

**UiT**

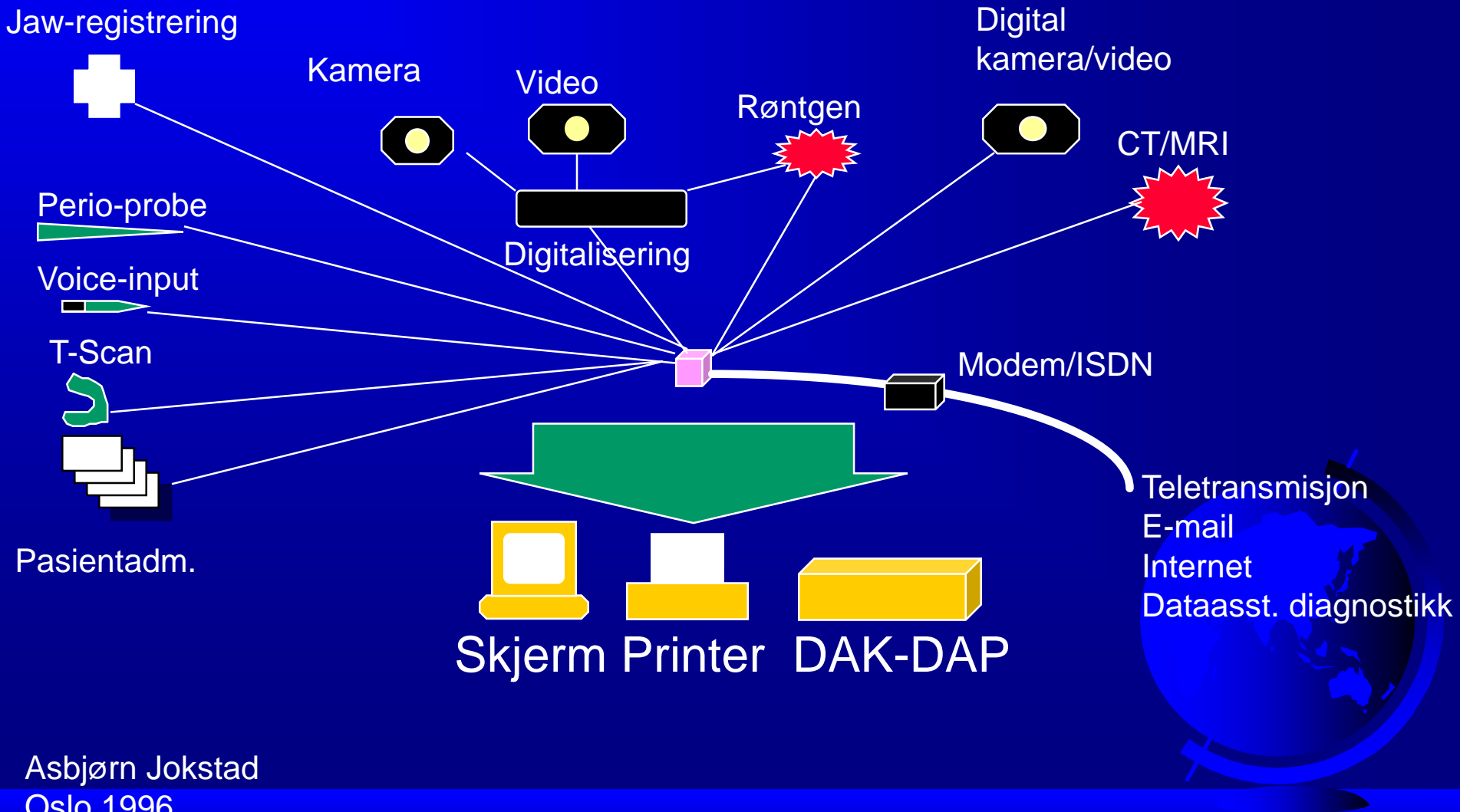
**NORGES  
ARKTISKE  
UNIVERSITET**

# Oral protetikk-terapi Bruk av nye digital teknologier

*Asbjørn Jokstad  
UiT Norges arktiske universitet  
asbjorn.jokstad@uit.no*



# Mikroprosessoren i tannklinikken



# Datamaskin kapasitet I 1996

The clock rate is the frequency of the clock in any synchronous circuit, such as a central processing unit (CPU)

Klokkehastighet(MHz)

<1	1971	Intel 4004 / Texas Instrument TMS100
1	1974	Motorola / Intel8008 / ZilogZ80 <u>8bit.Cp/M</u> (Commodore 64, Apple II)
4.77	1976/8	Intel 8086 <u>16bit</u> ; (Compaq, IBM PC) / Intel 8088 (IBM (1981))
8	1978	Motorola 68000 (Macintosh128k, Amiga1000)
6 – 25	1982-85	Intel 80286 / <u>DOS(1981)</u> / IBM-AT (1984)
12 – 40	1985-90	Intel 80386 / <u>32bit</u> ; Motorola 68040 (Macintosh, Amiga, NeXT))
20 – 100	1989-94	Intel i486; Cyrix
	1993-95	Intel Pentium / Pentium MMX → Pentium Pro
110	1994	IBM PowerPC 601 / Power Macintosh 8100



From  
← Minicomputers to PC →



From: [www.old-computers.com/museum](http://www.old-computers.com/museum)

# Datamaskin kapasitet i 1996 og innovasjoner i digitale teknologier innen odontologi

## Klokkehastighet(MHz)

<1 1971 Intel4004/ Texas Instrument TMS100

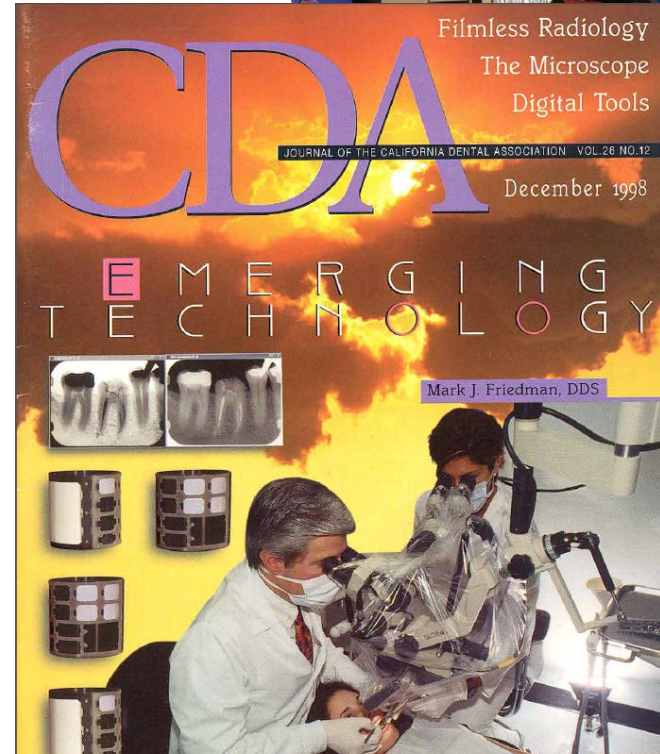
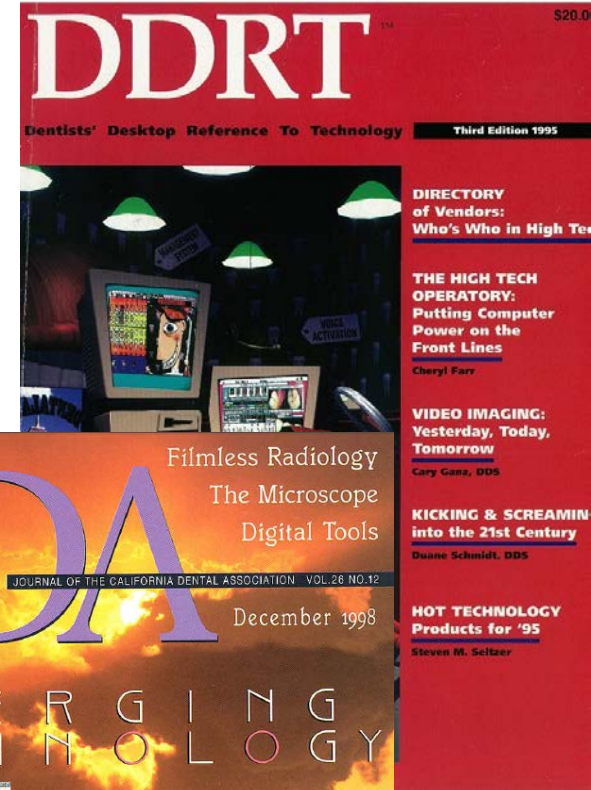
...

...

...

...

110 1994 IBM PowerPC 601 (Power Macintosh 8100)





# Digital teknologi-innovasjoner ~1996

ONCE YOU GET THE PICTURE... THE RESULTS ARE BEYOND WORDS.

1. All in one patient record - created with the D-Capture and Charting software - puts you at patient's fingertips. Includes patient information, medical conditions and full face photo ID.

2. A new picture taken with the INSIGHT I-SD Camera gives you the full picture without a bulky extender.

3. Starting with the right patient chart, obtain accurate video stills. We'll let patient record with the INSIGHT I-SD Camera and CAPTURE-IT software.

4. Using CHART-IT, you can quickly take cuts, redraws, re-orientations. Also, you can crop a ready-to-print image into a photograph by using corresponding video images.

5. All in one patient record - created with the D-Capture and Charting software - puts you at patient's fingertips. Includes patient information, medical conditions and full face photo ID.

6. CHART-IT I-SD software patient selection capability expands to all the procedures you're performing with you, directly to other needs.

7. Chapter 6 of the homepage software. IMAGE-IT provides all when an extra photo image you check the best decision together.

8. All left the early one setting - it's just that easy. Because you can compare your "old case" with INSIGHT I-SD software and CHART-IT software (with the new setting).

Take one patient through an exam with an INSIGHT system, and you'll understand how easily and naturally it fits into your practice. INSIGHT has refined the most advanced imaging technology into a total patient management system of unparalleled simplicity and capability. The only camera system with two lightweight handpieces - a 0° and 90° - eliminating the need to change lenses. Mobile cart-based and portable wall-mount networked systems make electronic patient files available to any team member, anywhere in the practice. With a PC and software for capture, charting

and imaging, you'll have seamless compatibility with almost all practice management software. Voice-activation and dozens of other features save critical time and energy. And special on-screen displays build confidence and enhance communication with your patients. Leaving you free to focus on one thing. *Dentistry Best* of all, INSIGHT can start small with an affordable video camera and printing system. Then simply add PC-based digital capabilities at any time to fit the needs of your practice. You've got the picture. Now get the details. Call 1 800 654-0200. **INSIGHT**  
It Takes Insight To Build A Better Practice



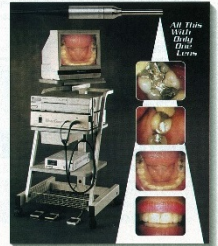
**"VistaCam VALUE - That's what you get from your DENTAL DEALER when you buy a VistaCam Intraoral Camera."**

Digitalt smil

Digitalt intraoral kamera

...more than making out the check. As your full service networking needs and aftersales support, I call it

...more than making out the check. As your full service networking needs and aftersales support, I call it



## Chairside patient education / communication

**PATIENT COMMUNICATION**

**Cyrano CD**      **ChairTime CD**

Dentistry's finest practice appreciation CD is enhancing Dr./Patient relations forever!

Dentistry's premier patient education CD guarantees more successful case presentations!

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- Standardizes your message - relieving staff for clinical support.
- Reduces the necessity to sell. Increases the opportunity to answer the questions that generate treatment plans.
- The most cost-effective multimedia delivery system available.
- Customized photography overlays (optional).
- Networks with all multiple operator configurations.
- Audio output to telephone-on-hold is ideal for added value. (No additional charge)

Created by dentistry's most "in touch" multimedia developer.

- Your patient's "moment of decision" deserves ChairTime CD - worthy of their trust in you.
- Unmatched 3-D graphics and dentistry's best selection of cosmetic before/after.
- Your best "return-on-investment" interactive CD product - guaranteed.
- Will network with all multi-operator configurations - computer and video.
- Illustrates and explains your most challenging clinical concepts and treatment options.
- 5 disc CD changer and our technical assistance helps you build your own custom CD library.

Sealants Form a Protective Barrier

**INTERVISION**  
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*The Patient Education System that gets results.*

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"The MultiMedia System paid for itself in just two weeks." Stuart L. Graves, D.D.S., M.S.

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Every Practice Can Benefit From An Intraoral Camera...

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Rated No. 1 By The Nation's LEADING INDEPENDENT DENTAL RESEARCH INSTITUTIONS  
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Digitalt radiografi

### Trophy Makes The Products. You Make The Decision.

**EVEREST™ RVG-STV**

- Interfaces with RVG and most major practice management software.
- Plug into standard PC.
- Save images on hard disk drive.
- Operates as a standalone system or on a computer network.

**Filmless Digital X-Ray (RVG)**

- Replaces the most recent digital x-rays.
- Low radiation. High definition sensor takes full periapical & bitewing.
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**IRIX-70 X-Rays**

- Only a x-ray designed to work with RVG.
- 18 month prorated warranty.
- 25% lower radiation than conventional aluminum.
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Trophy Radiology develops and markets intraoral cameras, filmless digital x-ray systems and traditional intraoral x-rays. In fact, Trophy is the world leader in sales of both filmless digital x-ray systems (over 12,000 sold) and intraoral x-rays. You can purchase our products separately or you can combine them into the most powerful digital imaging system available today...EVEREST™. It's up to you.

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**trophy**  
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**800-642-1246**

