Investigation Service
New Products

- Curing lights
- Bonding Agents
- Composite Resins
Curing Lights

- White light
  - filtered down
    - halogen
    - plasma-arc
- Blue light
  - at the source
    - argon laser
    - LED
Quartz-Tungsten-Halogen

• Most common dental curing light

• Quartz
  – encasing structure
  – crystalline
  – heat resistant

• Tungsten
  – filament coil
  – flow of electricity
Quartz-Tungsten-Halogen

• Halogen gas
  – protects filament
    • oxidation
  – re-deposits tungsten to filament
    • “halogen cycle”
Quartz-Tungsten-Halogen

- Radiant output
  - infrared energy (IR)
    - heat
- Cooling critical
  - do not turn off fan
    - halogen gas lost
    - oxygen enters
    - bulb life dramatically decreases
Quartz-Tungsten-Halogen

• Filters
  – band-pass
    • restricts to narrow visible light
      – 400 – 500 nm
      – range of photo-initiators
    – 99.5% of original radiant energy filtered
      • inefficient
Quartz-Tungsten-Halogen

• Filters
  – dichroic
    • silver reflective surface
    • passes IR energy
    • reflects visible light
    • provides focal spot

• QTH bulb
  – 30 – 50 hours useful life
  – $30 - $80
Quartz-Tungsten-Halogen

- **Demetron LC**
  - inexpensive ($250)
  - simple
  - 600 mW/cm²

- **Optilux 501**
  - cost $975
  - powerful (1200 mW/cm²)
  - variable modes
Halogen:Reloaded

- Swiss Master Light
  - 3000 mW/cm²
  - water-cooled bulb
  - disposable light guide
  - expensive
    - $2900
Plasma-Arc (PAC)

- Two tungsten electrodes
  - small gap
- Pressurized chamber
  - xenon gas
- High-voltage spark
  - ionizes gas
    - plasma
Plasma-Arc (PAC)

- High levels of IR and UV
  - extensive filtering
    - down to 400-500 nm
  - remote light source
    - liquid-filled light cord
    - fiber-optic cord
Plasma-Arc (PAC)

- High irradiance
  - $> 2000 \text{ mW/cm}^2$
  - claim 1-3 sec cure
    - DIS – 10 secs
- Expensive
  - $3,000 - $4,995
    - bulbs $>500$
    - hard to replace
  - Apollo 95E (DMD)
  - Sapphire (Den-Mat)
  - PAC Light (ADT)
Argon Laser

- High energy
  - coherent, non-divergent
  - non-continuous
- Expensive
  - $6000 - $9000
- Accucure 3000 (Laser Med)
Light-Emitting Diodes (LED)

- Semiconductors
  - electrically-excited atoms
- Gallium-nitride blue
- Narrow spectrum
  - 430 – 490 nm
    - peak at 470 nm
    - near absorption max of camphoroquinone

Jandt  Dent Mater  2000
LED Curing Lights

• Long lasting light source
  – minimal bulb aging
  – minimal decrease in output
• Less lateral heat production
  – minimal or no fan necessary
• No filters
• Typically cordless
Increase in Temperature
(pulpal)

Time (seconds)

°C

DIS Evaluations 2004
LED Curing Lights

• First generation
  – cost
    • $1000 - $1500
  – low irradiance
    • < 300 mW/cm²
    • increase exposure time
  – NRG (Caulk)
  – Versalux (Centrix)
  – Zap (CMS)
LED Curing Lights

- Second generation
  - cost
    - $540 - $1295
  - higher irradiance
    - > 600 mW/cm²
  - L.E.Demetron 1 (Kerr)
  - SmartLite iQ (Dentsply)
% Degree of Conversion Ratio

2 mm composite for 5 seconds

DIS Evaluations 2004
Light Projections

SmartLite  
LEDemetron  
FLASH-lite  
Optilux 501  
UltraLume  
Allegro

DIS Evaluations 2004
New Developments

• Narrow spectrum lights
  – argon laser
  – LED
• Other photoinitiators absorb at lower wavelengths
  – PPD
  – TPO
• Narrow spectrum lights may not polymerize materials containing other initiators
Spectral Emission / Absorption

- LED
- Camphoroquinone
- Phenyl propanedione
- PPD

Althoff Amer J Dent 2000
LED – Resin Incompatibilities

• Products
  – Biscover (Bisco)
  – Cabrio (Discus Dental)
  – Principle (Dentsply)
  – Pyramid (Bisco)
    • neutral & translucent
Multi-Spectrum LED Light

