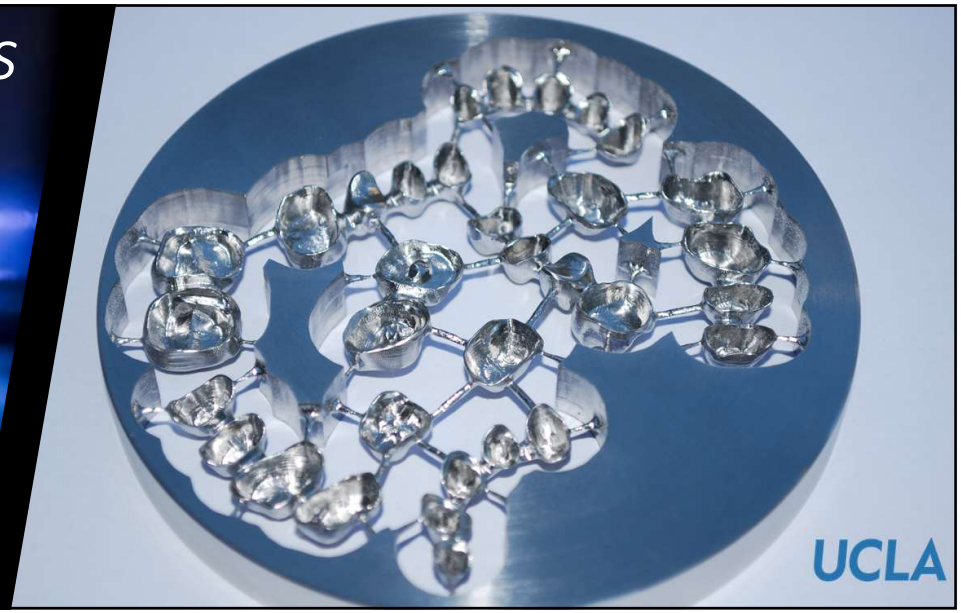
Technology Advancements in Restorative Dentistry:

Scanning, Milling & Printing



Colby Smith, DDS, MAGD

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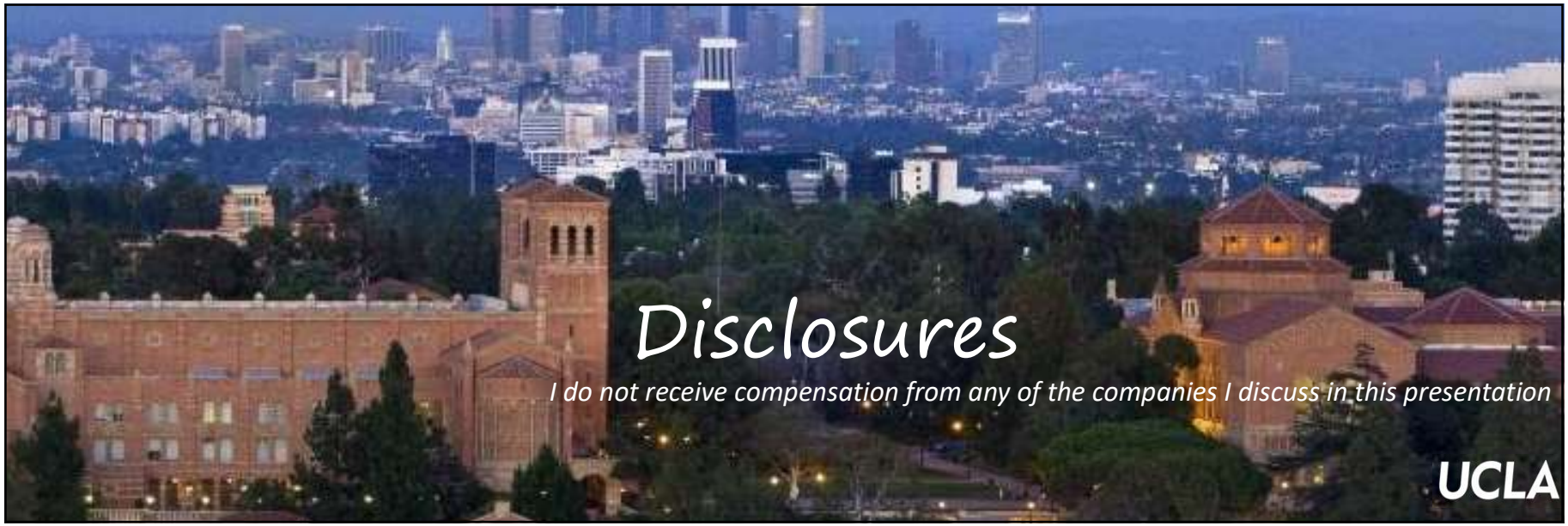
Disclosures
I do not receive compensation from any of the companies I discuss in this presentation
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Topics