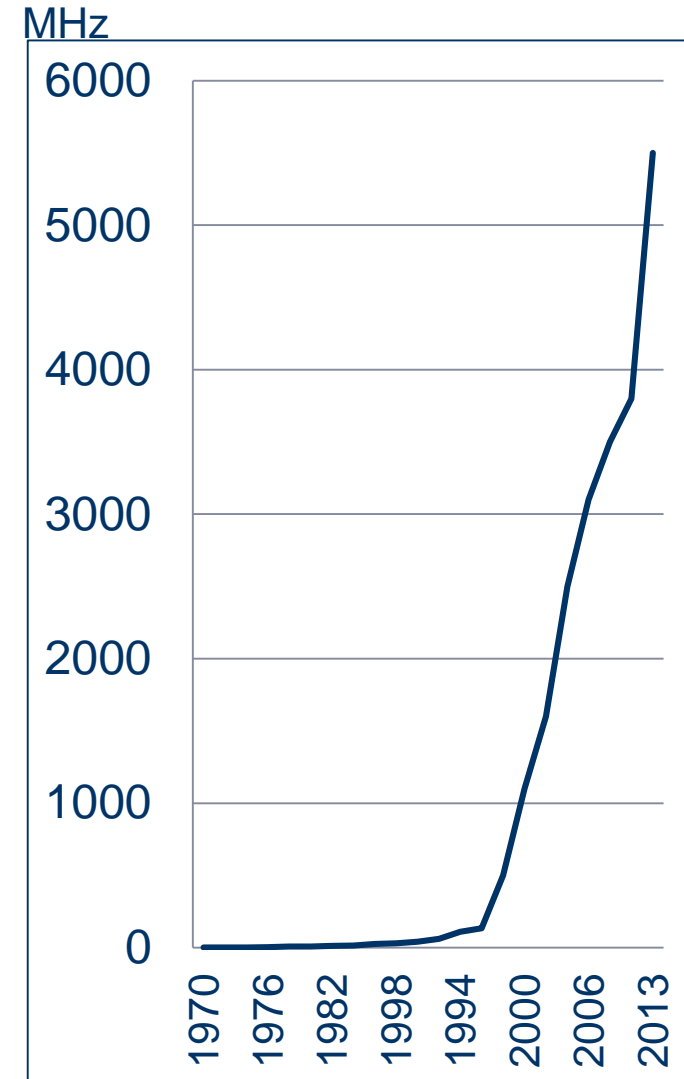


# Datamaskin kapasitet i dag

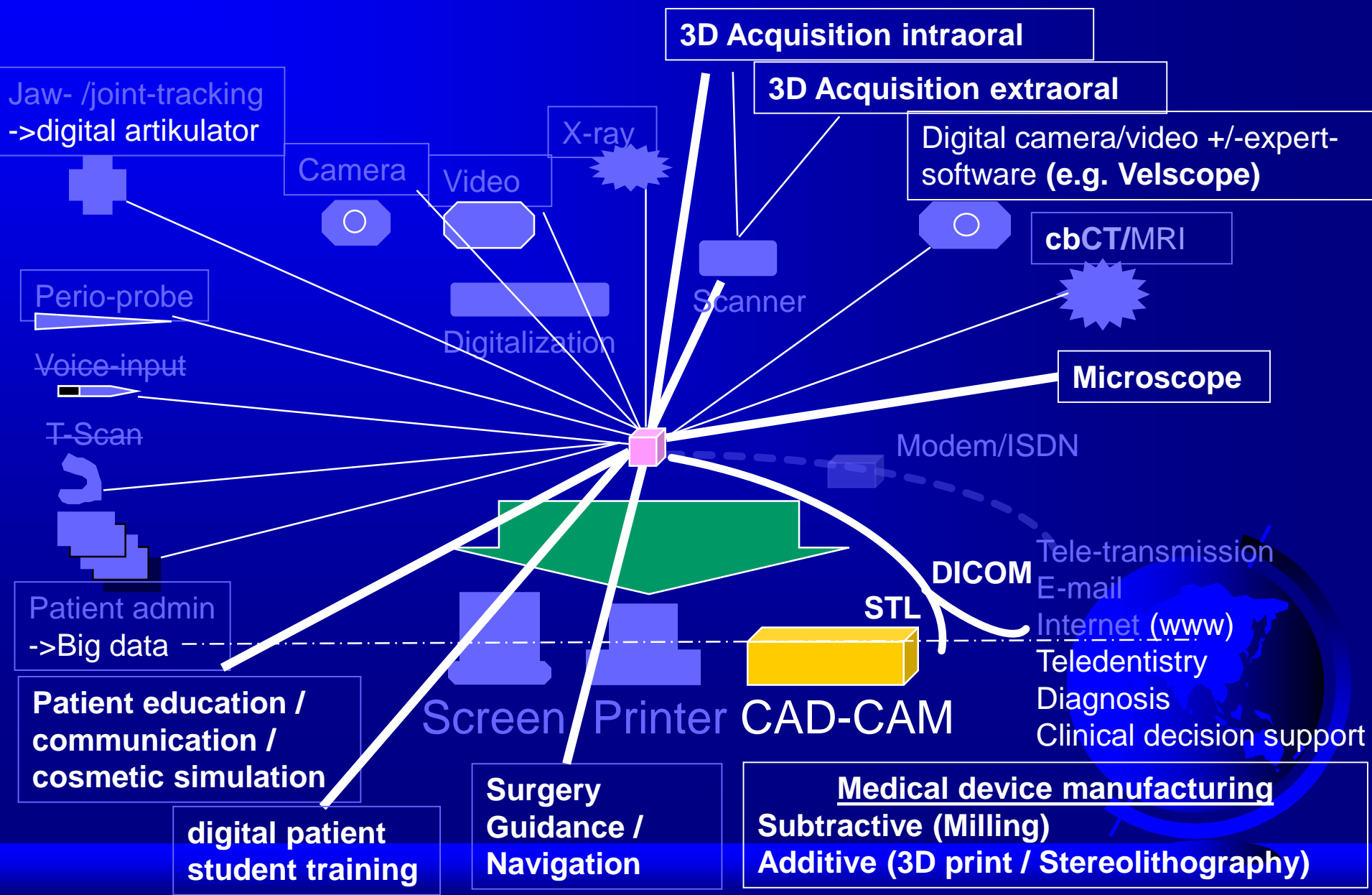
**Different benchmarking tests provide different performance indicator**

Clock rate is no longer considered as a reliable benchmark since there are different instruction set architectures & different microarchitectures – “MIPS” is more common)

<1	1971	<u>4 bit</u>
	1974	<u>8bit</u>
4.77	1976	<u>16bit</u>
12 – 40	1985	<u>32bit</u>
20 – 100	1989-94	→ Pentium Pro
110	1994	IBM PowerPC 601 / Power Macintosh 8100
.....		
500	1997	IBM PowerPC 750 (iMac)
1400	2002	Intel Pentium III (Celeron/Zeon)
3000	2001	IBM PowerPC950 (PowerPC G5)
3800	2001	Intel Pentium 4 (Pentium M/D)
3000	2003	AMD Athlon <u>64bit</u>
3200	2005	AMD Athlon <u>64bit X2</u>
.....		
5500	2013	IBM zEC12



# Computer-assisted technologies in dentistry







# Digital Electron Microscopes life range



# Moore's law & digital tooth shade acquisition

Chromacan (Sterngold)

Castor (Nordmeditech)



ShadeEye (Shofu) EX → NCC

Dental Color Analyzer (Wolf)

SpectraScan (PhotoResearch)

DigitalShadeGuide DSG4 (A.Rieth)

dcm-ikam (DigitalcolorMeasurement)

ShadeScan (Cynovad)

ClearMatch (Clarity → Smart Technology)

ShadeScanSystem (Cortex Machina)

ShadeVision (X-rite) → Shade-Rite → Colortron II → Shade-X

iKam (Metalor)

Spectroshade (MHT) → SpectroshadeMicro

EasyShade (VITA) → EasyshadeCompact → EasyshadeAdvance

iDentacolor II (iDenta)

ShadePilot (Degudent)

CrystalEye (Olympus)

BeyondInsight (BeyondDental)

ShadeWave

ZfX Shade (ZfX)

MOORE'S LOV RULER!

1990

1995

2000

2005

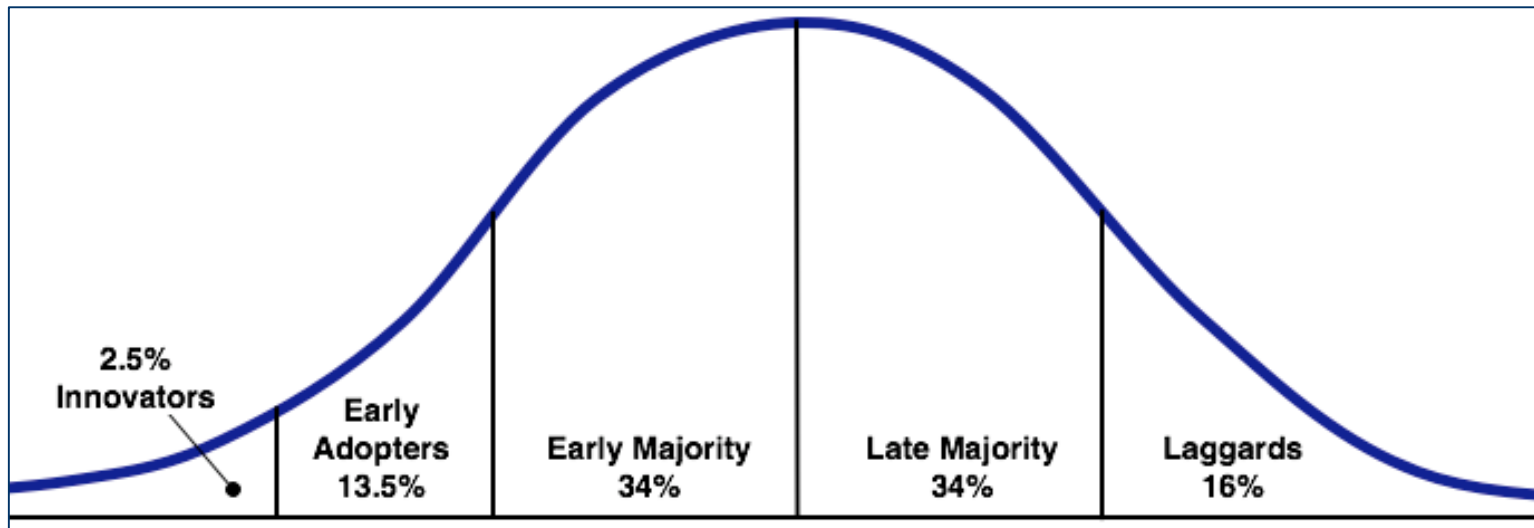
2010

2015



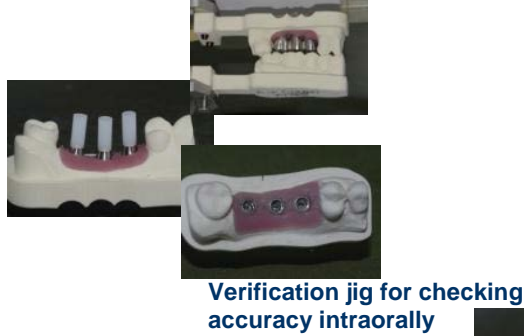
# The diffusion of innovations

- People have different levels of readiness for adopting new innovations
- The characteristics of a product affect overall adoption
- Individuals can be classified into five groups\*

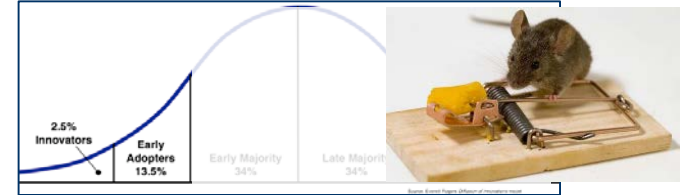
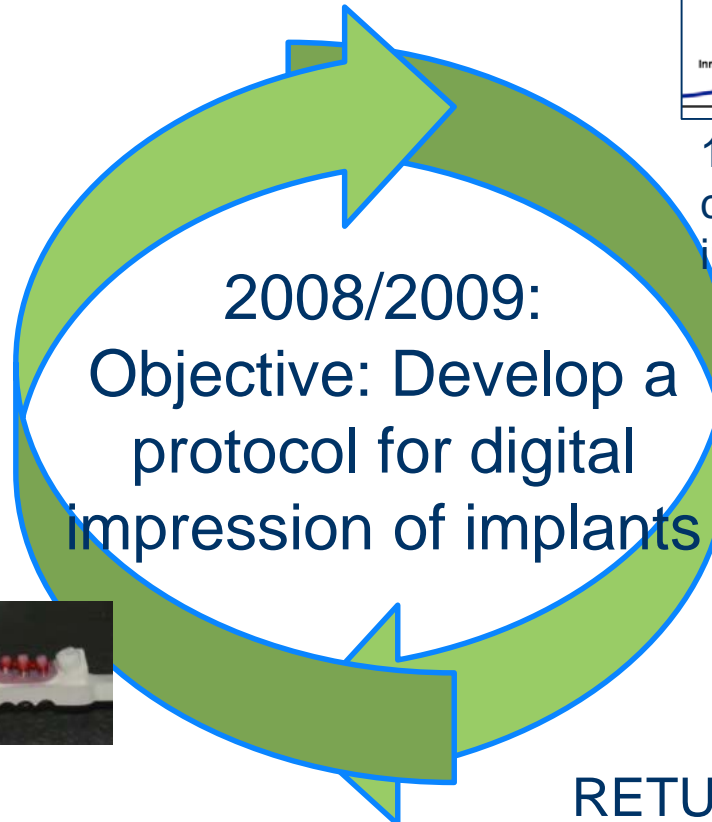


\*according to Everett Rogers (1962)

# Are the early adopters like the first mouse that try to eat the cheese in the trap? -1



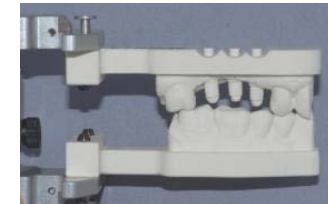
Lab.photos: S Bilko LHM, Toronto



1<sup>st</sup> generation two-piece impression copings (PEEK) for digital impressions of Straumann Implants



RETURNED: Polyurethane model – with no implant analogues!





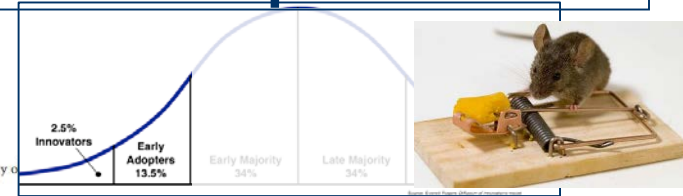
# Are the early adopters like the first mouse that try to eat the cheese in the trap? -2

CLINICAL ORAL IMPLANTS RESEARCH 2015

*Eszter Somogyi-Ganss  
Howard I. Holmes  
Asbjørn Jokstad*

## Accuracy of a novel prototype dynamic computer-assisted surgery system

Somogyi-Ganss et al. Accuracy of



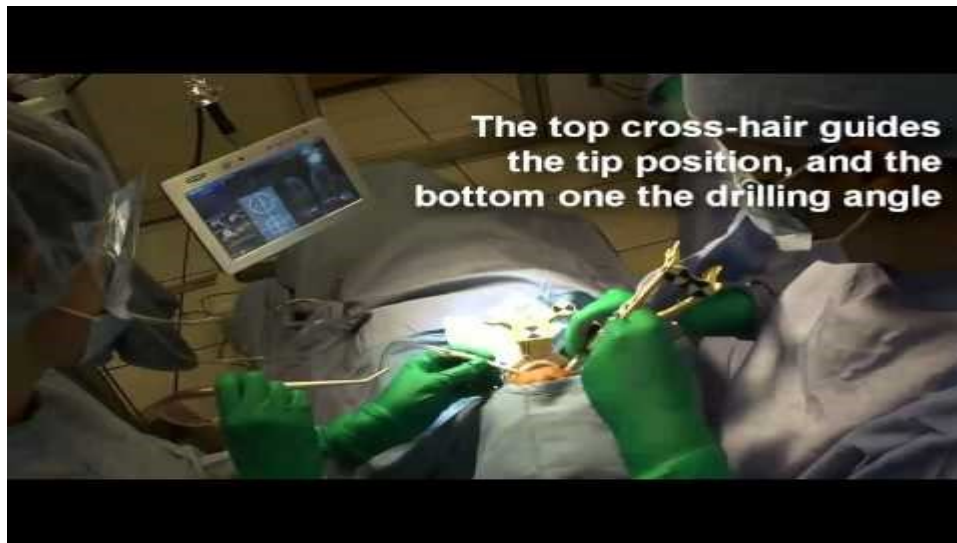
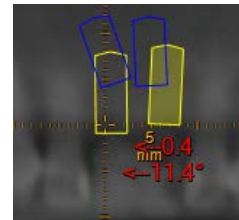
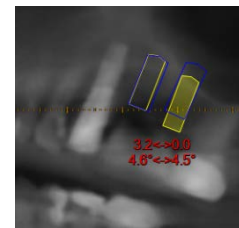
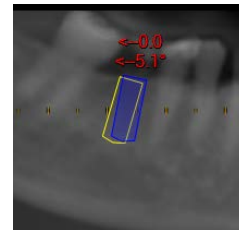
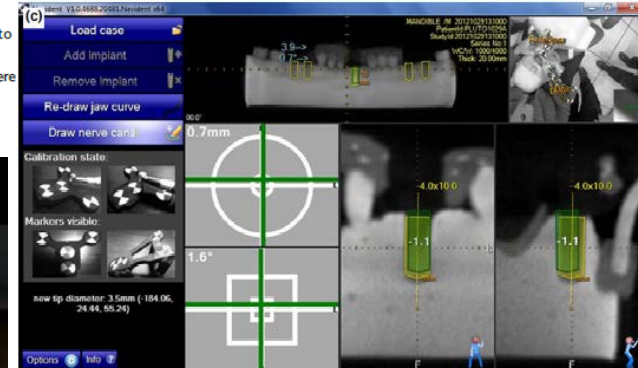
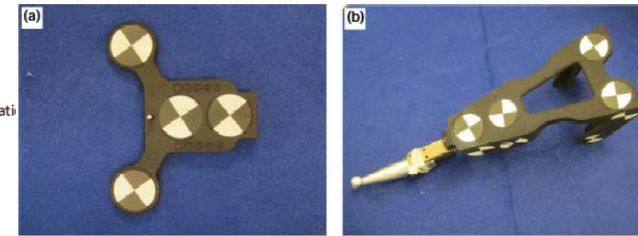
**Authors' affiliations:**  
Eszter Somogyi-Ganss, Discipline of Prosthodontics, Faculty of Dentistry, University of Toronto, Toronto, ON, Canada  
Howard I. Holmes, Discipline of Oral and Maxillofacial Surgery, Faculty of Dentistry, University of Toronto, Toronto, ON, Canada  
Asbjørn Jokstad, Discipline of Prosthodontics, Faculty of Dentistry, University of Toronto, Toronto, ON, Canada  
Faculty of Health Sciences, UiT The Arctic University of Norway, Tromsø, Norway

**Key words:** accuracy, computer aided, computer guided, dental implant, navigation, static guide, stereolithographic guide

**Abstract**

**Objectives:** To implement and evaluate the accuracy of a prototype dynamic computer-assisted surgery (CAS) system for implant osteotomy preparation and compare its accuracy vs. three commercial static CAS systems and the use of an acrylic stent.