- **UltraLume LED 5 (Ultradent)**
  - bimodal emission spectrum
- cures all photo-initiated materials
Selecting a Light

- Basic features
  - irradiance
  - cost
- Convenience features
  - built-in radiometer
  - timer
  - interchangeable tips
  - ease of maintenance
Purchasing Considerations
Federal Service

• Halogen
  – established technology
  – relatively inexpensive
  – multiple curing modes
  – poor efficiency
    • heat
    • fan
  – limited bulb life
Optilux 501
(halogen)

- Cures ALL resins
- High irradiance
  - >1000 mW/cm²
- Built-in radiometer
- Multiple tips available
- Noisy fan
- Inefficient
- More expensive

Product of the Year 2001
5-Stars 2002
Purchasing Considerations
Federal Service

• LED
  – similar curing to halogen
  – lightweight and quiet
  – longer LED “source” life
  – more efficient
    • less lateral heat
      – little or no fan necessary
  – may not polymerize all photo-initiated materials
  – batteries may have to be replaced
LEDemetron 1

- Cordless handpiece
  - fan
  - removable light guides
- Battery charger
- 2 rechargeable batteries
  - removable
- Retail: $1200.00
- Government: $750.00
- Rated “Recommended” by DIS
SmartLite iQ

• Cordless handpiece
  – no fan
  – rechargeable battery
  – removable light guides
• Battery charger
• Retail: $1100.00
• Government: $803.00
• Rated “Recommended” by DIS
Price Comparisons
(Government)

- Allegro
- UltraLume 5
- SmartLite
- LEDemetron
- FLASHlite
- Demetron LC
- Opti 501

[Bar chart showing price comparisons among different products with LED and Halogen options]
Purchasing Considerations
Federal Service

• Plasma Arc
  – shorter curing times
  – more expensive
  – higher heat potential

• Argon Laser
  – very expensive
  – excellent collimation
  – impractical for routine use
Bonding Agents

- Total-etch (etch&rinse)
- Self-etch
Etch & Rinse (Three-Step)

- Conditioner
- Primer
- Adhesive resin

Examples
- Scotchbond Multi-Purpose
- Optibond FL
Conditioner

- Chemical alteration of surface
  - acids
    - phosphoric, citric, maleic, nitric
- Removes dentinal smear layer
  - exposes collagen fibrils
- Simultaneous enamel etch
- Rinse
  - keep moist
Primer (wetting agent)

- Hydrophilic monomers
  - dissolved in acetone, alcohol or water
- Displaces water
- Promotes infiltration into collagen
- Lightly air dry
  - drive off solvents, water
- Transforms hydrophilic to hydrophobic

Swift JADA 1994
Primer (wetting agent)

- Bifunctional monomer
  - Link
    - hydrophilic collagen
    - hydrophobic resin
  - HEMA
  - 4-META
  - BPDM
  - PMDM

```
H2C=CH2
  \   /  \\
  \ /  |
CO-CH2-CH2-OH
```
Adhesive Resin

- Unfilled or lightly-filled monomers
  - Bis-GMA, UDMA, TEGDMA
- Stabilize the hybrid layer
  - fills up remaining pores
- Resin tags
- Links primer to resin composite
  - typically light cured
Etch & Rinse (Two-Step)

- Conditioner
- Combined primer and adhesive
  - higher technique sensitivity
  - higher solvent-to-monomer ratio
    - risk of applying too thin
    - apply multiple layers

- Single Bond, Optibond Solo Plus, One Step
Pros/Cons of Etch & Rinse

• Separate 37% phosphoric acid etch
  – good enamel etch pattern
• Potential to over-etch dentin
  – except sclerotic dentin
• Post-conditioning rinse necessary
  – sensitive to level of dentin wetness
• Multiple long-term clinical studies available
Dentin Wetness
Etch & Rinse

• After conditioning dentin
  – dentin must be wet
  • prevent collagen collapse
Hybridoid Zone

- Too little water
  - collagen collapse
- Ineffective resin penetration
- Leads to nanoleakage

Sano, Oper Dent 1995
Class V Clinical Studies
Etch & Rinse Three-Step

- Scotchbond MP (3M ESPE)
  - 100% retention at 3 yrs
    - Van Meerbeek Quint Int 1996
    - 98-100% retention at 3 yrs
    - Trevino JDR 1996
  - 100% retention at 2 yrs
    - Alhadny Am J Dent 1996
Class V Clinical Studies
Etch & Rinse Two-Step