Background and History

Restorative Workflows

Digital Impressions

Chairside & Lab Milling

3D Printing

Surgical Guides & Navigation

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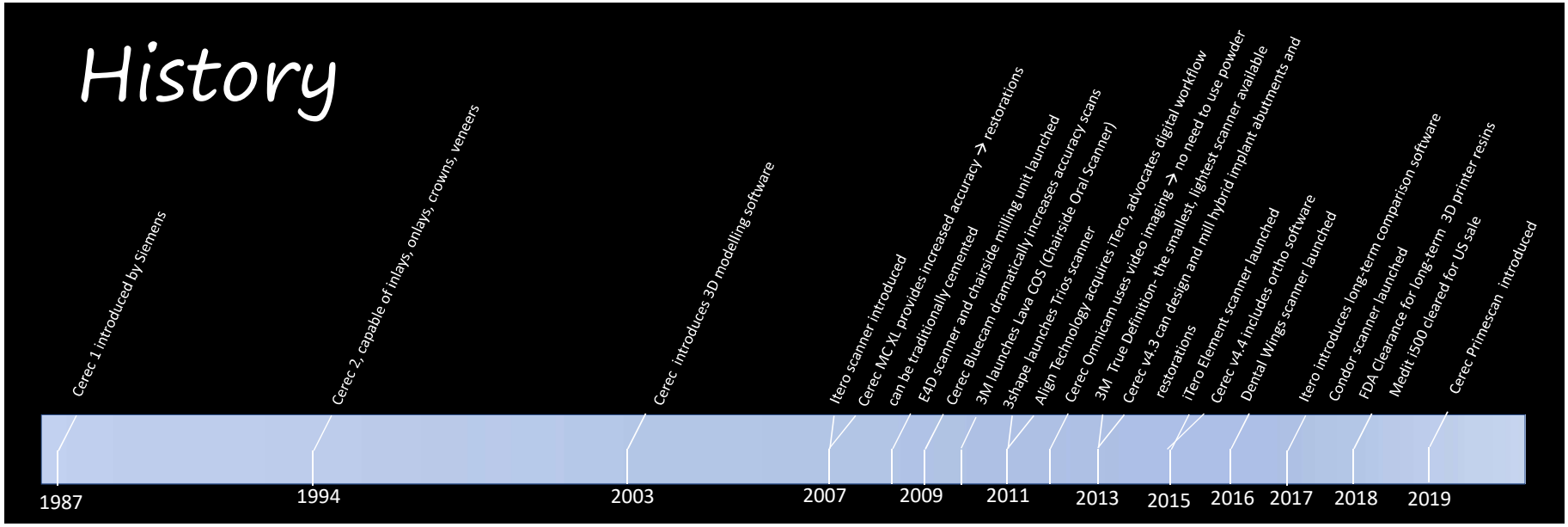
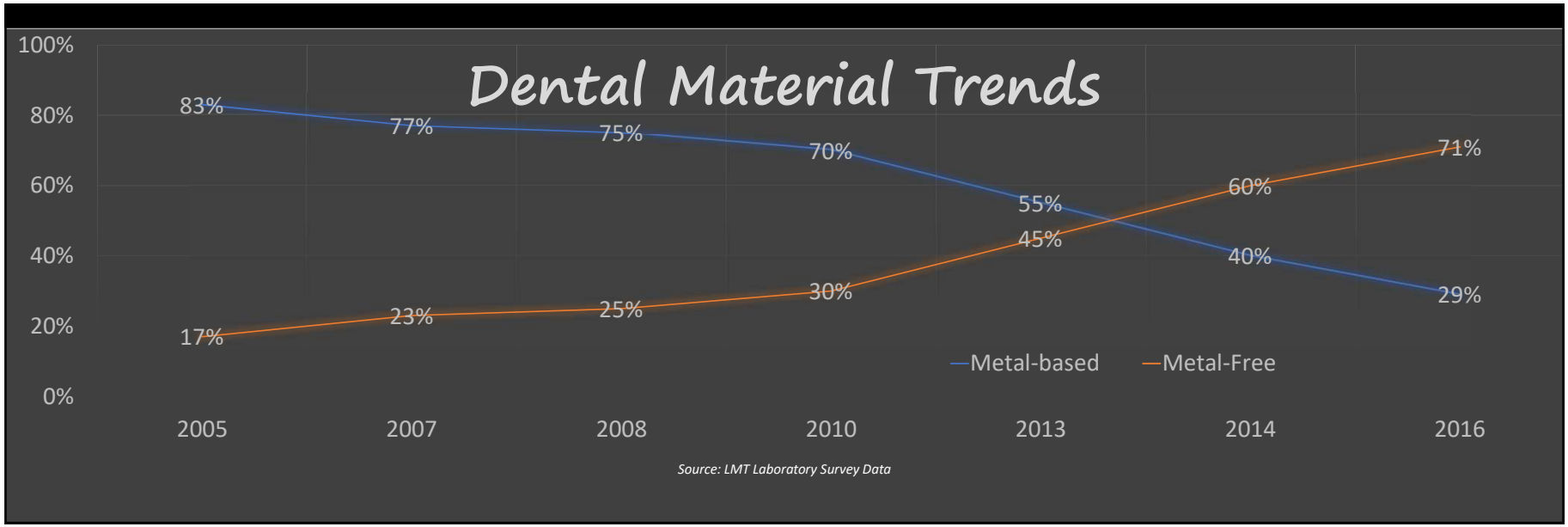

History
Cerec 1 introduced by Siemens
Cerec 2, capable of inlays, onlays, crowns, veneers
Cerec introduces 3D modelling software
Itero scanner introduced
Cerec MC XL provides increased accuracy → restorations
can be traditionally cemented
E4D scanner and chairside milling unit launched
Cerec Bluecam dramatically increases accuracy scans
3M launches Lava COS (Chairside Oral Scanner)
3shape launches Trios scanner
Align Technology acquires iTero, advocates digital workflow
Cerec Omnicam uses video imaging → no need to use powder
3M True Definition- the smallest, lightest scanner available
Cerec v4.3 can design and mill hybrid implant abutments and
restorations
iTero Element scanner launched
Cerec v4.4 includes ortho software
Dental Wings scanner launched
Itero introduces long-term comparison software
Condor scanner launched
FDA Clearance for long-term 3D printer resins
Medit i500 cleared for US sale
Cerec Primescan introduced
1987
1994
2003
2007
2009
2011
2013
2015
2016
2017
2018
2019


Dental Material Trends
100%
80%
60%
40%
20%
0%
83%
77%
75%
70%
55%
40%
29%
17%
23%
25%
30%
45%
60%
71%
Metal-based
Metal-Free
2005
2007
2008
2010
2013
2014
2016
Source: LMT Laboratory Survey Data

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Digital Laboratory Trends

- Over 75% of dental labs have digital model scanners
- Over half have a milling system
- 90% of labs offer digitally-fabricated restorations
  - In-House or Outsourced
- 37% of Invisalign cases are sent digitally
- Only 7% of restorative dentists currently send digital impressions

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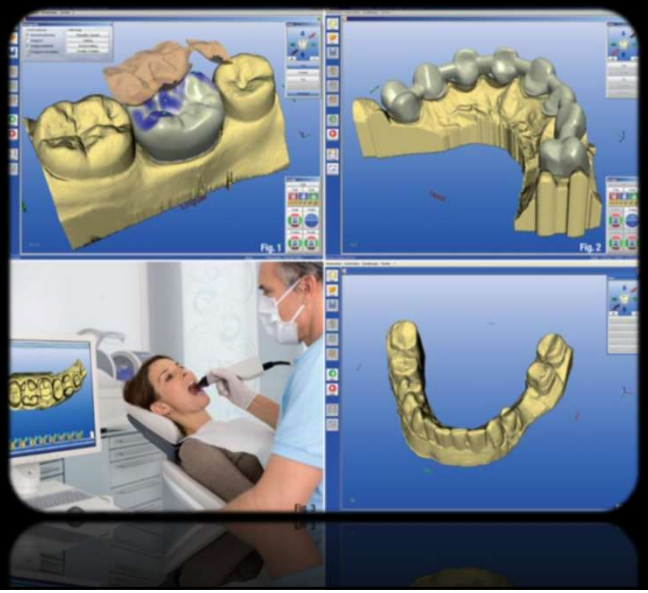
The Question