**Material and methods:** Eight osteotomies were prepared in radiopaque partially edentulous mandible and maxilla typodonts. After cone-beam CT acquisition, DICOM files were imported into a prototype dynamic, and three static CAS systems (NobelClinician, Simplant, and CoDiagnostiX). Implant placements were planned to replicate the existing osteotomies and respective guides were



In-vitro accuracy  $\neq$  in-vivo accuracy

# Dynamic Navigation market 2017: 10 products



Launched Sep 19, 2017



ROBOT-ASSISTED  
DENTAL IMPLANT  
SURGERY IS HERE

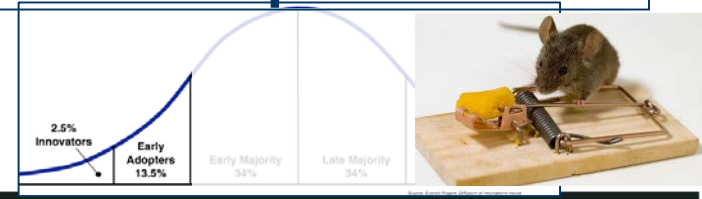
Yomi® provides an unprecedented level of precision and control.

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or inquiries,  
click here

**YOMI**<sup>®</sup>  
Robot-Assisted Dental Surgery  
*Precisely Where You Want To Be*

See Yomi in  
action

# Are the early adopters like the first mouse that try to eat the cheese in the trap? -3



CLINICAL ORAL IMPLANTS RESEARCH 2015

Perforated PMMA stent on original stone model → Intraoral scan (iTero) → STL-file  
 + Desktop scan (D810, 3Shape) of a cleaned FDP → STL-file



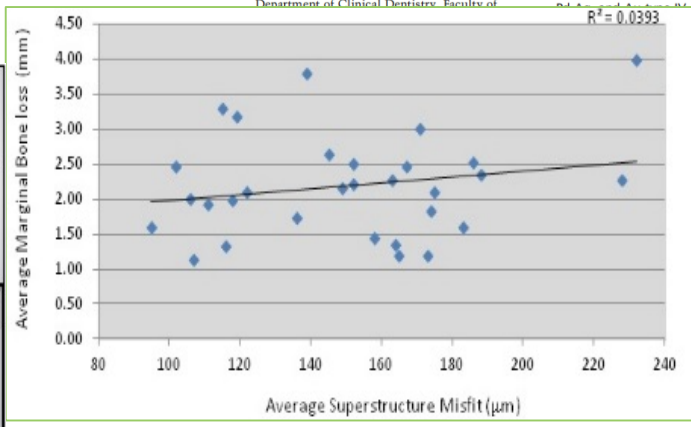
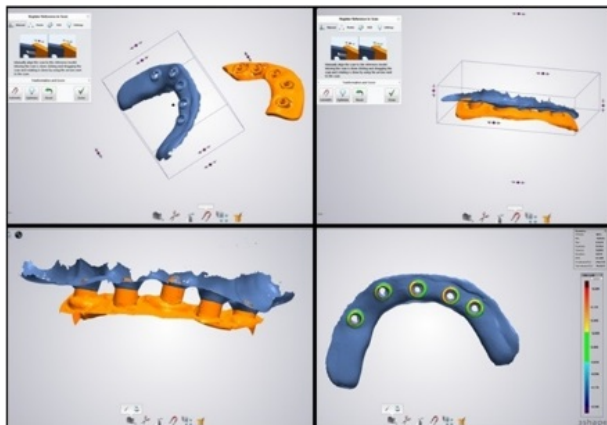
Asbjørn Jokstad  
 Babak Shokati

New 3D technologies applied to assess the long-term clinical effects of misfit of the full jaw fixed prosthesis on dental implants

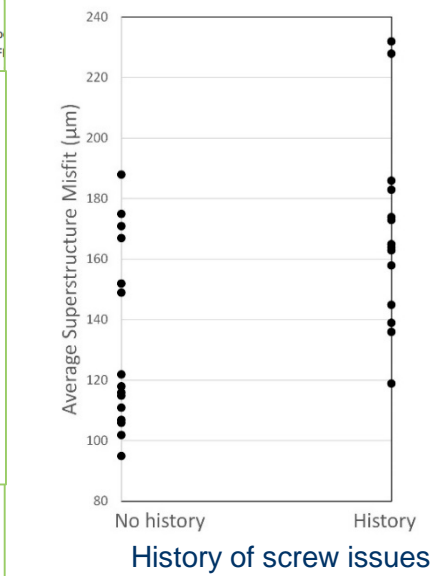
= STL-files compared by use of an industrial metrological software (Convince Premium, 3Shape)

**Authors' affiliations:**  
 Asbjørn Jokstad, Faculty of Dentistry, Discipline of Prosthodontics, University of Toronto, Toronto, ON, Canada  
 Asbjørn Jokstad, Faculty of Health Sciences, UiT The Arctic University of Norway, Tromsø, Norway  
 Babak Shokati, Faculty of Dentistry, Discipline of Prosthodontics, University of Toronto, Toronto, ON, Canada  
**Corresponding author:**  
 Asbjørn Jokstad  
 Department of Clinical Dentistry, Faculty of

**Key words:** 3D measurement, 3D scanner, intra-oral digital optical impression  
**Abstract**  
**Objectives:** To assess implant-suprastructure misfit in patients with an edentulous jaw restored by an implant-retained fixed dental prosthesis (FDP) and its association with biologic and mechanical adverse events over an extensive period.  
**Material and methods:** supported prosthetics b 6 implants to retain a F



FDPs 12-32 years (mean 19 yrs)



History of screw issues



# Current computer- aided/-assisted tools and concepts in prosthodontics

## Patient administration

Electronic charting → “Big data”

## Education

Student learning / assessment

## Patient management

Detect/diagnose pathology

Radiography / tomography

Jaw-/TMJ-joint-tracking → “digital artikulator”

Decision support system (AKA expert system)

Treatment (surgery) planning

Surgery guidance (dynamic /static)

## Patient communication

Visualization of procedures

digital treatment outcome

## Medical device\* production

Shade-matching

Designing “CAD”

Manufacturing “CAM”

\*Intra- / Extra- -oral / -tissue /-tooth or interface constituents

Tissue-engineering constructs

## Other applications

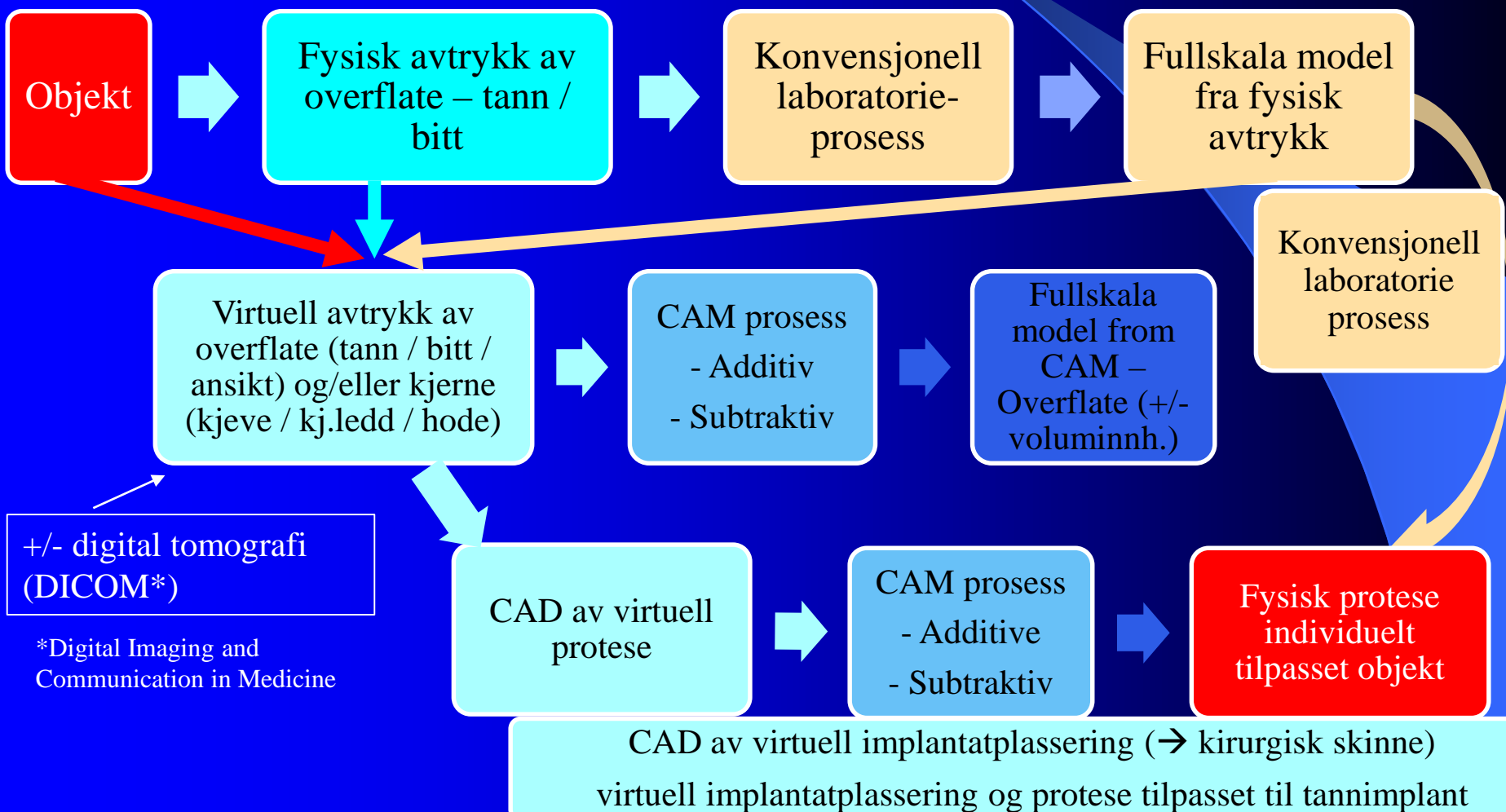
Quality assurance “Registration”

Tele-dentistry

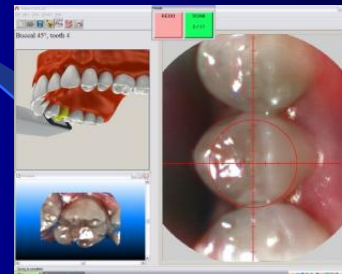
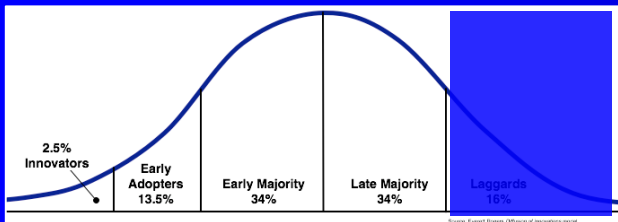


# Nye data-assisterte additive / subtraktive produksjonsmetoder siden ~2016

## Alternative produksjonsmetoder av orale proteser



# Nye data-assisterte additive / subtraktive produksjonsmetoder siden ~2016



**Produksjon-  
prosessen**

**Overflate /  
volumgjenkjenning**

Teknologi

Registrering

Data eksport format(er)

Scan gjenstander

**Innovasjoner i  
CAD-CAM  
teknologier**

**Produksjon  
programvare**

**Konstruksjon-  
programvare**

# Intraoral overflats scanning før 2010



CEREC  
BlueCam

Laser Triangulation  
Confocal lys

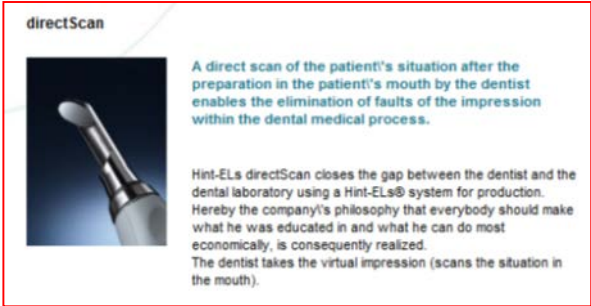


LAVA COS  
(2008)

Per 2010;  
4 produkter  
(+E4D)



Cadent Itero  
(2006)



Hint-ELs (2009)

# Intraoral overflute-scanning

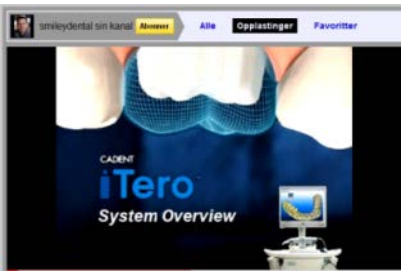
2010/2011:  
4 Nye produkter



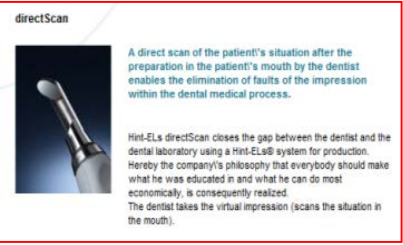
CEREC  
Bluecam



LAVA COS



Cadent Itero



Hint-Els



Densys3D: MIA3d



Intellidenta/ Clon3D: IODIS



MHT: Cyrtina/3DProgress



3Shape: TRIOS /(Dentaswiss)



# Intraoral overflatscanning

2012:  
3 nye produkter



## Zfks / Intrascan

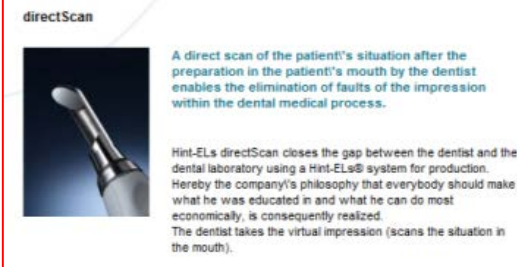
BLUESCAN-I INTRAORAL 3D SCANNER



## Bluescan / a.tron3D



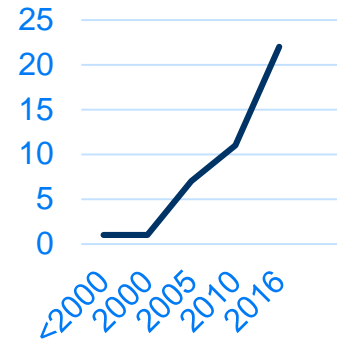
## IOS: Fastscan



# Intraoral surface scanning

2017: 22 products+

Product name	Manufacturer	Refs
3D Progress MHT	MHT (Medical High Technologies, Italy / Switzerland)	#
Aadva IOS ← Bluescan-I ← a.tron 3D	GC, Belgium ← 2016 a.tron 3D, Klagenfurt, Austria	0
Apollo DI	Sirona Dental Systems, Germany	#
CEREC OmniCam / BlueCam	Sirona Dental Systems, Germany	2
Condor	Condor International, Belgium	0
CS3500 / CS3600	Carestream Dental, USA	0
Dentium rainbow iOS	Dentium, Korea	0
Detection Eye	Zirkonzahn, Italy	0
directScan	Hint-Els, Germany	0
DWIO ← DiglImprint Steinbichler	Dental Wings, Canada ← 2013 Steinbichler	#
IntraScan Zfx	zfx, Germany	0
i/s/canoral	Goldquadrat, Germany	0
IOS Fastscan	Glidewell Laboratories, USA ← 2015 IOS technologies, USA	0
Itero Element / Itero	Align Technology, USA ← 2011 Cadent, Israel	3
KaVo Lythos	KaVo, Germany ← 2015 Ormco Corp.	0
MIA3D	Densys, Israel	0
Organical Scan Oral	R+K CAD/CAM Technologie, Germany	0
PlanScan ← E4D	PlanMeca, Finland ← 2015 E4D Tech, USA	1
Progress IODIS	Clon 3D / IODIS / Intellidenta (USA?)	0
TRIOS 3 / TRIOS Color / Standard	3Shape, Denmark	3
True Definition Scanner ← Lava COS (Chairside Oral Scanner)	3M ESPE, USA ← 2006 Brontes Technology	4



**MOORE'S  
LOV  
RULER!**



# Overflate/volum gjenkjenning - parametre

## Teknologi

### Overflate:

mekanisk-elektrisk  
+/-laser-justert

optisk-struktur lys

optisk-laser/video

optisk-laser-  
triangulering/konfokal

optisk konoskopisk  
holografi

### Volumetrisk:

Radio- tomografi

Magnetisk res. tomo.

Optisk koh. tomo.