• Optibond Solo (Kerr)
  – 93.3% retention at 3 yrs
    • Swift JADA 2001

• Prime & Bond 2.1 (Caulk)
  – 89.4% retention at 3 yrs
    • Swift JADA 2001
Three-step

- $4.50 / ml
- $9.42 / ml

Two-step

- $11.12 / ml
- $13.23 / ml

Prices current as of 04/03
Self-Etch (Two-Step)

- Combined conditioner and primer
- Adhesive resin
  - Clearfil SE
  - Optibond SE
  - AdheSE
Self-Etch (One-Step)

• Combined
  – conditioner
  – primer
  – adhesive

• Examples
  – Prompt L-Pop
  – One-up Bond F
  – Touch and Bond
  – iBond
  – Xeno III
Self-Etch Components

Acidic monomers

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

Crosslinking monomers

- Bis-GMA
- UDMA
- TEGDMA
- GDMA
- HEMA

Solvent

- water based
Pros/Con of Self-Etch

• Good dentin conditioning
  – simultaneous infiltration
    • depth of demineralization
• Possible reduction in post-op sensitivity?
• No post-conditioning rinse
  – not sensitive to level of dentin wetness

Perdigao Am J Dent 1997
Hara Am J Dent 1999
Clinical Study

• 66 Class 1 or 2 composite restorations
  – Clearfil SE
    • self-etch
  – Prime & Bond NT
    • etch & rinse
• Tested for post-op sensitivity
• No difference
  – Baseline, 2 weeks, 6 weeks, 6 months

Perdigao  Oper Dent  2003
Application Time

Source: USAF DIS  N=3
Pros/Con of Self-Etch

• Potential under-etch enamel
  – equal or reduced enamel bonding
• Smear layer dissolved into resin
• Limited clinical data
Shear Bond Strength to Dentin

Source: USAF DIS  Horizontal lines connect nonsig diff at 0.05 level
Class V Clinical Studies
Self-Etch Two-Step

• Clearfil SE Bond (Kuraray)
  – 100% retention at 2 yrs
    • Peumans J Dent Res abstr #0911
  – 93% retention at 2 yrs
    • Turkun J Dent 2003
Class V Clinical Studies
Self-Etch One-Step

• Prompt L-Pop (3M ESPE)
  – 65% retention at 1 yr
    • Brackett Oper Dent 2002
  – 79% retention at 2 yrs
    • van Dijken EFOS abstr #8
Government Prices

($/ml)

Prices as of 11/03
Recommendations

- 4\textsuperscript{th} generation
  - etch & rinse three-step
    - Scotchbond MP Plus
    - Optibond FL

- 5\textsuperscript{th} generation
  - etch & rinse two-step
    - Optibond Solo Plus
    - Single Bond
    - Excite
Recommendations

• 6th generation
  – self-etch two-step
    • Clearfil SE Bond
  – self-etch one-step ??????
“Although there is a tendency toward adhesives with simplified application procedures, simplification does not guarantee equal or improved bonding effectiveness.”

Van Meerbeek  Oper Dent  2003
Composite Resins

- Multiple shades/opacities
- Nanofilled
Classification System

• Chronological
• Based on particle size
  – traditional
  – microfilled
  – small particle
  – hybrid

Lutz  J Prosthet Dent  1983
Microfills

- Better esthetics and polishability
- Tiny particles
  - 0.04 micron colloidal silica
  - increases viscosity
- To increase filler loading
  - filler added to resin
  - heat cured
  - ground to large particles
  - remixed with more resin and filler
Microfills

- Lower filler content
  - inferior mechanical properties
    - increased fracture potential
    - lacks coupling agent
- Linear clinical wear pattern
- Suitable for Class 3, 5
  - exceptions
    - Heliomolar RO in Class 1 or 2
    - overlay hybrid in Class 4
- Examples: Filtek A110, Heliomolar RO
Hybrids

• Popular as “all-purpose”
• 0.4 to 1 micron average particle size
  – distribution of particle sizes
    • maximizes filler loading
  – microfills added
    • improve handling
    • reduce stickiness
Hybrids

- Strong
- Good esthetics
  - polishable
- Suitable
  - Class 1 to 5
- Examples:
  - Z250
  - Prodigy
Newer Classification System