Computer Aided Design

Computer Aided Manufacturing



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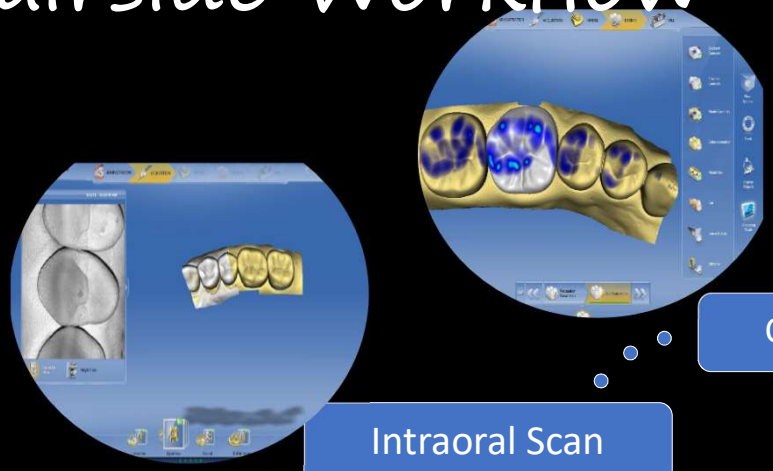
Chairside Workflow



Intraoral Scan

Chairside Design

In-Office Milling

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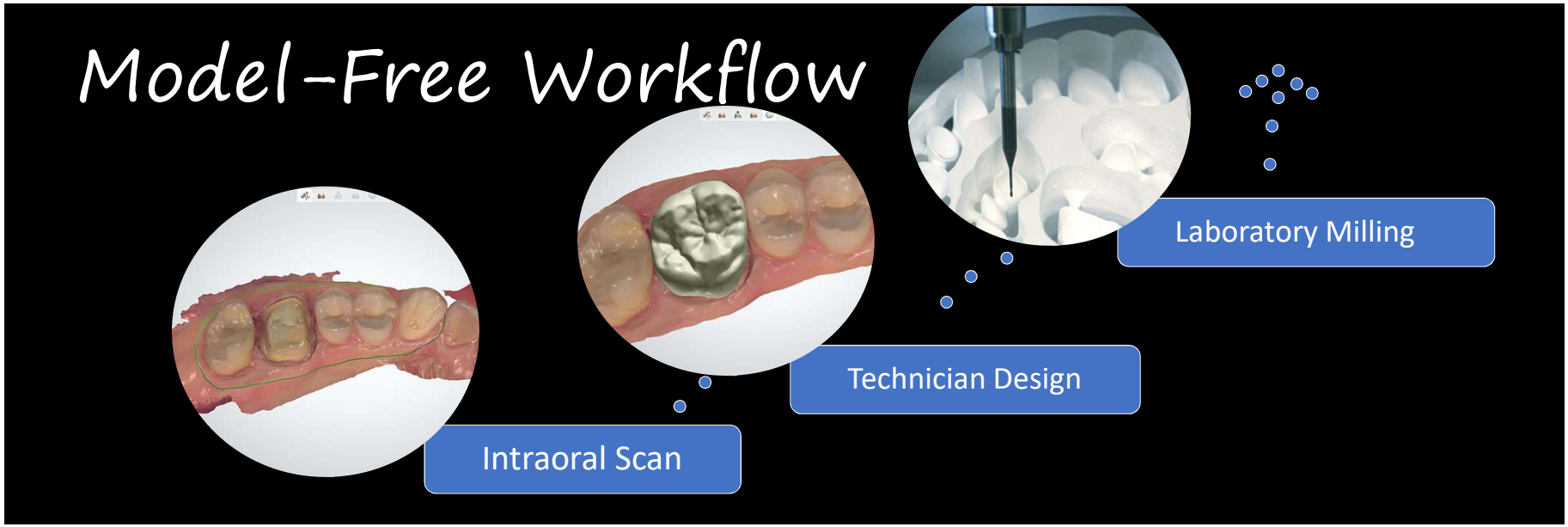
Model-Free Workflow
Intraoral Scan
Technician Design
Laboratory Milling

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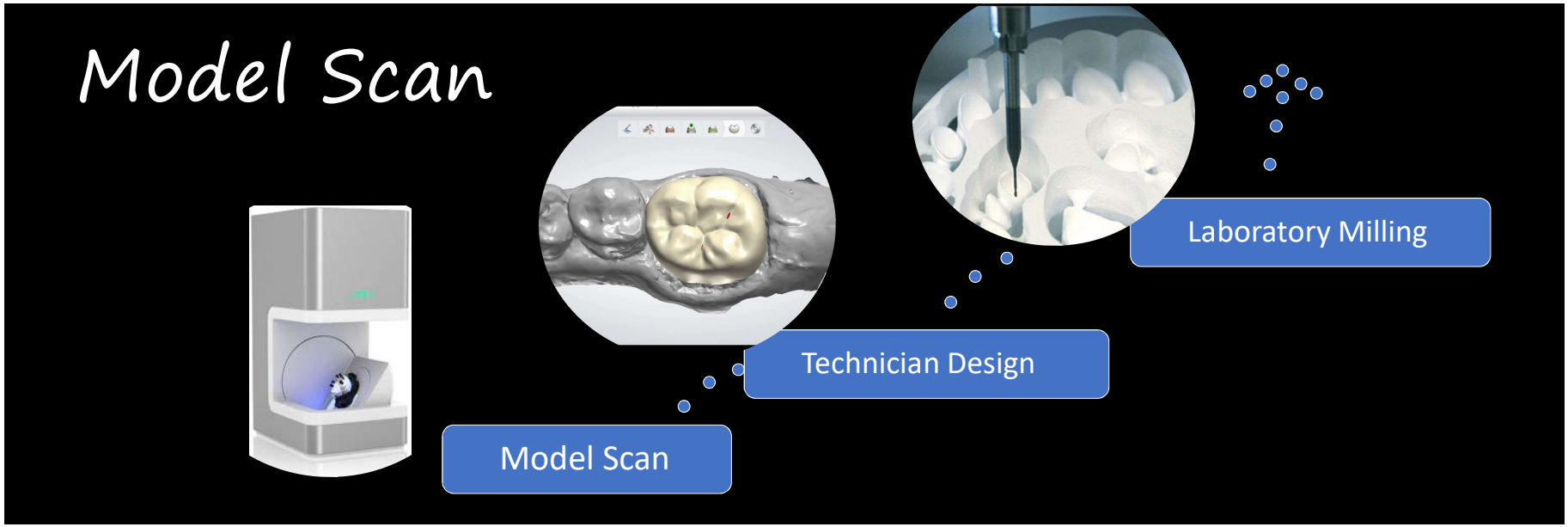
Model Scan
Laboratory Milling
Technician Design
Model Scan