Ultralyd tomografi

## Registrering

Intraoral

Ekstraoral

Intra-& ekstraoral

### **Scan eksport format**

“Åpne system” format

Lukkede systemer

## Scan gjenstander

Antagonist

Bittregistrering

Tannmodell

Fullkjeve

Implantatdistanse

Model

Proteser

Oppvoksning

Refleks/opasitet

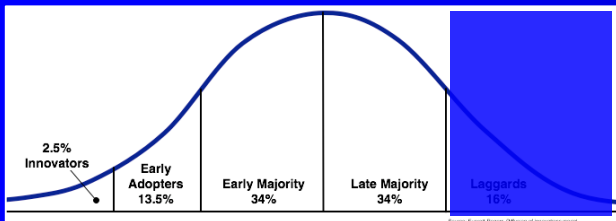
Overflatebehandling

Overflatesjikt

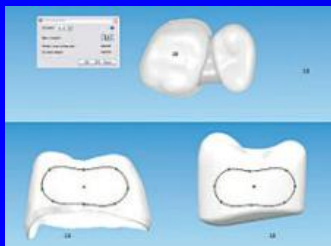


Unntatt DICOM\*, finnes ikke ISO-standarder  
spesifikt til tannpleie

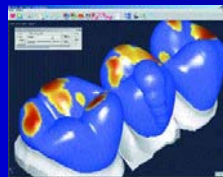
# Innovasjoner i data-assisterte additive / Subtraktive produksjonsmetoder siden ~2016



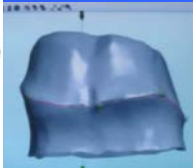
**Produksjon-  
prosessen**



**Produksjons-programvare**  
Data import/eksport formater / -  
formattering  
Produksjon-applikasjoner



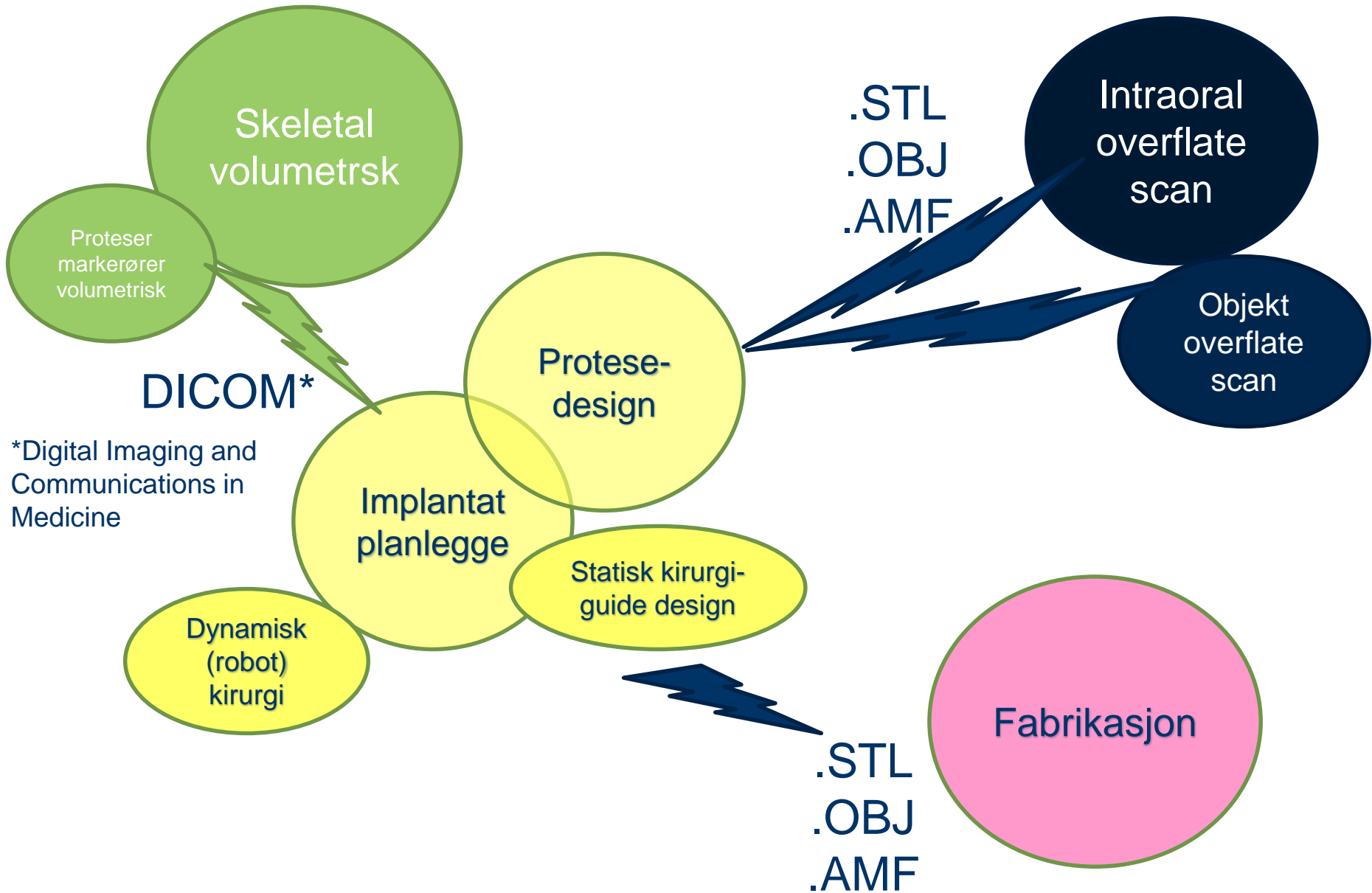
**Overflate- / volum  
gjenkjenning**



**Konstruksjon- programvare**  
Data import/eksport  
formater / formattering  
utforming applikasjoner



# Data / fil / system -formater



\*Digital Imaging and Communications in Medicine

# Åpne (data- / fil-) formatter (“frie filformater”)

---

## .STL (Standard Tessellation Language)

- a format native to stereolithography and supported by several software packages; it is widely used for rapid prototyping and computer-aided production
- describes only the surface geometry of a three dimensional object with no representation of color, texture or other common CAD model attributes
- describes a raw unstructured triangulated surface by the unit normal and vertices of the triangles using a three-dimensional Cartesian coordinate system

## .OBJ (Object files)

- include surface texture/color, was developed originally for 3D graphics animation applications

## .AMF (Additive Produksjon File)

- describe color, materials, lattices, and constellations of objects for additive production processes (e.g., acellular scaffold production by printing)

# Konstruksjon / Produksjon programvare - Parametre

## Import & eksport format(er)

Åpne system (.stl, .obj, .amf)

CAD-CAM pakkede (Lukkede)

## Top 3 O.S. markedsledere:

3shape 

exocad

 dental wings

## Applikasjoner

Oppvoksning / temporær  
Inlay / Onlay

Single-enhet coping

krone / monolitisk krone

3 → 16enhet / (4 → 7cm) bro

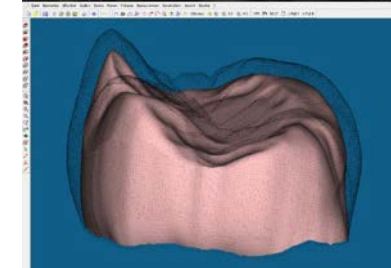
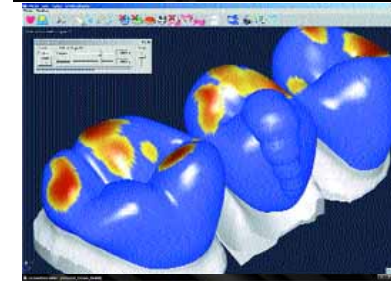
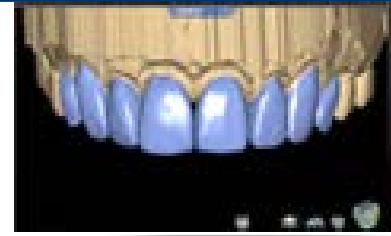
Avtakbar tannprotese (Partial / Full)

Implantat

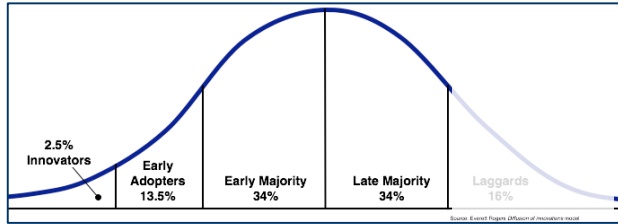
“customised” distanse

Implant-sup. meso-struktur

Implant-sup. super-struktur



# Innovasjoner i data-assisterte additive / Subtraktive produksjonsmetoder siden ~2016



## Produksjon-prosessen

Produksjon  
**Subtraktiv**

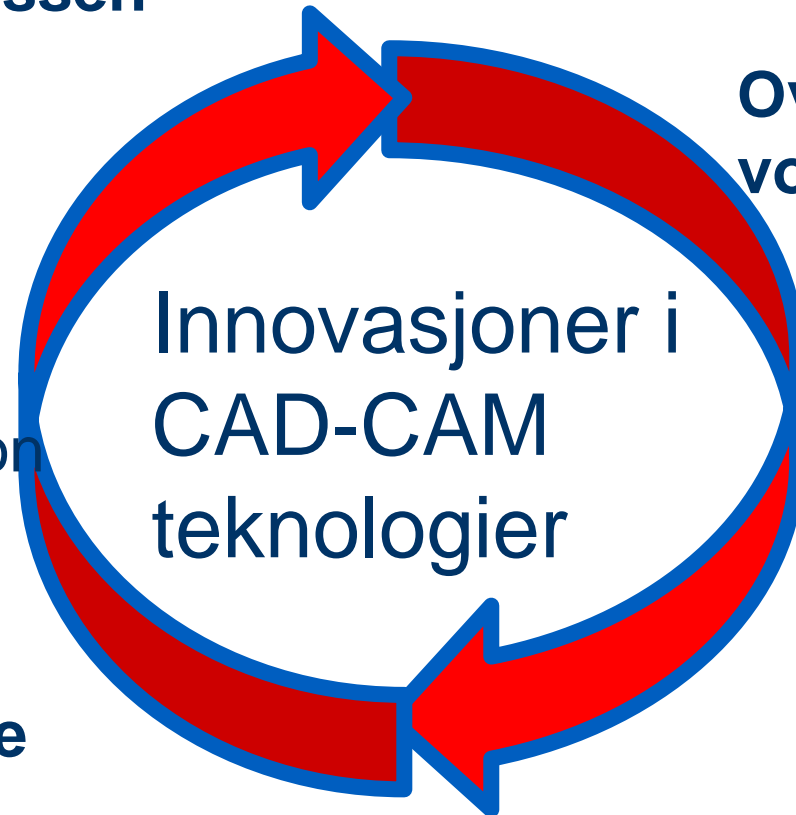
Additiv

Utstyr

Protese

Vevsrekonstruksjon

**Produksjon  
programvare**

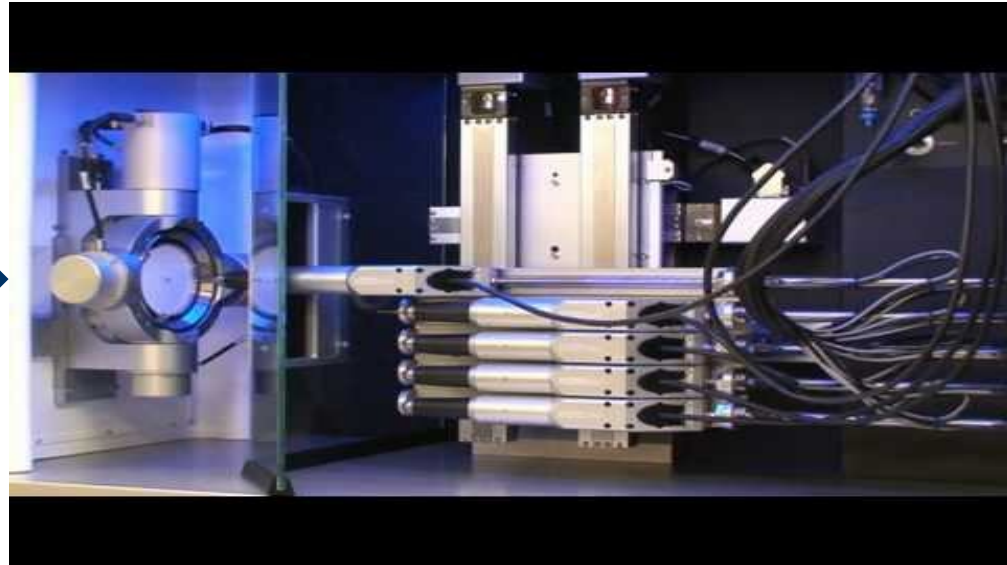


**Overflate- /  
volumgjennkjening**

**Konstruksjon  
-  
programvare**



# Fresing – Fra 3→5→5+5 akser

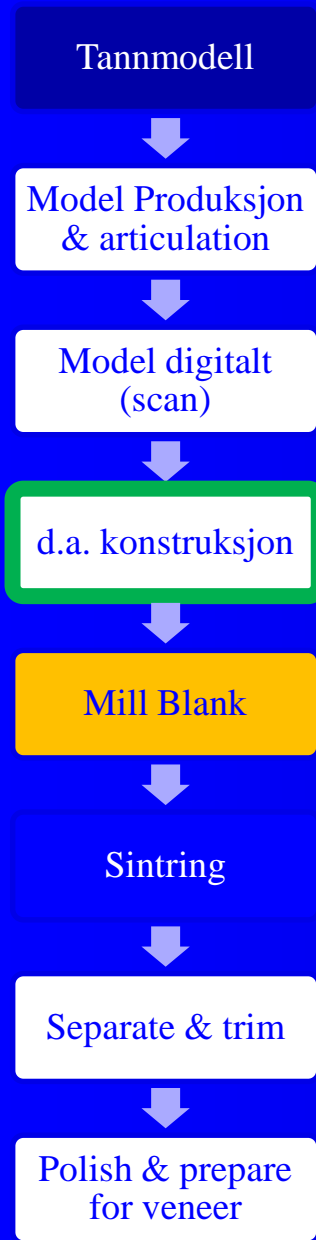


<https://youtu.be/vC7QDL0H-HA>



Fresemaskiner har endret seg fra manuelle til mekaniske til digitalt styrte vha s.k. computer numerical control (CNC). Styringen endrer f.eks, moment, vinkler, bevegelses-hastighet på objektet, valg av borhode, osv.

# Subtraktiv produksjon



MOORE'S LOV RULER!



Desktop size, e.g.	Mid-size	Heavy duty, e.g.
<u>Bien Air</u>	CEREC	Agie Charmilles
<u>Biolase</u>	Charlyrobot	Datron
Carestream	DentMaster	Dent-Tech
Ceramill	Dental Plus	DMG
CEREC	Lycodent	Dyamach
<u>Degudent</u>	<u>Roland Noritake</u>	iCM
Diasu	Rübeling	<u>Imes-Icore</u>
<u>Flussfisch</u>	Sisma	<u>Isel</u>
IOS	<u>Upcera</u>	LAVA
<u>KaVo</u>	VHF	<u>Mikron</u>
Kreos	<u>Wieland</u>	<u>Roland</u>
<u>Lyra</u>	Yena Dent	<u>Röders</u>
Reitel		<u>Sauer</u>
Planmeca		WilleminMacodel
Robocam		Wissner
Roland		Witech
ZirkonZahn		
Zubler		

# Produksjonsmetoder - parametre

## Additiv Produksjon

Laser sintering

Printing

## Subtraktiv Produksjon

3 / 3.5 / 4 / 5 / 6-aksis -fresing

med / uten

Sintrings-ovn

## Utstyr

In-/Onlays/Veneers

Single-enhet copings

krones

monolitisk krones

3 → 16enhet(/4 → 7cm)-FDPs

Implantatdistanses

Implantat bars / Meso-strukturs

(Endossous dental implants)

Surgical guidance stents

Partial / Full Removable Protese

Oppvoksnings / Provisionals / Splints

## materialer - restaurerende

Base alloys

Gold alloys

Non-precious alloys

Titanium / - alloys

Composite plast

Casting plast / Waks

Polymers (PEEK, PMMA)

*Hi/low-glass content keramer*

Feldspathic

Glass-keramer, e.g.,  $\text{Li}_2\text{Si}_2\text{O}_5$

In-Ceram (Porous Alumina)

*No glass content*

Alumina (sintered)

Zirconia (porous/green state)

Zirconia (pre-sintered state)

Zirconia (sintered)

Zirconia (sintered & HIP-ed state)



# Software algorithm compensation for errors introduced during milling processes

- Geometrical compensation
- Force compensation
- Thermal compensation
- Errors in the final dimensions of the machined part are determined by the accuracy with which the commanded tool trajectory is followed, combined with any deflections of the tool, parts/fixture, or machine caused by the cutting forces
- The effect of geometric errors in the machine structure is determined by the sophistication of the error compensation algorithms
- The cutting tools' trajectories are subject to performance of the axis drives and the quality of the control algorithms



torque  
feed-rate  
cooling



# Bor for dental (5 akset-) fresing



**Milling Bur 4 L**  
Used to mill pre-sintered zirconia (rough preliminary and internal milling)



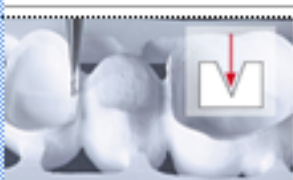
**Milling Bur 3 L**  
Used to mill pre-sintered zirconia (rough milling)