- Based on particle size
  - megafill
    - 0.5 - 2 millimeters
  - macrofill
    - 10 - 100 microns
  - midifill
    - 1 - 10 microns
  - minifill
    - 0.1 - 1 microns
  - microfill
    - 0.01 - 0.1 microns
  - nanofill
    - 0.005-0.01 microns

- Most new systems
  - minifillers

- Newest trend
  - nanofillers
  - trimodal loading
    - prepolymerized

Bayne JADA 1994
Placement Techniques

- Shaded
- Anatomic
Placement Techniques

• Shaded
  – 4 Seasons
  – Esthet-X
  – Filtek Supreme
  – Point 4
  – Venus
  – Renamel
  – Gradia Direct

• Anatomic
  – 4 Seasons
  – Vitalescence
  – Miris
Recent DIS Evaluations

- Venus (Heraeus Kulzer)
- 4 Seasons (Ivoclar Vivadent)
- Gradia Direct (GC America)
- Filtek Supreme (3M ESPE)
Venus

- Filler particles
  - average: 0.7 microns
  - filled: 61% vol / 78% wgt
- Kit very complete
  - 27 shades
    - 3 opacities
  - shade guide
    - layered with actual composite
- Moderate cost
- Rated “acceptable” by DIS
4 Seasons

• Filler particles
  – average: 0.6 microns
  – filled: 76% wgt
• Kit very complete
  – 40 shades
• Very inexpensive
• Rated “acceptable” by DIS
Gradia Direct

- Filler particles
  - average: 0.85 microns
- Anterior and posterior shades
  - 26 shades
- Inexpensive
- Rated “acceptable” by DIS
New Nanofilled Composites

• **Nano-filled**
  - $1 \text{ nm} = 1/1000 \text{ micron}$

• **Universal**
  - strength of a hybrid
  - polish of a microfill

• **Examples**
  - Filtek Supreme (3M ESPE)
  - Simile (Pentron)
Filtek Supreme

• Filler particles
  – filled: 78% wgt
  – nanomers
    • 0.02 – 0.07 microns
  – nanocluster
    • act as single unit
      – 0.6 – 1.4 microns
Filtek Supreme

- 30 shades
  - 4 opacities
  - only 12 in profession kit
- No shade guide
  - use Vita
  - shade wheel
    - layering
- Most expensive composite evaluated
- Rated “acceptable” by DIS
Radiopacity
*(mm of aluminum)*

Source: USAF DIS Project 03-037
Knoop Hardness
(24 hrs)

Source: USAF DIS Project 03-37

Horizontal lines connect nonsignificant differences (p<0.05); N=5
Diametral Tensile Strength
(24 hrs)

Horizontal lines connect nonsignificant differences (p<0.05); N=5

Source: USAF DIS Project 03-037
Flexural Strength
(24 hrs)

Horizontal lines connect nonsignificant differences (p<0.05); N=5

Source: USAF DIS Project 03-037
Depth of Cure
(% KHN ratio)

Source: USAF DIS Project 03-037

Horizontal lines connect nonsignificant differences (p<0.05); N=5
Volumetric Shrinkage

Source: USAF DIS Project 03-027

Horizontal lines connect nonsignificant differences (p<0.05); N=5
## Government Price

($/gm of refill resin)

<table>
<thead>
<tr>
<th>Product</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Seasons</td>
<td>6.3</td>
</tr>
<tr>
<td>Gradia Post</td>
<td>6.5</td>
</tr>
<tr>
<td>Gradia Ant</td>
<td>7.58</td>
</tr>
<tr>
<td>Herculite XRV</td>
<td>8.49</td>
</tr>
<tr>
<td>Prodigy</td>
<td>8.53</td>
</tr>
<tr>
<td>Point 4</td>
<td>8.79</td>
</tr>
<tr>
<td>Z100</td>
<td>8.9</td>
</tr>
<tr>
<td>Venus</td>
<td>9</td>
</tr>
<tr>
<td>Vitalescence</td>
<td>9.44</td>
</tr>
<tr>
<td>EsthetX</td>
<td>9.95</td>
</tr>
<tr>
<td>Z250</td>
<td>10.15</td>
</tr>
<tr>
<td>Filtek Supreme</td>
<td>11.36</td>
</tr>
</tbody>
</table>

Source: USAF DIS; prices current as of 03/03
Recommended by DIS

- **Prodigy (Kerr)**
  - filler particles
    - average: 0.6 microns
    - filled: 79% wgt
  - inexpensive
  - great handling
  - convenient packaging
    - Optibond
  - 18 shades
    - only 5 in kit
    - capsules