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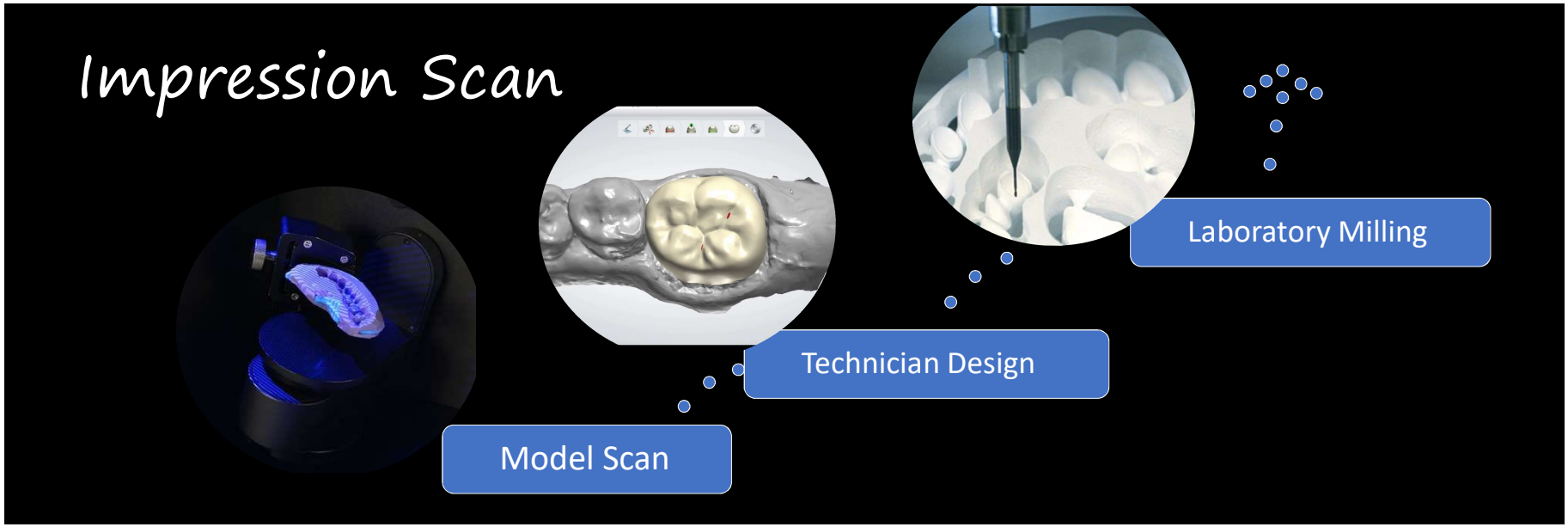
Impression Scan
Model Scan
Technician Design
Laboratory Milling

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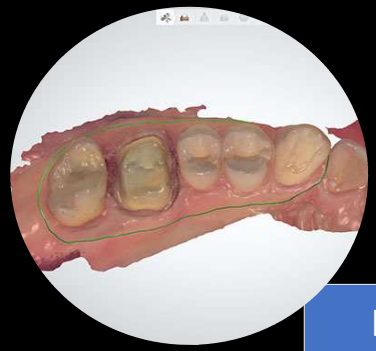
The future?



Intraoral Scan

Remote Design

In-Office Milling

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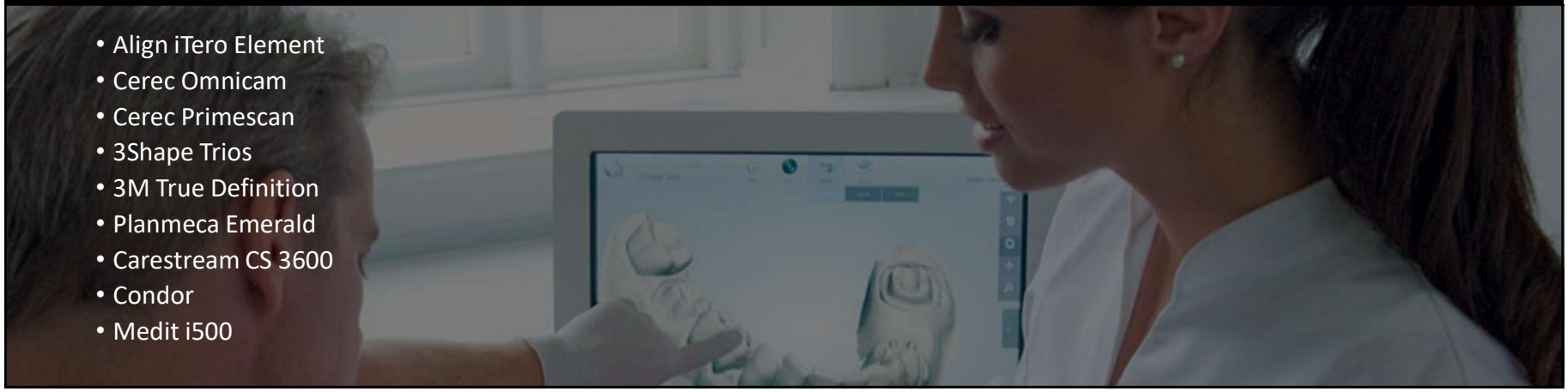
Intraoral Scanners



- Align iTero Element
- Cerec Omnicam
- Cerec Primescan
- 3Shape Trios
- 3M True Definition
- Planmeca Emerald
- Carestream CS 3600
- Condor
- Medit i500

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iTero Element (Align Technology)

- Open system
- Highest selling scanner in the USA ~50% market share
- Color imaging
- Largest scanner size
- 6,000 frames/sec capture
- Integration with Invisalign → immediate chairside "Outcome Simulator"
- Touchscreen display- cart or counter stand

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Cerec Omnicam (Dentsply Sirona)

- Closed system (somewhat…)
- Integrated technologies
  (Impression, Design, Chairside/Lab Milling, CBCT)
- Wheeled cart with wireless connection
- Color video capture
- Optimized for in-office milling
- Capable of working with most materials, implant systems, restoration styles
- Relatively small scanner head

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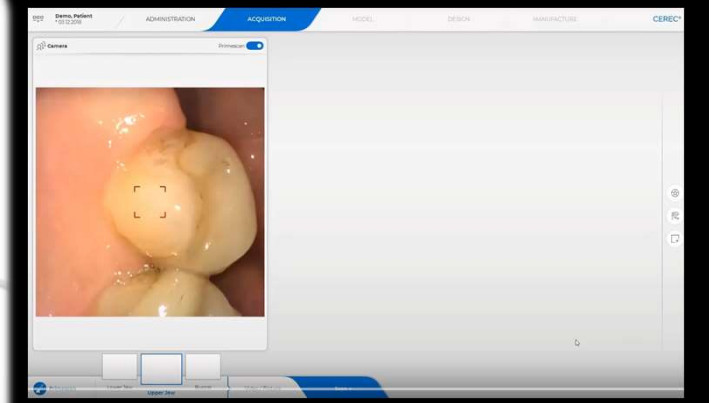
Cerec Primescan (Dentsply Sirona)

- Same design/mill ecosystem as Omnicam
- Wheeled cart with touchscreen
- Faster image capture
- Large scanner head
- Option for removable/autoclavable heads



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3Shape Trios

- Open system
- Large market share with lab scanner/software
- Very accurate
- Lifelike color images
- Can directly communicate shade
- Two grip designs
- Wireless Connection available