**Milling Bur 2 L**  
Used to mill pre-sintered zirconia (defined milling/precise milling)



**Milling Bur 1 L**  
Used to mill pre-sintered zirconia (precise milling)



**Milling Bur 0,5 S**  
Used to mill pre-sintered zirconia (high precision milling)



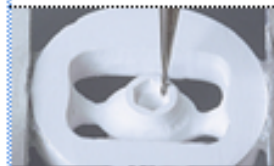
**Milling Bur 1 XXL**  
Used to mill pre-sintered zirconia (abutment)



**Milling Bur 2 A**  
Used to mill pre-sintered zirconia (abutment)



**Milling Bur 1,5 A**  
Used to mill pre-sintered zirconia (abutment)



**Milling Bur 0,6 A**  
Used to mill pre-sintered zirconia (abutment)



**Milling Bur 2W30**  
Used to mill screw seats



**Milling Bur 3 C**  
Used to mill pre-sintered zirconia (2° coned flank)



**Milling-Bur-1-XL**  
Used to mill pre-sintered zirconia (precise milling of deep)



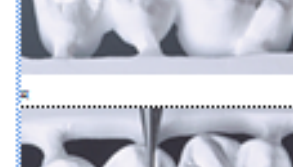
**Milling-Bur-3-U**  
Used to mill pre-sintered zirconia (undercut)



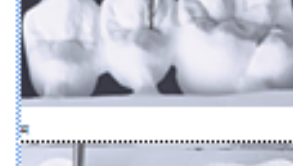
**Milling-Bur-2-U**  
Used to mill pre-sintered zirconia (undercut)



**Round-Head-Bur-2-K**  
Rapid and easy smoothing of surfaces and undercuts



**Milling-Bur-0,3-C**  
Used to mill occlusal fissures



**Milling-Bur-2-UR**  
Used to mill undercuts



**Milling-Bur-2,5-UR**  
Used to mill undercuts



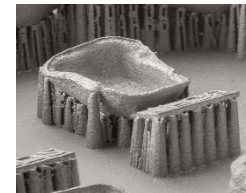
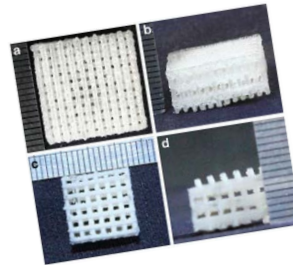
# Additiv produksjon - teknologier

Mange betegnelser: 3D printing / Additive (freeform) manufacturing / Layered manufacturing / Rapid prototyping, etc.

Solid friform Produksjon(SFF)\*  
Stereolitografi (SLA)  
Powder-fusion printing (PFP)  
Bioprinting (Laser/Inkjet/Extrusion)

Vevsrekonstruksjon  
Anisotropic matriser  
Presisjon-matriser  
Stive matriser  
Celle-infusert matrise

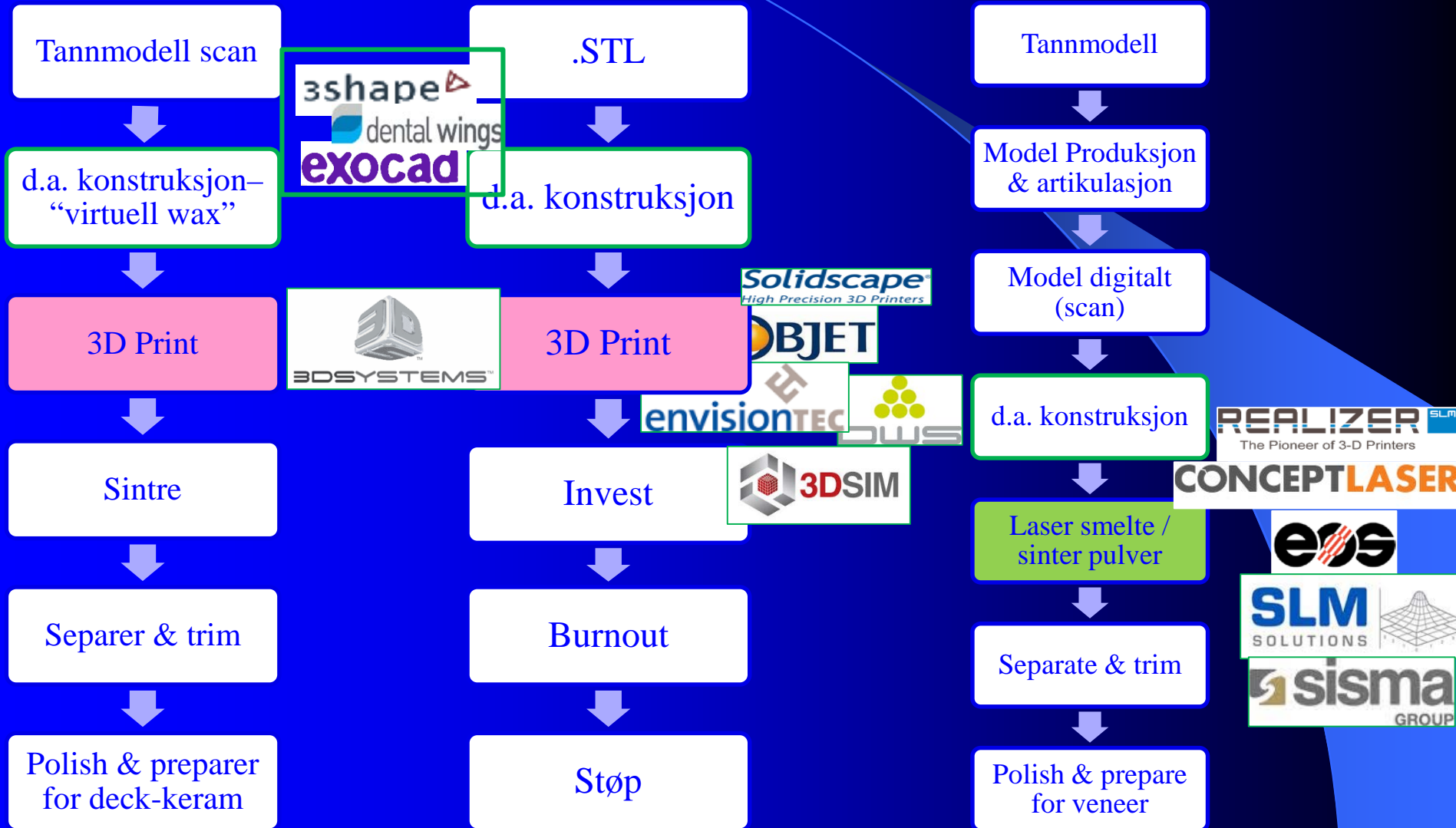
Oral protetikk  
I utstrakt bruk  
Semi-permanent  
Eksperimentelt  
Bløtvev



Introdusert på åtti-tallet som *rapid prototyping* for å lage prototyper av deler uten å investere tid og penger i nye maskiner.

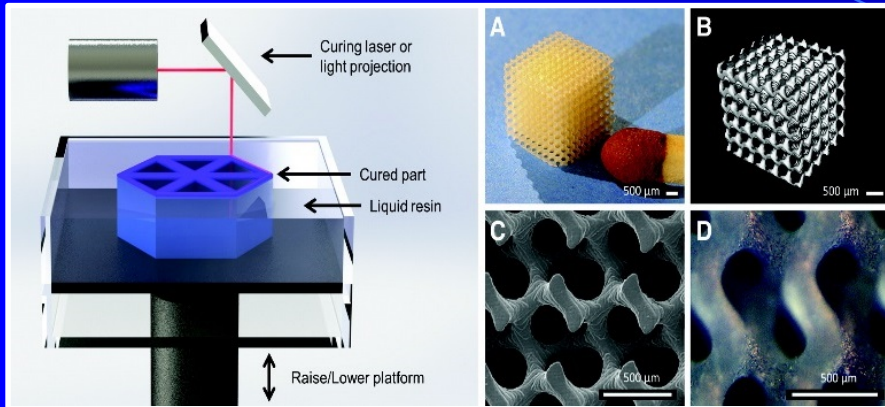
\*"Fused deposition modelling", "Laminated object modelling", "Direct Metal Printing", "Selective laser sintering", "Solid ground curing", "Robocasting"

# Additiv produksjon - teknologier



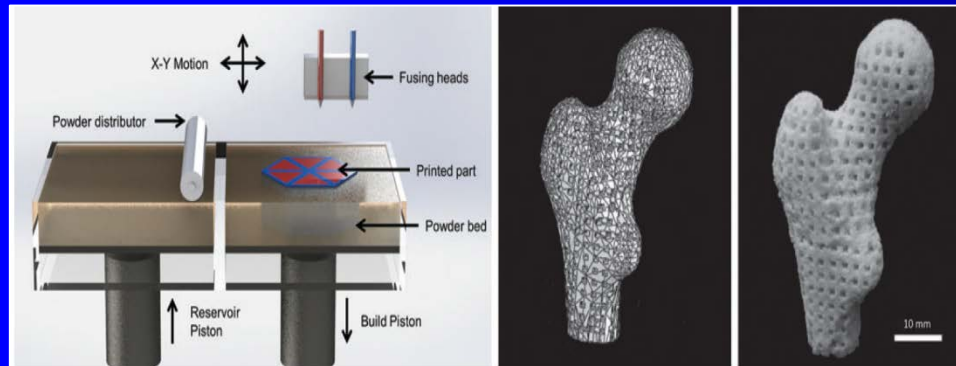
# Additive Produksjoner i vevsoppbygging\*

\*Tissue Engineering



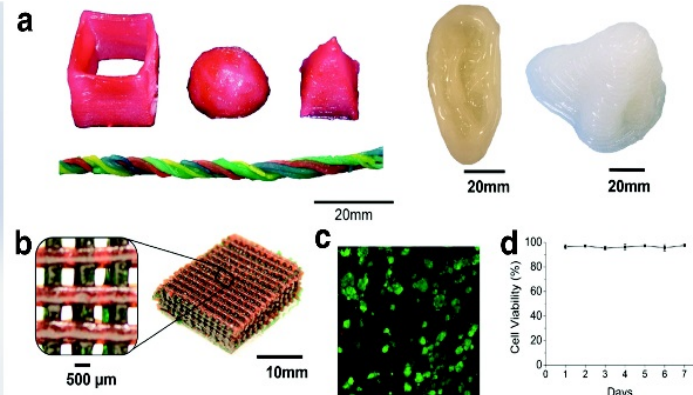
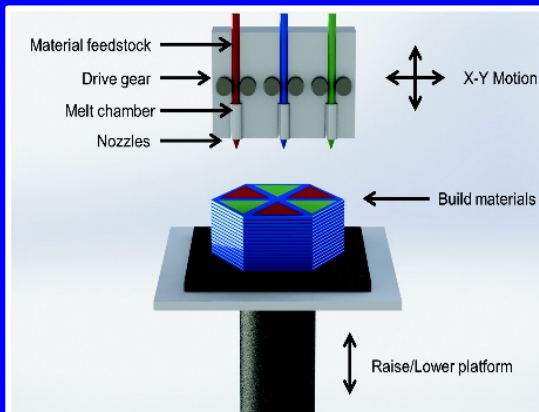
## Stereolitografisk printing teknikk

Eksempel på vevsoppbyggingsmatrise bestående av poly(d-l lactic acid)



## Powder-fusion printing teknikk

Eksempel på vevsoppbyggingsmatrise bestående av calcium fosfat–poly(hydroksybutyrat-kohydroksyvalerat,



## Solid friform Produksjon

Eksempel på vevsoppbyggingsmatrise bestående av poly(etylen glycol) diakrylat, nanosilikater, og alginat

Fra: Sears ea. *Tissue Engineering*, 2015



# Stereolitografi

- Metoden og apparater fremstiller solide objekter ved å lagvis “trykke” tynne sjikt i et UV-polymeriserende material lag på lag.
- Den konsentrerte UV-lys-strålen fokuserer på overflaten i et kar fylt med flytende fotopolymer. Lysstrålene tegner objektet på overflaten for å forme objektet som deretter senkes ett hakk ned for deretter å gjenta prosessen
- Objektet må renses grundig etterpå, noe som er tidkrevende

Kirurgiske guider for  
implantater



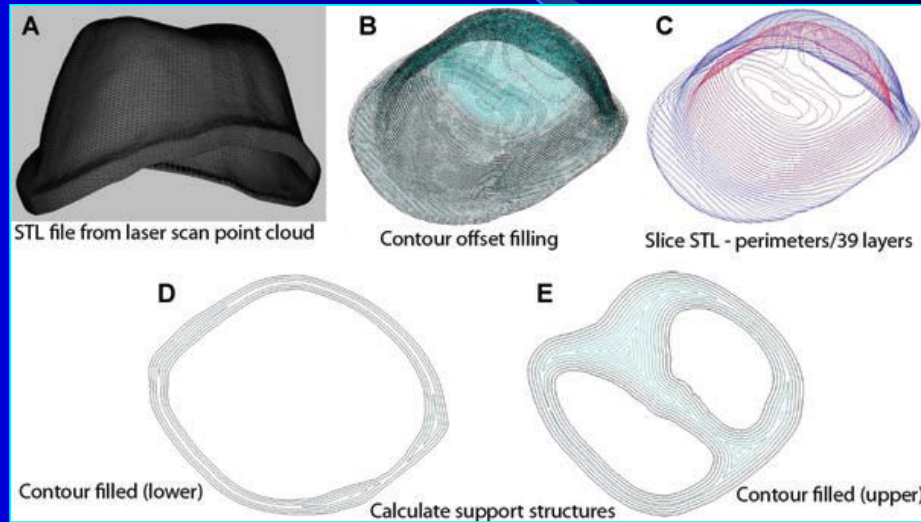
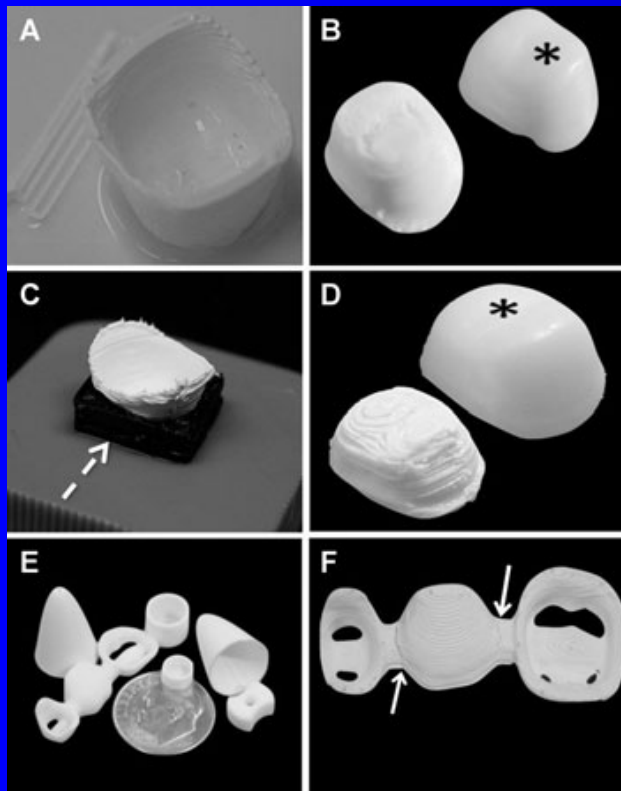
Simplantat Surgiguide



Nobelguide

# Powder-fusion printing

- Et material er deponert ved rom-temperatur i form av en flytende del eller keramisk “suppe” -- Materialet blir deretter herdet etter deponeringen



Also:

## RESEARCH REPORTS

Biomaterials & Bioengineering

J. Ebert<sup>1</sup>, E. Özkol<sup>1</sup>, A. Zeichner<sup>1</sup>,  
K. Uibel<sup>1,2</sup>, Ö. Weiss<sup>3</sup>, U. Koops<sup>3,4</sup>,  
R. Telle<sup>1</sup>, and H. Fischer<sup>5\*</sup>

<sup>1</sup>Department of Ceramics and Refractory Materials, RWTH Aachen University, Mauerstrasse 5, 52064 Aachen, Germany; <sup>2</sup>ESK, Max-Schaidhauff-Strasse 25, 87437 Kempten, Germany; <sup>3</sup>Heraeus Kulzer, Quarzstrasse 8, 63450 Hanau, Germany; <sup>4</sup>W.C. Heraeus, Heraeusstrasse 12-14, 63450 Hanau, Germany; and <sup>5</sup>Dental Materials and Biomaterials Research, University Hospital Aachen, Pauwelsstrasse 30, D-52074 Aachen, Germany; \*corresponding author, hfischer@ukaachen.de

*J Dent Res* 88(7):673-676, 2009

## Direct Inkjet Printing of Dental Prostheses Made of Zirconia

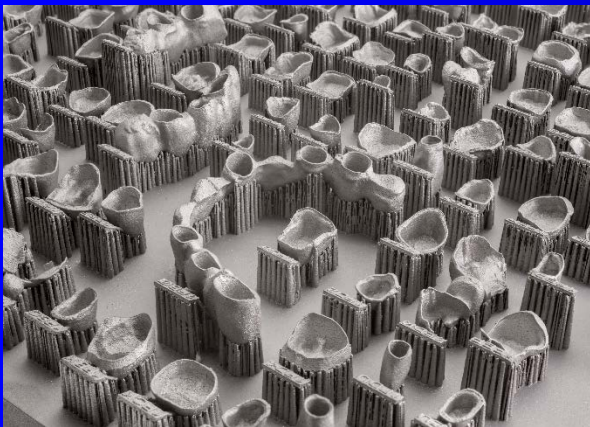
### INTRODUCTION

The introduction of CAD/CAM milling systems in the dental field zirconia ceramics to be used as a standard material for dental

Fra: Silva ea. J Prosthodont 2011

# Solid friform-Produksjon

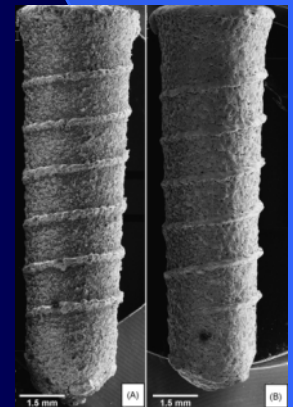
- En høy-energy-laser (f.eks CO<sub>2</sub>) smelter sammen små partikler. Kan være plastikk, metal, keramer eller glasspulver til en 3-dimensjonal form
- Laserstrålen smelter selektivt overflate-laget av et pulverbasseng fra et 3-D tverrsnitt
- Etter hvert nivå senkes pulverbasseng et hakk, det spres ut et nytt skikt med pulver og prosessen gjentas.