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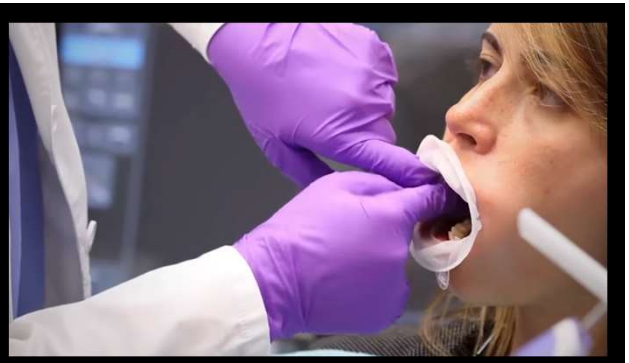
3M True Definition

- Open system
- Low purchase price
- Small wand and scanner head
- Very accurate
- Requires reflective TiO powder to capture images
- Operates on a tablet- most portable



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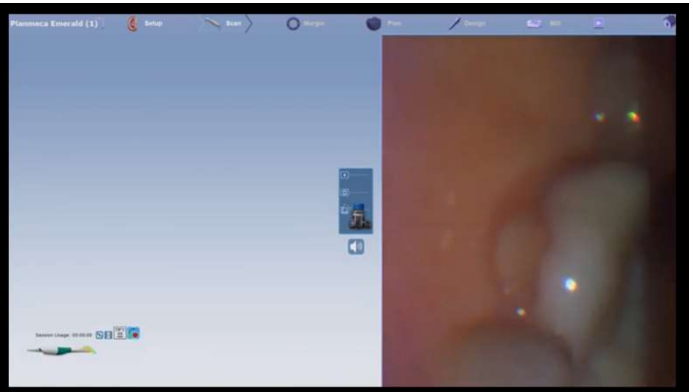
Planmeca Emerald

- Open System
- USB connection- “Plug & Play” Design
- Very Lightweight
- Pairs with PlanMill Chairside milling unit or others
- Lifelike color scanning



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Carestream CS 3600

- Open System
- USB connection- “Plug & Play” Design
- True color scanning
- Automatic margin-finding & bite registration
- Pairs with CS3000 chairside milling unit or others
- Intraoral camera function for still images
- No additional fees after purchase

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Dental Wings (Straumann)

- Open System
- Cart-based or countertop
- Multiple simultaneous scans- increase scan speed
- Very small handpiece
- Gesture & Voice Controls
- LED provides visual cues to operator

dental wings
10 YEARS
TRANSFORMING CREATIVITY

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Condor

- Open System
- True color scan
- High performance for low price
- Very small handpiece
- Longer focal distance
- Somewhat more technique-sensitive

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Medit i500

- Open System
- True color scan
- High performance for low price
- Impression scan capability
- HD camera and scanning
- Occlusal analysis software

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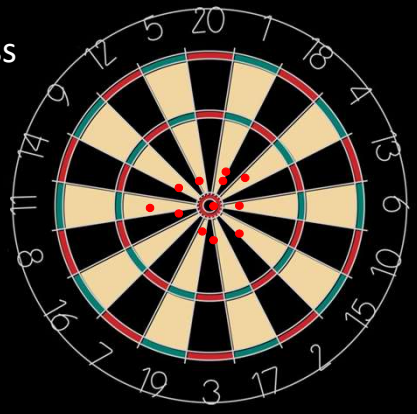
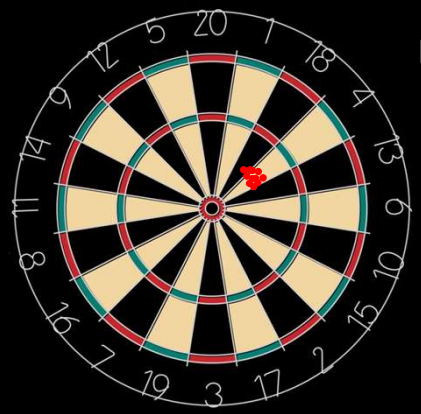
Comparing Accuracy

Trueness





Precision

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Most Accurate?

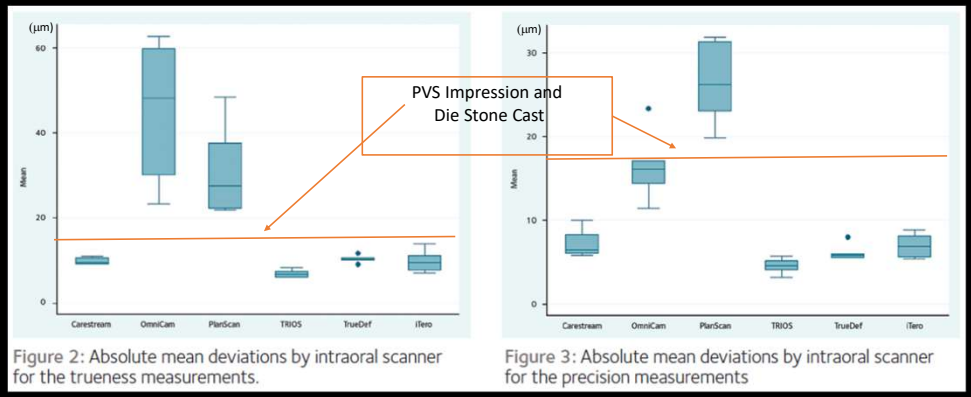

Figure 2: Absolute mean deviations by intraoral scanner for the trueness measurements.

Figure 3: Absolute mean deviations by intraoral scanner for the precision measurements

**Hack & Patzelt. Evaluation of the Accuracy of Six Intraoral Scanning Devices: An In-vitro Investigation. JADA. 2015*

Lowest Price?

MEDIT

3M

True Definition

CONDOR®
intra oral scanner

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Best for Chairside Milling?

PLANMECA Emerald™

Dentsply Sirona Primescan

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Smallest Scanner?