Kroner/broer



Partialprotese



Implantat

# Individualiserert kjeve-implantat laget med SLS (2012)

Ti6Al4V ELI (ekstra-lav interstitial) pulver  
+ dekket av hydroksylapatitt

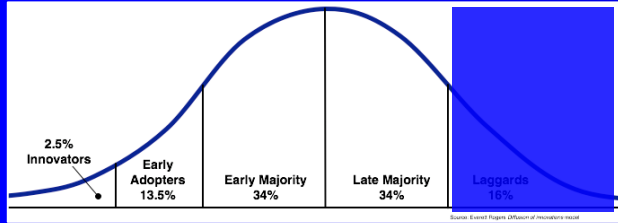


University Hasselt, ksios  
Hogeschool, University Leuven  
, Orbis Medisch Centrum  
Sittard-Geleen, Belgium &  
ksilloc medisinsk BV, Cam  
Biokeramer BV, Nederland





# Innovasjoner i data-assisterte additive / subtraktive produksjonsmetoder ~2016 og senere



## Produksjon-prosessen

Produksjon

Subtraktiv

**Additiv**

Utstyr

Protese

Vevsrekonstruksjon

**Produksjon  
programvare**



Overflate- og  
volumgjennkjennning

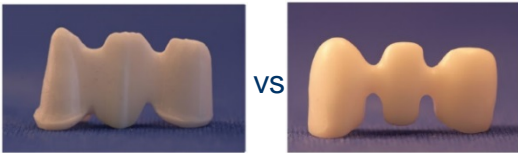
**Konstruksjon-  
programvare**



# Restorative materials for CAM



Photos: Song et al. (2013)

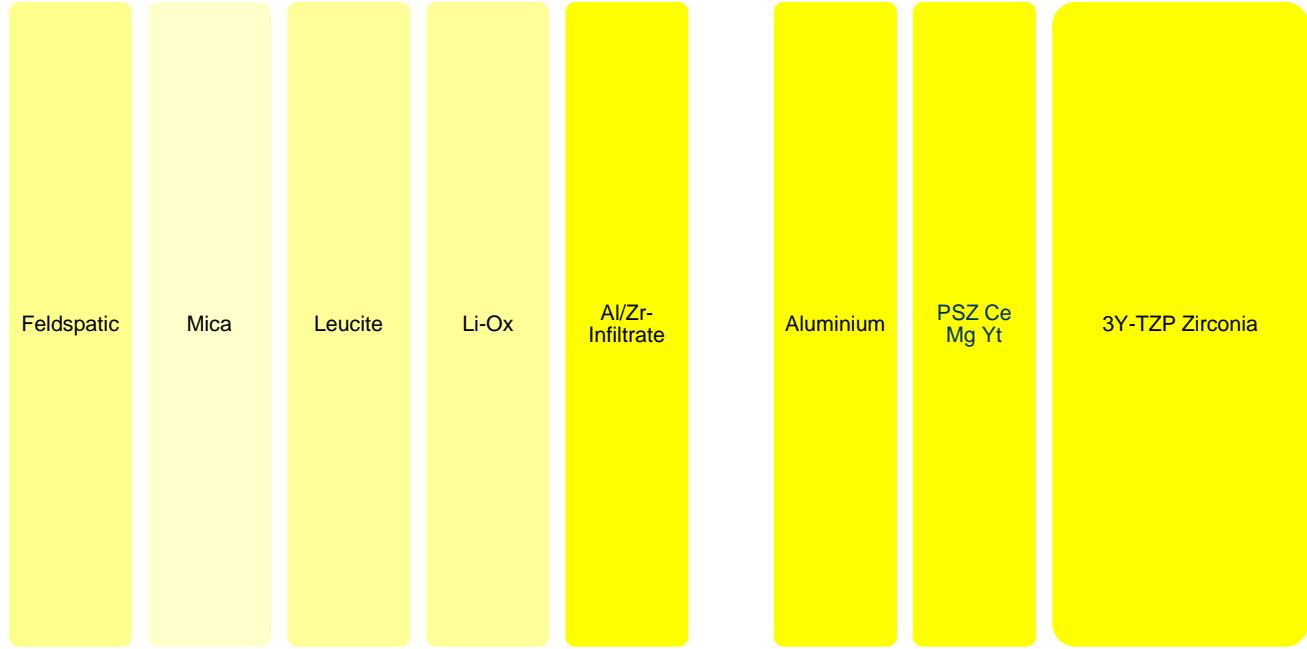


Photos: Mahmood et al. (2015)

FPD substructure dimensions?



Monolithic Veneer



High Temperature  
Lava Ultimate  
Cerasmart  
Shofu block-HC

Light cured  
Paradigm  
MZ100

VITA Enamic

Polymers

Polymer-infiltrated Ceramic Network (PICN)

Glassy Ceramics

Poly-crystalline

# Zirkonium-oksider til fresing er ikke identiske! 1/3

		%
<b>TZP*</b>	$\text{ZrO}_2 / \text{Y}_2\text{O}_3$	95 / 5
<b>TZP-A</b>	$\text{ZrO}_2 / \text{Y}_2\text{O}_3 / \text{Al}_2\text{O}_3$	~95 / ~5 / 0.25
<b>FSZ</b>	$\text{ZrO}_2 / \text{Y}_2\text{O}_3$	90 / 10
<b>PSZ</b>	$\text{ZrO}_2 / \text{MgO}$	96.5 / 3.5
<b>ATZ</b>	$\text{ZrO}_2 / \text{Al}_2\text{O}_3 / \text{Y}_2\text{O}_3$	76 / 20 / 4

**Stor variasjon mht:**

**Hardhet**

**Frakturmotsand**

**Kornstørrelse**

**Strek-styrke**

**Elastisitetsmodul**

**Opasitet**

**Sintringstid**

Hvem tror du sjekker:

Dekk-protese-kompatibilet?

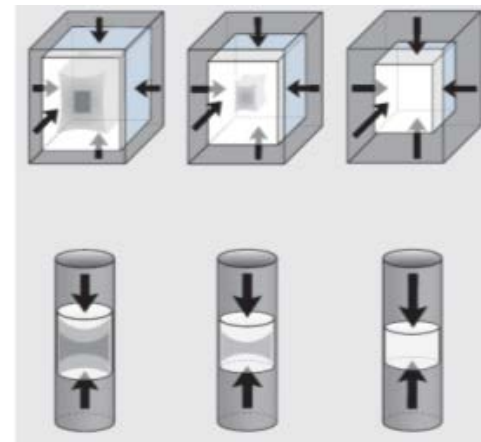
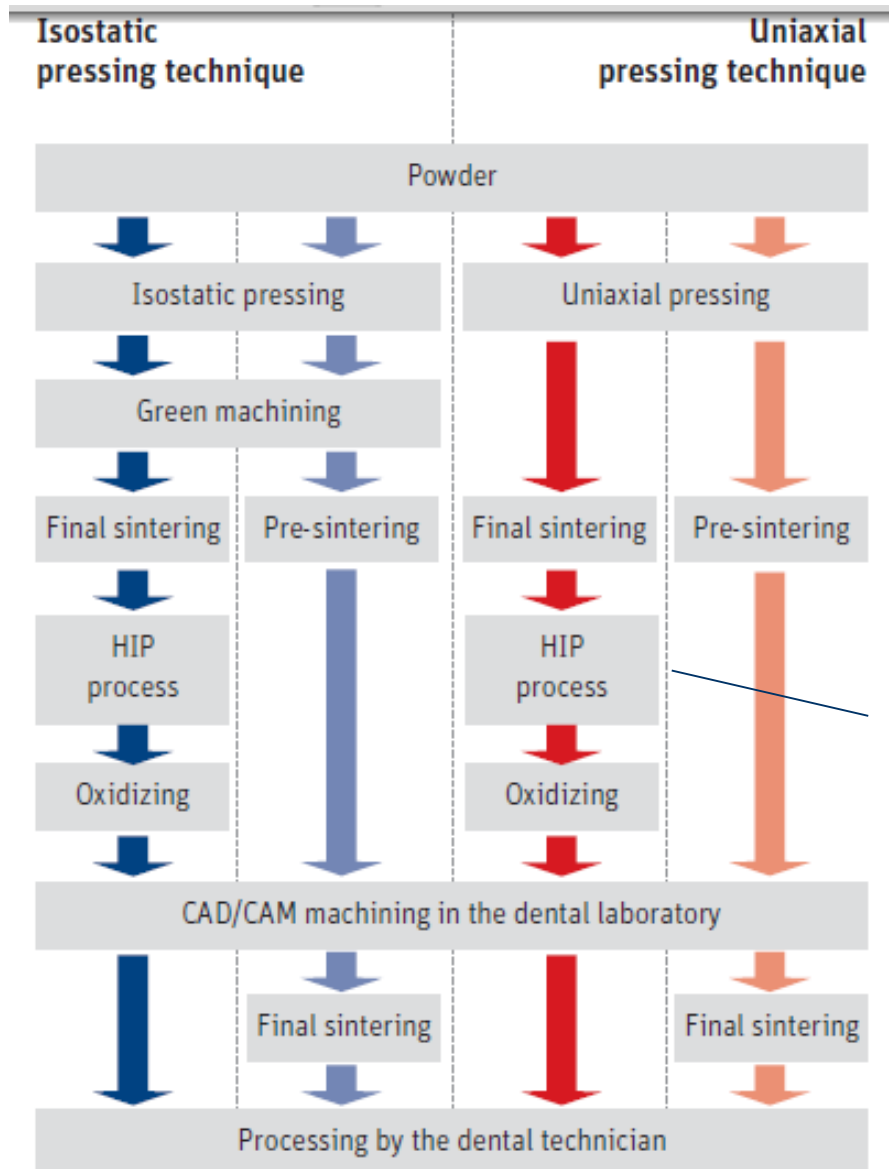
Optimal kjerne-dekkprotese tykkelser?



\*TZP=(Tetragonal zirconia polykrystaller)

# Zirkonium-oksider til fresing er ikke identiske! 2/3

Partielt sintret



Isostatisk

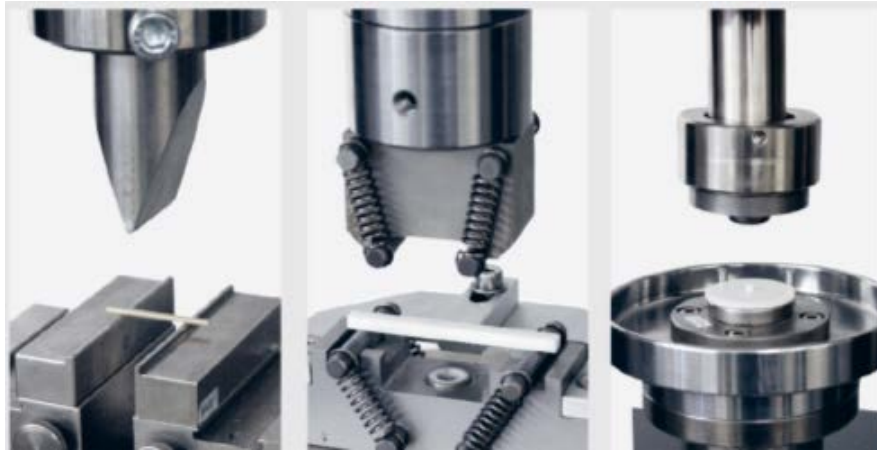
Uniaksial

(HIP prosess: Hot Isostatic Post sammenpressing)

Sluttsintring: ~1350°C (cercon) - 1500°C (lava) - 1530°C (vita)

Påvirker kornstørrelsen → translusens (& klinisk holdbarhet?)

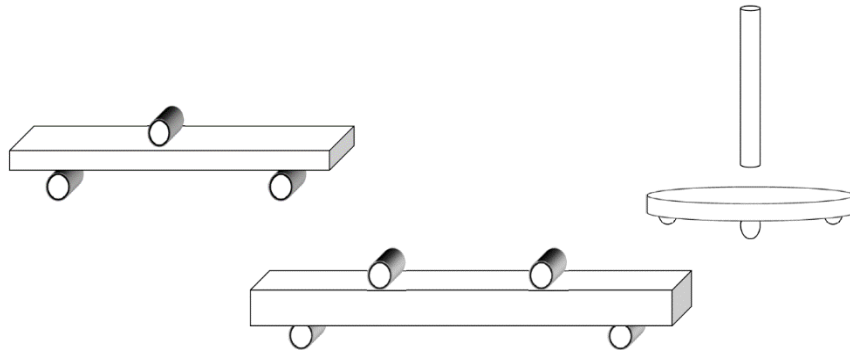
# Zirkonium-oksider til fresing er ikke identiske! 3/3



3 punkt

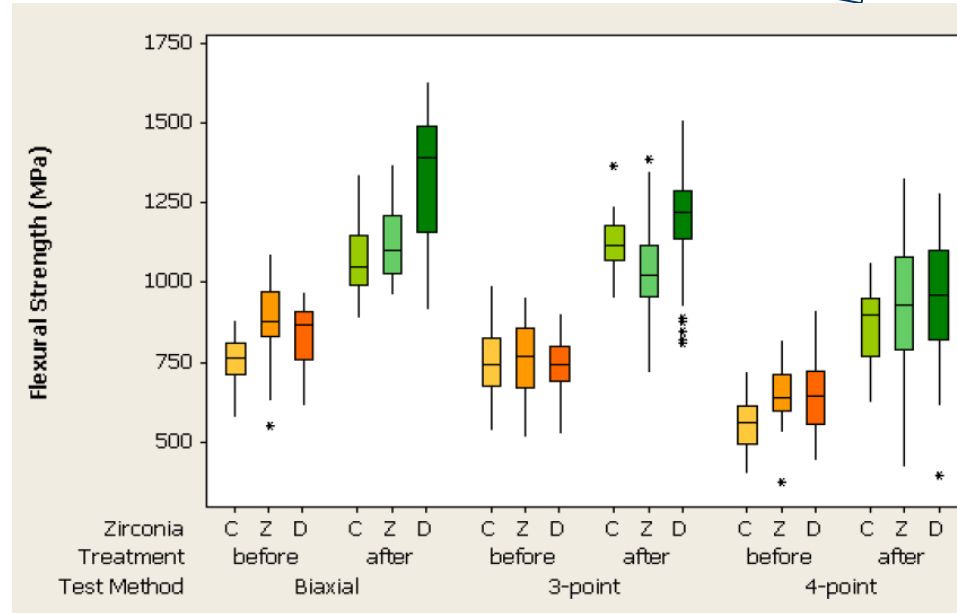
4 punkt  
bøystyrke -test

biaksial



Fracture toughness kan  
være en bedre prediktor

OBS ved sammenlikning  
av styrkedata



\* tørrpolert før sintring eller  
våt-polert før sintring



# FREMTIDSTRENDER I ORAL PROTETIKK?

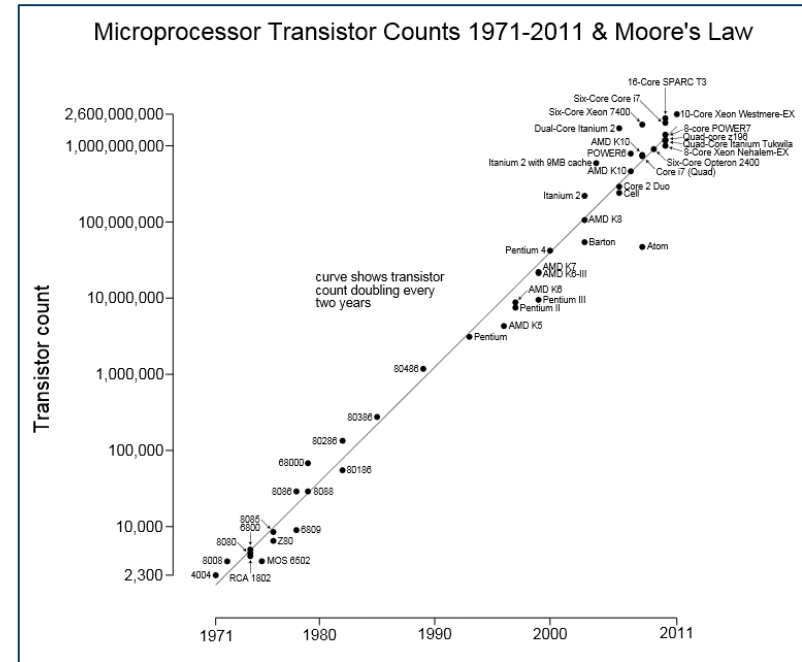


# Datamaskin kapasitet i fremtiden

MOORE'S LOV RULER!

Digital devices will likely continue to be **faster and with lower cost** per performance unit; and Innovative software programs will harness these improvements in performance. 😊

The wwww of Internet will likely continue to be commercialized, driving other devices to VPN-like solutions. 😞



Moore's law: the number of transistors in a dense integrated circuit doubles approximately every two years

# Digital Motion Capture System + ElectroMyoGraphy (EMG)



2xIR cameras - 40Hz

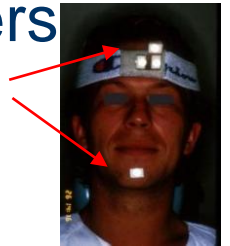
Graphic controller  
EMG

Analogue x-y & y-z  
video screens

Calibration frame for  
3D recording



Fiducial markers  
(IR reflectors)



MacReflex software:  
Triangulation of centre  
points (40 Hz)  
MacIntosh computer

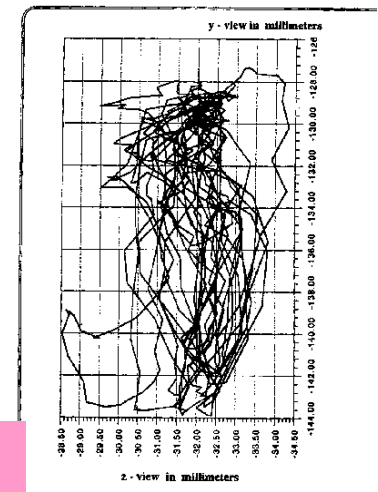
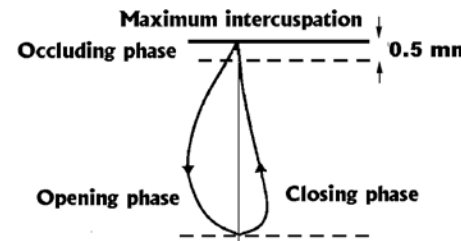
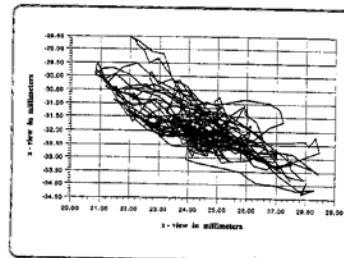
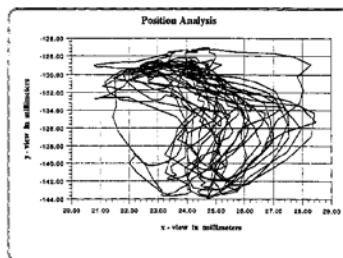


# Digital Motion Capture System - chewing

## Chewing Movements in TMD Patients and a Control Group Before and After Use of a Stabilization Splint

Una Soboleva, DDS, MSc<sup>a</sup>  
Asbjørn Jokstad, LDS, Dr Odont<sup>b</sup>  
Thomas Eckersberg, LDS, MSc<sup>c</sup>  
Bjørn L. Dahl, LDS, Dr Odont<sup>d</sup>

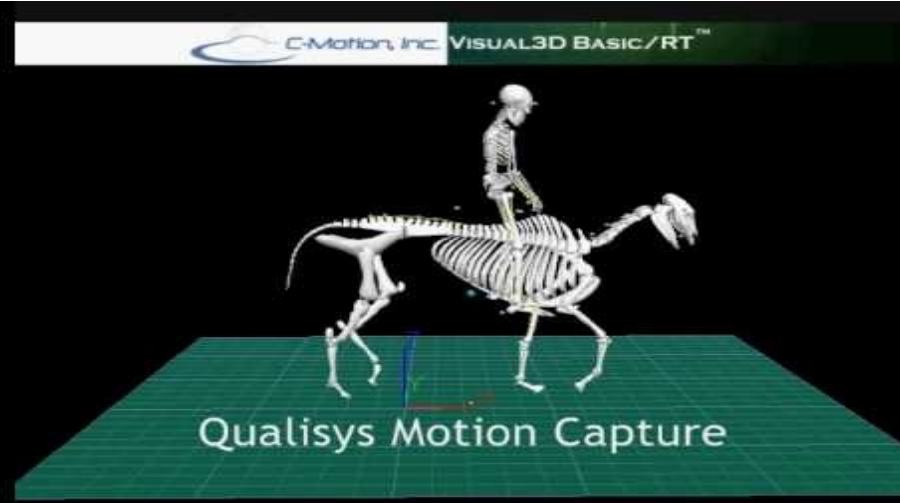
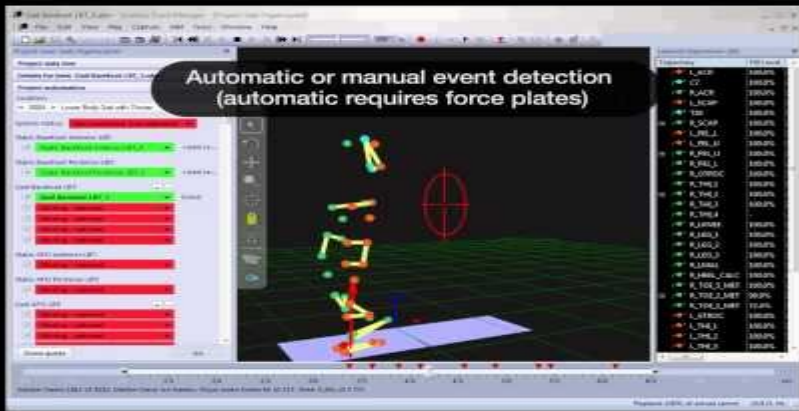
**Purpose:** This study assessed the effect of using an occlusal stabilization splint in the maxilla for 6 weeks on certain parameters of chewing movements in subjects with and without temporomandibular disorder symptoms. **Materials and Methods:** Twelve male and 30 female temporomandibular disorder patients with and without a prior whiplash incidence, and individuals without signs and symptoms of temporomandibular disorders participated. The participants formed three groups matched according to gender and age ( $n = 3 \times 14$ ). A maxillary stabilization splint was used during sleep for 6 weeks. An optoelectronic system (MacReflex, Qualisys) was used to record chewing movements at baseline, before using the splint, and after 6-weeks' use of the splint. Calculated parameters were the duration of the chewing cycles, the spatial displacement, and the mean velocity of the mandible while chewing paraffin wax for 20 seconds. **Results:** On a group basis, the use of an occlusal stabilization splint for 6 weeks did not change the jaw movement parameters in a predictable pattern as recorded under the conditions of this study. On an intraindividual basis, large variations in changes of chewing parameters over time were observed. **Conclusion:** The use of an occlusal stabilization splint for 6 weeks did not alter the jaw movements when chewing a substance with a soft consistency. *Int J Prosthodont* 1998;11:158–164.



ideal versus reality:

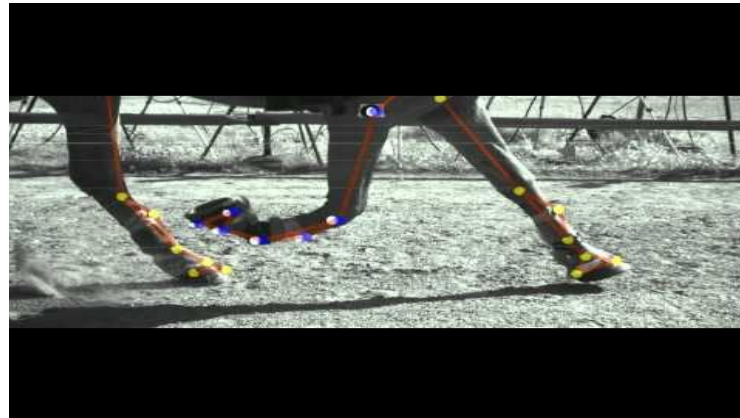


# Digital Motion Capture Systems in the 90's



40 Hz

**QUALISYS**  
Motion Capture Systems



...a few years  
later...  
200 Hz

# Digital motion capture systems & oral dyskinesia

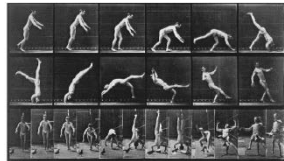
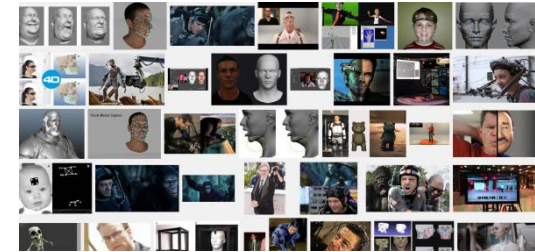
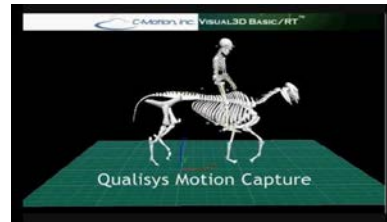
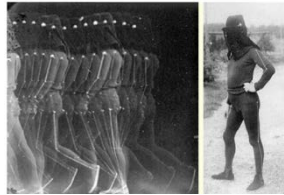


Figure 1. Decomposition of a motion frame to a succession of pictures. (E. Mayhew)



1990'ies: 3 dim., 40 Hz

I dag: Multi-dimensional  
→ 4000Hz

Før: 2 dim.

“MoCap”: is used extensively in films and cartoons; e.g., Avatar, Planet of the apes, etc.



## Neuromedisin

*Sensors* **2015**, *15*, 21710-21745; doi:10.3390/s150921710

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**sensors**

ISSN 1424-8220

www.mdpi.com/journal/sensors

Review

### Technologies for Assessment of Motor Disorders in Parkinson's Disease: A Review

Qi Wei Oung <sup>1,\*</sup>, Hariharan Muthusamy <sup>1</sup>, Hoi Leong Lee <sup>1</sup>, Shafriza Nisha Basah <sup>1</sup>, Sazali Yaacob <sup>2</sup>, M. C. J. S. L. H. R.

Research Article

### Face-Referenced Measurement of Perioral Stiffness and Speech Kinematics in Parkinson's Disease

Shin Ying Chu,<sup>a</sup> Steven M. Barlow,<sup>b</sup> and Jaehoon Lee<sup>c</sup>

# The pace of technological developments compress the learning curve time for

- operating new devices for surface or volumetric rendering
- mastering CA designing software
- handling CA manufacture numerical control programs
- controlling new additive and subtractive manufacturing technologies
- optimal handling of new CAD-CAM-biomaterials

→ **Brokers & “bundle package industries”**



# Patient

Dentist

Dental  
Technician

Prosthesis  
designing

Biomaterial  
selection

Fabrication  
process



# Patient

## Dentist

## «Broker»

Prosthesis  
designing

Biomaterial  
selection

Fabrication  
process



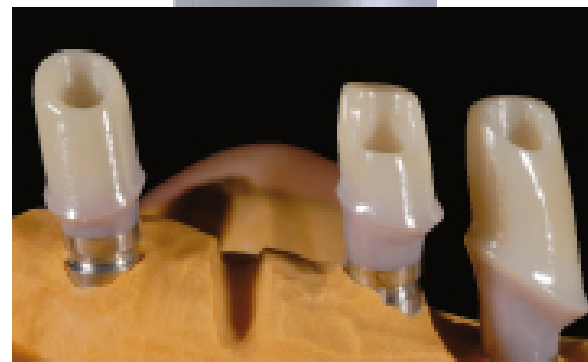


# Medical device customised for your patient

## ESSENTIAL:

1. It is always a **responsibility of a doctor** to maintain the control of the choice of biomaterial and chain of fabrication method
2. The choice of biomaterial and CAM method may not be compatible – time will tell
3. Stay with a validated concept or upgrade your knowledge about properties of new material & new CAM methods

Example, Customized abutments with CAM



Who decides whether the interface is in ceramic or metal?  
The clinician or the CAM owner?

# Digital totalplanlegging finnes allerede



*An exclusive 3D face photo  
of our 3D X-ray units. This  
system produces a realistic  
3D image in a single imaging  
session like a separate 3D face photo  
patient to any radiation.*

The world's first  
X-ray integrated  
face camera



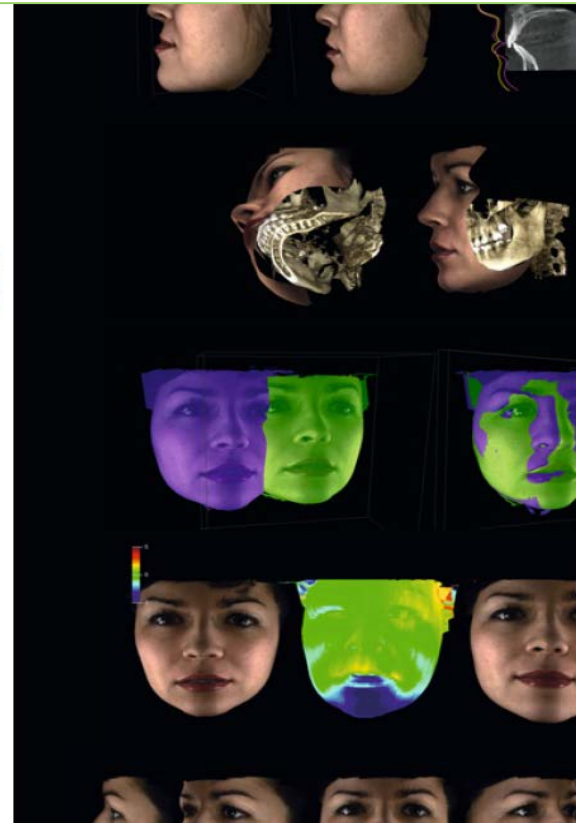
## Face in 3D

For diagnostic needs of today's  
dentists, **Planmeca ProFace\*** is  
an innovative planning and treatment  
solution for motivation and for sharing

## Safer and faster facial surgery

The 3D photo visualises soft tissue in relation to dentine  
and facial bones. As both a CBCT image and a 3D photo are  
generated in one imaging session, the patient position, facial  
expression, and muscle position remain unchanged – resulting  
in images that are perfectly compatible.