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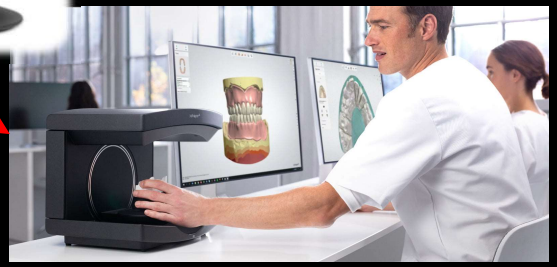
Key Connections

3shape



iTero element

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Restoration Fabrication

Chairside Milling

- Single Units
- Short Spans
- Only monolithic ceramics and composite
- Hybrid abutments possible
- Less robust

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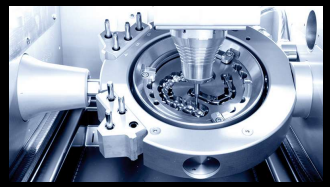
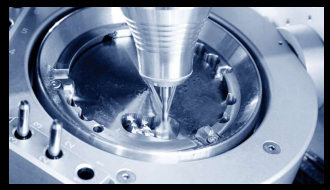
Restoration Fabrication

Chairside Milling	Laboratory Milling
• Single Units • Short Spans • Only monolithic ceramics and composite • Hybrid abutments possible • Less robust	• Multiple Unit • Long spans • One-piece Abutments • Many Materials (Cobalt Chromium, Titanium, Zirconia, Wax)





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Restoration Fabrication

Chairside Milling	Laboratory Milling	3D Printing
• Single Units • Short Spans • Only monolithic ceramics and composite • Hybrid abutments possible • Less robust	• Multiple Unit • Long spans • One-piece Abutments • Many Materials (Cobalt Chromium, Titanium, Zirconia, Wax)	• Can be quite accurate • Primarily plastics (Models/Dies, Framework Copings, Surgical Guides) • Metals & ceramic are possible

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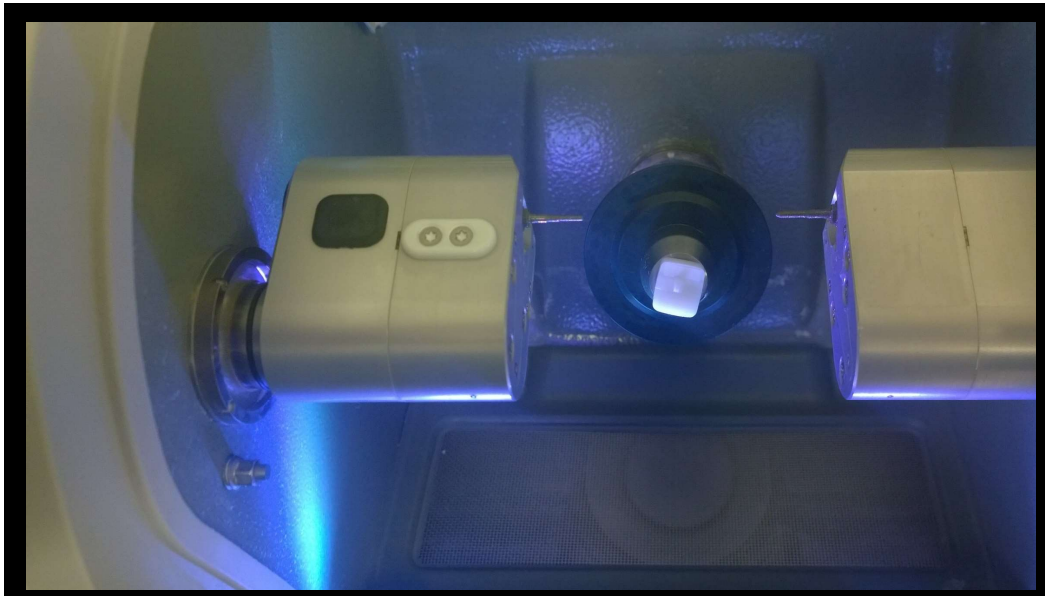

Chairside Milling Units

- Cerec MC XL (Dentsply Sirona)
- Planmill 40 (Planmeca/E4D)
- Fastmill.io (Glidewell)
- CS 3000 (Carestream)

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Cerec MC XL

- Closed system
  - Only compatible with Cerec scanners
- Most milling capability
  - Single- and multiple-unit restorations
  - Full- and partial-coverage
  - Implant hybrid abutments/crowns
  - Surgical guides
- Compatible with most materials
- Accurate milling

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Planmill 40

- Open system
- Many materials available
- Many restorations possible
  - Single- and multiple-unit restorations
  - Full- and partial-coverage
  - Implant abutments/crowns
- Highly accurate Milling
- Automatic bur Replacement

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Glidewell Fastmill.io

- Paired with iTero Scanner
- Limited materials
- Full crowns only
- Air-driven motor
  - Less control over contour and surface?
- Single bur milling

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Carestream CS 3000

- Relatively inexpensive unit
- Limited milling capacity
  - Single crowns, inlays & onlays
- Single bur milling
- Few materials available
  - Vita feldspathic porcelain

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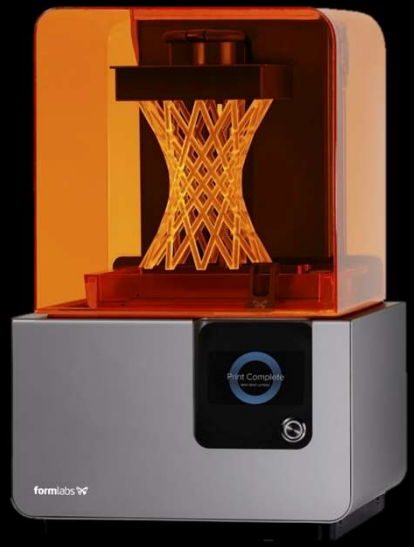
3D Printing



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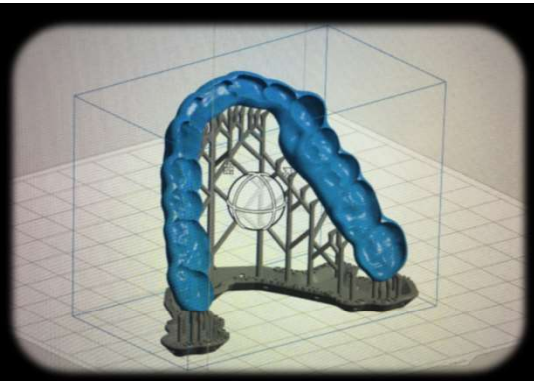
3D Printing

- What's possible now?
- What's coming?



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Available Dental Resins

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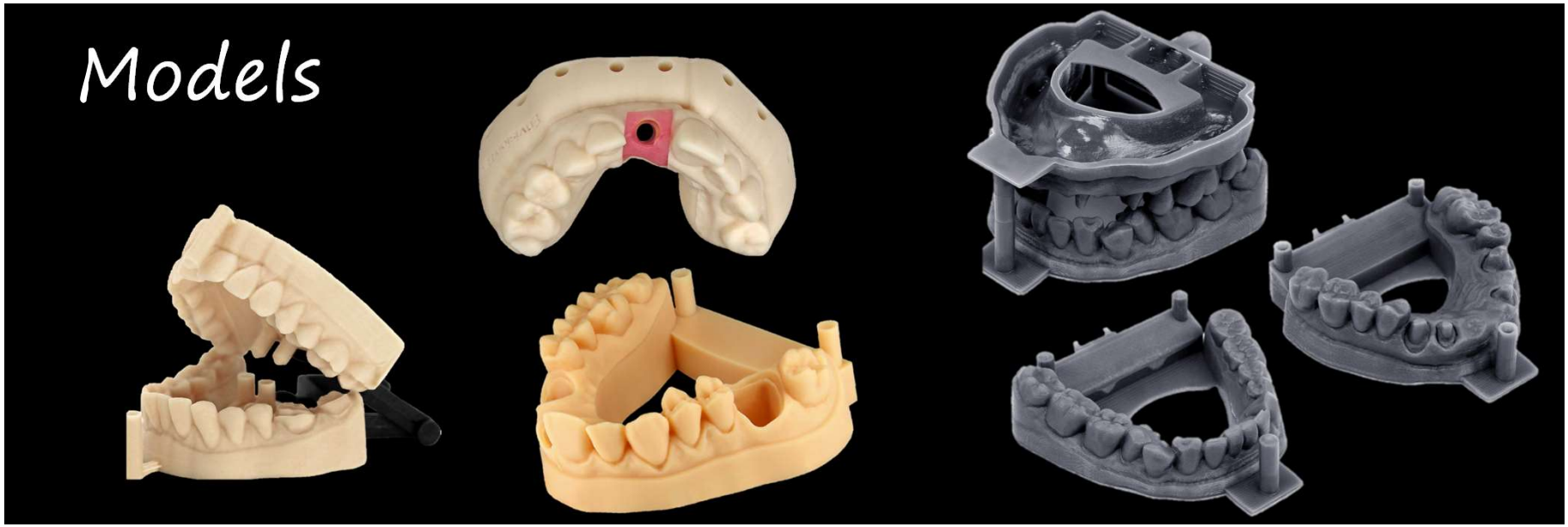

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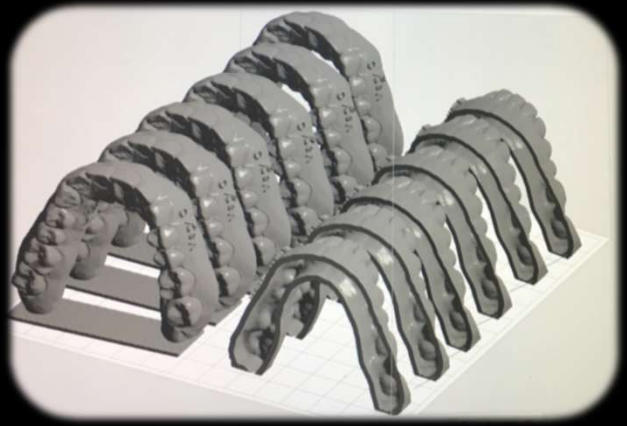
Clear Aligners



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Appliances & Guides

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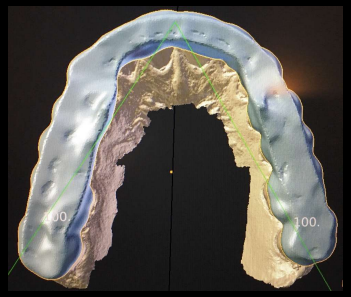
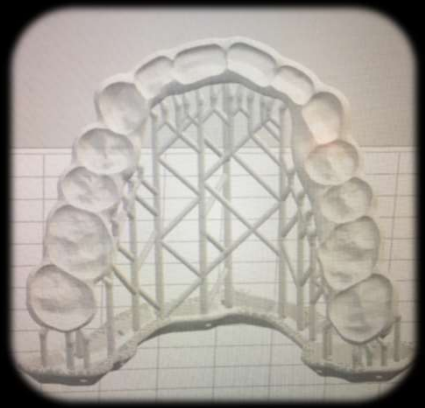
Appliances & Guides





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Dentures

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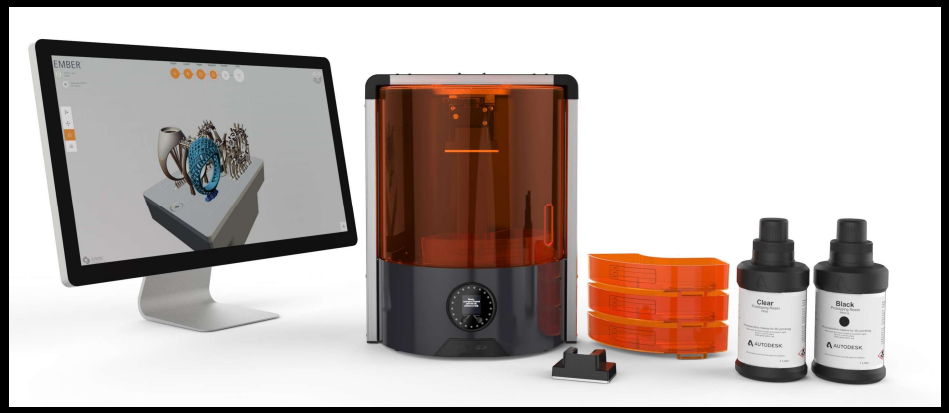
Patterns & Provisionals



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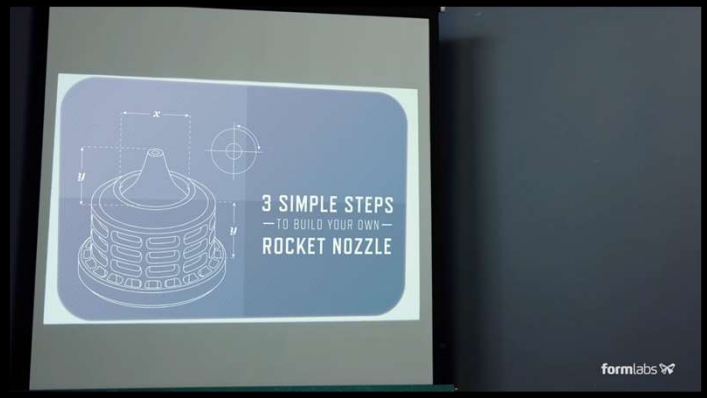
New Printing Possibilities- Ceramic



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New Printing Possibilities- Metal

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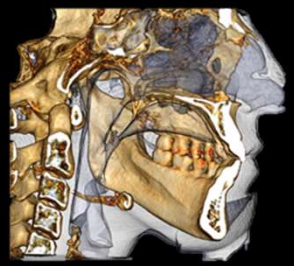
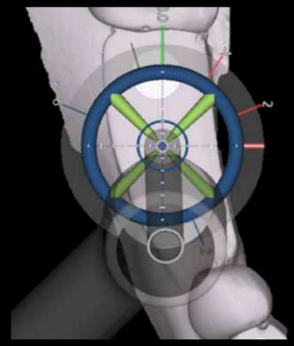
Surgical Guides/Implant Navigation

- Many systems to fabricate keyed guides from CBCT
  - Simplant
  - Anatomage
  - Nobel Clinician
  - Bluesky Bio
  - Many others
- Navigation Systems
  - X-Nav
  - Navident
- All rely on overlaying CBCT and digital scan for accuracy
  - Need large field of view to overlay images





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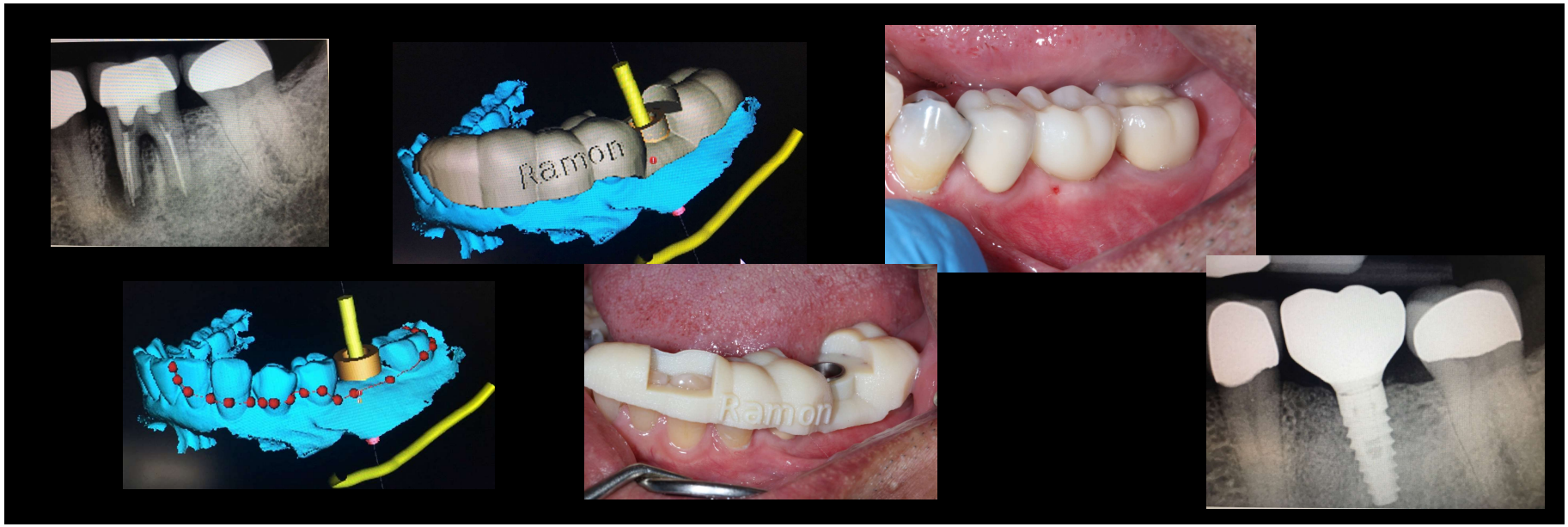

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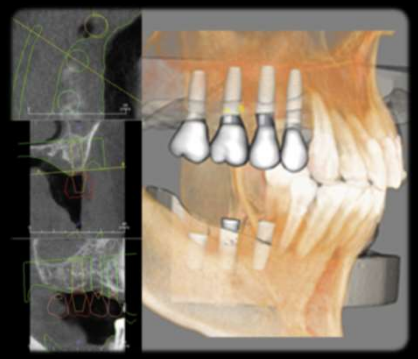
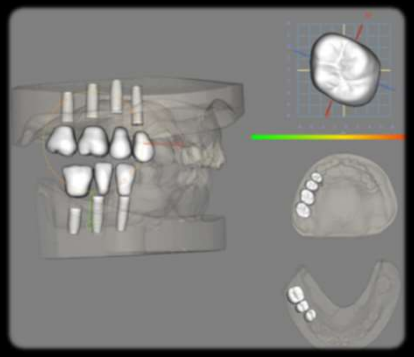
CBCT/Digital Impression Integration

- Cerec (Sirona) – Merges Galileos CBCT & Digital scan/waxup
  - CAD/CAM milled guide (in office)
- Bluesky Bio – Can export Dicom to STL file(fee)
  - Printed surgical guide (keyed)
- Anatomage – Can integrate STL file with Dicom (proprietary)
  - Milled surgical guide (keyed)
  - Export planned restoration as STL to mill abutments
- OnDemand3D – Merges STL (from stone model) and Dicom
  - 3D-printed surgical guide (in lab)





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What's here to stay?

- Digital impressions have arrived
  - Accurate, easy to use, widely accepted by labs
  - Several competing systems will continue to drive price down
  - All foreseeable advances in fabrication will require a digital image
- CAD/CAM technology is the state of the industry, but requires heavy investment
  - Already replaces many technicians, chairside and lab-side
  - Trend towards fewer, larger milling centers replacing small labs
  - Pendulum may swing back toward local technicians designing and customizing restorations

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What's here to stay?

- 3D Printing has exciting applications
  - Cannot replace CAD/CAM or hand-fabrication yet for restorative dentistry
  - Likely will push out milling in the next 10 years
- CBCT is becoming the standard of care for implant planning
  - Very accurate for implant placement, but not enough for fabricating permanent restorations
  - Guides and Navigation are constantly improving

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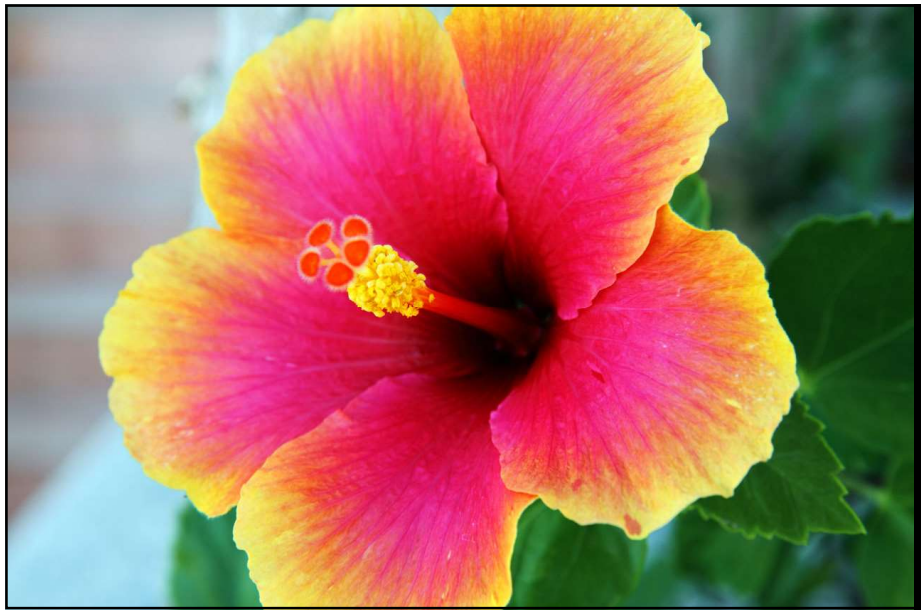

Mahalo!

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