Careful pre-operative planning – where you can study the facial  
anatomy thoroughly using our **Planmeca Romexis\*** software



**Planmeca**

**Cerec4.2(Sirona) 3dMDvultus**

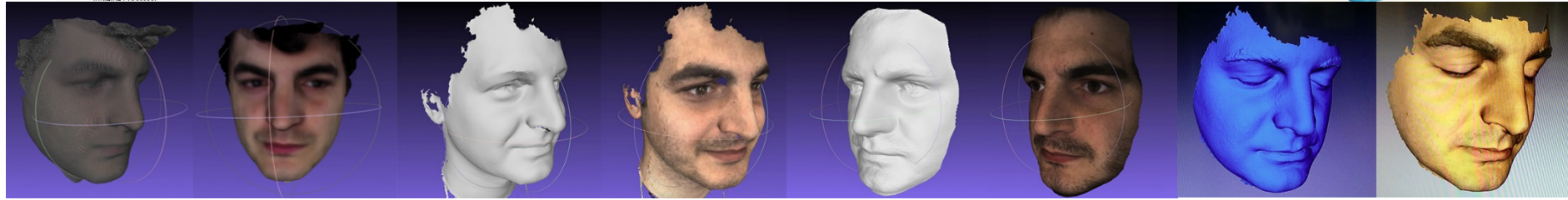
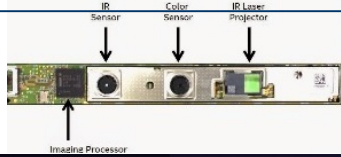
**Conebeam Rx**  
**Facial scan**

✓  
✓

✓

✓  
✓

# Ansiktsscanning (structured light / laser / stereophotogrammetry)



Intel RealSense 3D  
\$99

- Mesh Quality – 4/5: The mesh quality is really good. Dense and detailed.
- Texture Quality – 2/5: Texture quality is quite poor, the resolution of the sensor being limited to 640 x 480.

Synthesis: The 3D scans took a very long time to obtain. A decent result at an affordable price, however necessitates a lot of practice to get good results

[Intel on Amazon](#)

Shining 3D EinScan-Pro  
\$3,999

- Mesh Quality – 4/5: High mesh quality, hair tends to degrade the performance.
- Texture Quality – 4/5: Good sensor quality. However the color module is in option and costs an extra \$700.

Synthesis: the scan process takes some time. The Einscan-pro is not specifically designed for face scanning but is a very versatile portable scanner.

Fuel3D SCANIFY  
\$1,500

- Mesh Quality – 3/5: The mesh is really good in the center, the cheeks have less details and are more approximate.
- Texture Quality – 5/5: Excellent quality of the textures due to the technology and high resolution of the cameras.

Synthesis: Fuel3D SCANIFY delivers an excellent performance. The capture is instantaneous and the user can even keep his eyes open. The marker is the only constraint

Artec Space Spider –  
\$27,600

- Mesh Quality – 5/5: Excellent mesh resolution and accuracy.
- Texture Quality – 5/5: Texture is very detailed and high resolution. Colors are less realistic compared to the SCANIFY. (Example is not very good as it is a picture of a computer screen.)

Synthesis: A product made for metrology and reverse engineering but capable of producing amazing face 3D scans. Its price puts it in an entirely different category.

From: [aniwaa.com](#)

# Digital totalplanlegging finnes allerede



*An exclusive 3D face photo  
of our 3D X-ray units. This  
system produces a realistic  
3D image in a single imaging  
session, like a separate 3D face photo  
without any radiation.*

The world's first  
X-ray integrated  
face camera



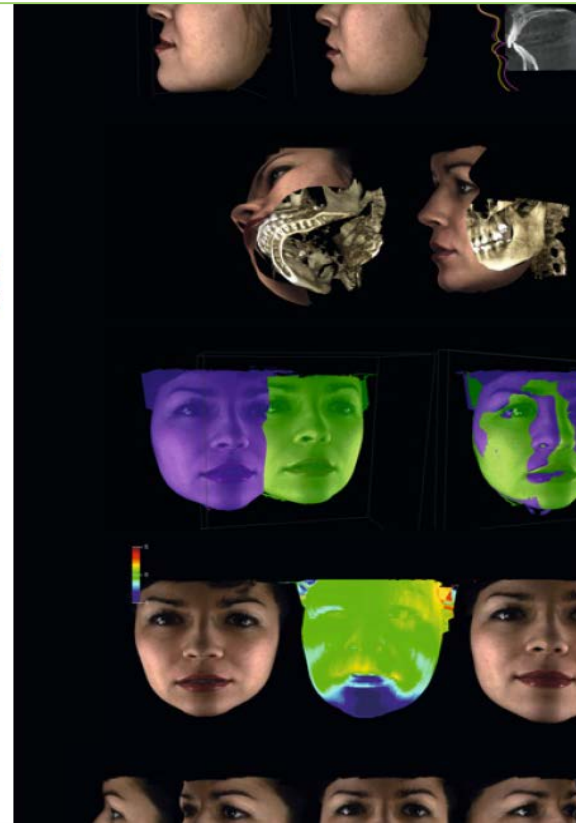
#### Face in 3D

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diagnostic planning and treatment  
motivation and for sharing

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Careful pre-operative planning – where you can study the facial  
anatomy thoroughly using our **Planmeca Romexis**® software



## Planmeca

## Cerec4.2(Sirona) 3dMDvultus

**Conebeam Rx**  
**Facial scan**  
**Jaw tracking**

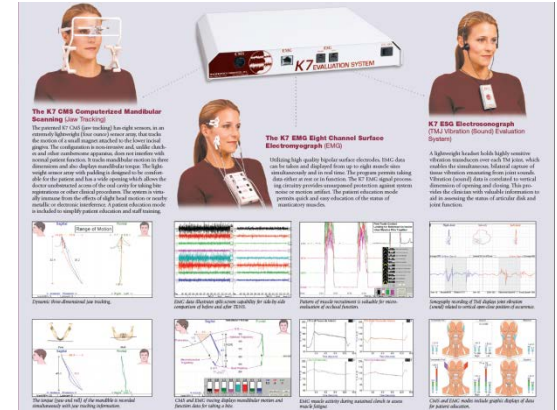
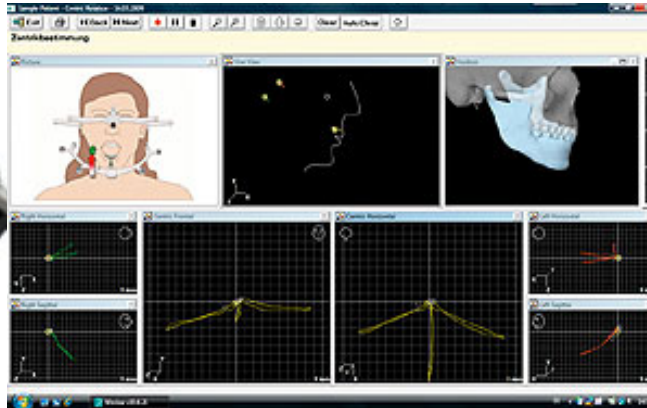
✓  
✓  
✓

✓  
  
✓

✓  
✓



# Kjeveledd-bevegelse → (digital) artikulator



WinJaw (Zebris) JMA20

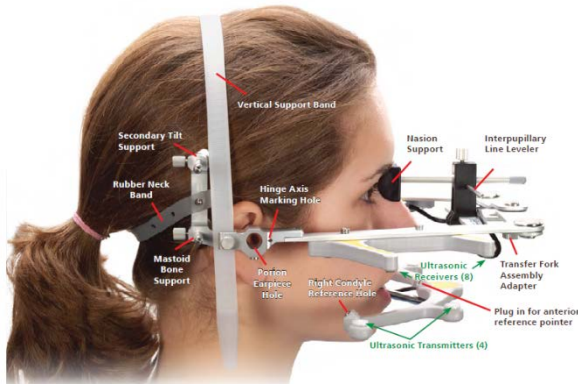
Myotronics

ARCUSdigma II (KaVo) Ultrasound

Axioquick Recorder (SAM)

Opto-electronic

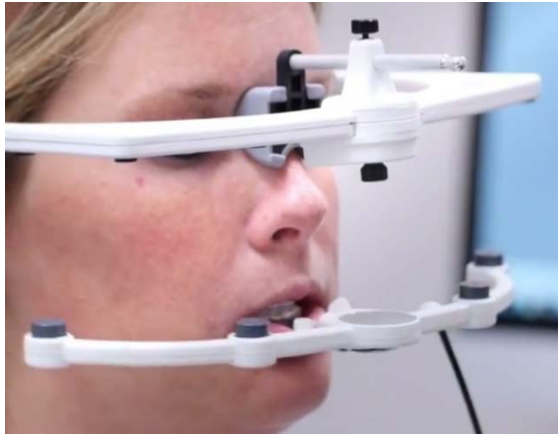
Cadiax



Freecorder BlueFox (DDI-Group)



# Digitale artikulatører erstatter kanskje mekaniske i vanskelige behandlingsskuss



Unique 3D combination

## Real-time jaw movement – in 3D

Planmeca 4D<sup>®</sup> Jaw Motion is the only true CBCT integrated solution for tracking, recording, visualising and analysing jaw movement in 3D. It offers incompatible visualisation and measurement data of mandibular 3D movements in real-time – creating a fourth dimension in diagnostics.



### Key features

- The only CBCT integrated jaw tracking solution
- Track, visualize and record in-line jaw movement in 3D
- Visualize movements in the Planmeca Romex<sup>®</sup> software without delay
- Record movements for later use and analysis
- Measure and visualize the movement path of one or more points of interest in a 3D image
- Export movement and measurement information to 3<sup>rd</sup> party software as an XML or CSV format for analysis and treatment planning
- High-contrast dental models with a CBCT image for occlusion analysis

### Key components of Planmeca 4D<sup>®</sup> Jaw Motion

- CBCT image of a patient, for example a Planmeca Vita Line<sup>®</sup> 7500
- Planmeca Profiler<sup>®</sup> 3D Model or Planmeca Profiler<sup>®</sup> 3D Block tray and equipped with the Planmeca Tracker<sup>®</sup> for 3D jaw motion
- Planmeca Tracker<sup>®</sup> 3D Jaw Motion software module
- Special glasses and a novel jaw tracking device with light weight reflective spheres

### Applications include:

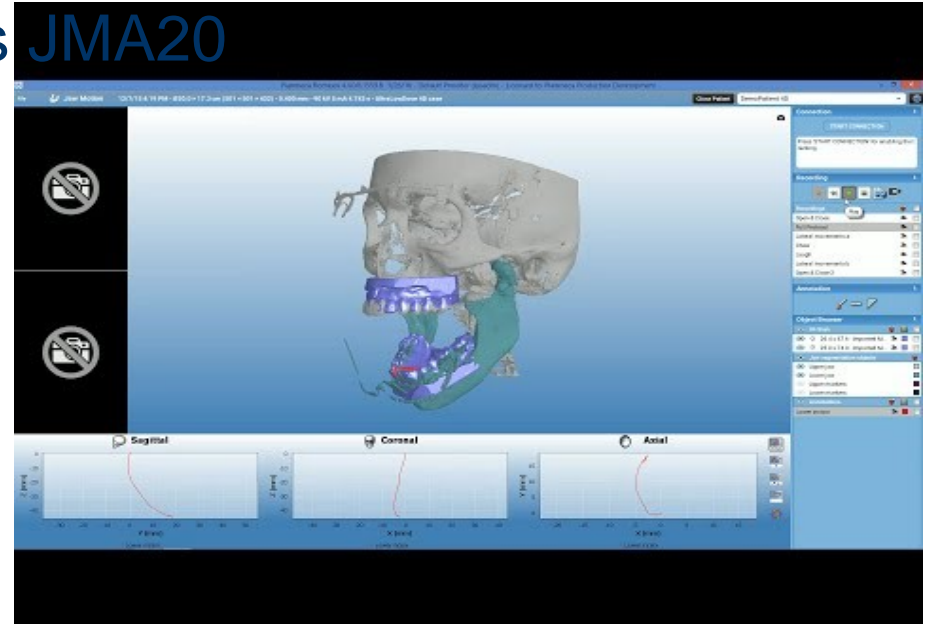
- Temporomandibular disorder (TMD) diagnosis
- Mandibular movement analysis
- Articulator programming
- Complete cross relationship during jaw movement
- Preoperative planning
- Postoperative treatment verification



zebris JMA20



**TREATMENT PLAN** : Analyze Jaw Motion



Sirona Scicat

Planmeca Romex

# Digital totalplanlegging finnes allerede



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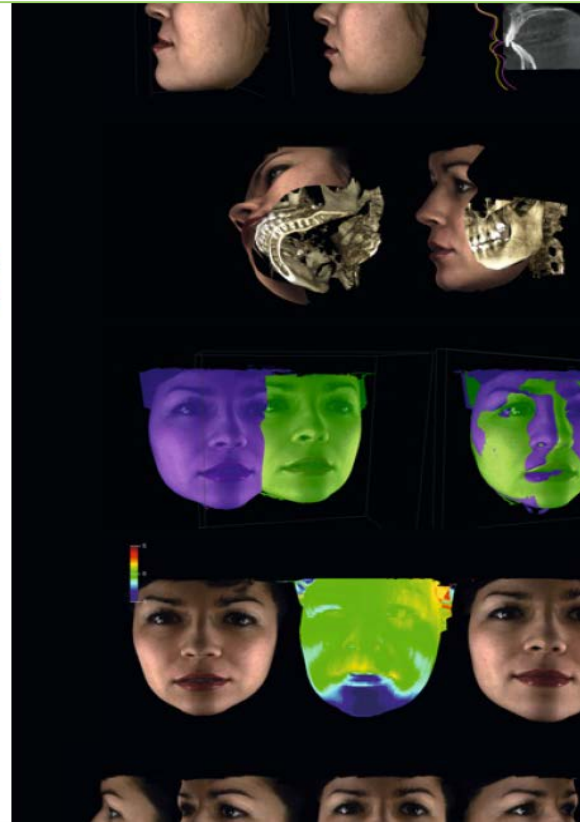
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## Planmeca

## Cerec4.2(Sirona) 3dMDvultus

Conebeam Rx



Facial scan



Jaw tracking



Smile design





# Innovasjoner i 2018 kontra 1996?

ONCE YOU GET THE PICTURE... THE RESULTS ARE BEYOND WORDS.

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2. A new window lets you view the INSIGHT L&D Camera's full face picture without a single adjustment.

3. Starting with the patient's chart, obtain an accurate video shot. The full patient record with the INSIGHT L&D Camera and CAPTURE-IT software.

4. Using CAPTURE-IT, you immediately take color, resolution-increased. Also, you can capture a ready-to-print image also immediately by holding corresponding video images.

5. All your dental records are just as easily accessed with single click commands.

6. CAPTURE-IT 2.0 enables patient selection easily except to all the procedures you're performing with you select to other needs.

7. One part of the software displays IMAGE-IT provides all with an extra step: image you need, the best decision together.

8. All that finally one setting - it's not that 20% in image, you've just completed your work with INSIGHT L&D Camera and CAPTURE-IT software (with no re-orientation).

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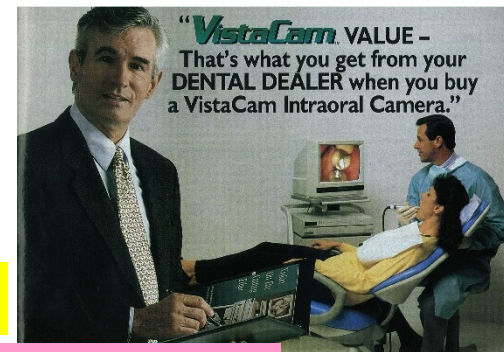
WOW!

Fantaastisk state-of-the-art teknologi i 1996



digital smile

Digitized intraoral camera

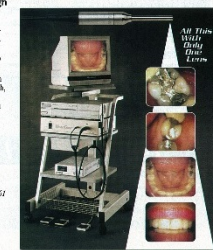


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9. The system that...  
10. The system that...

than making out the check. As your full service working needs and aftersales support, I call it



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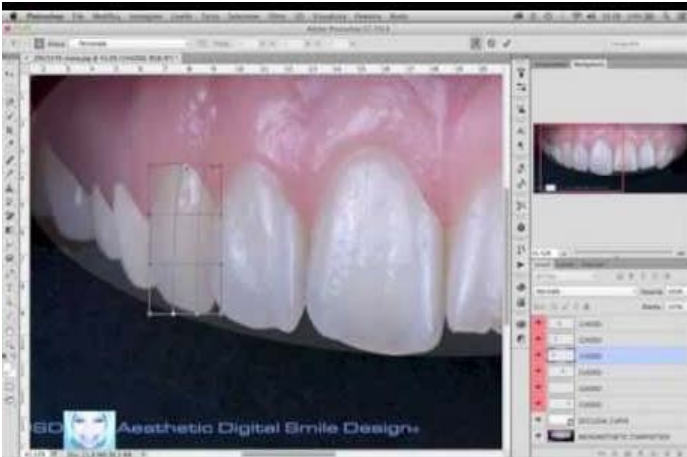
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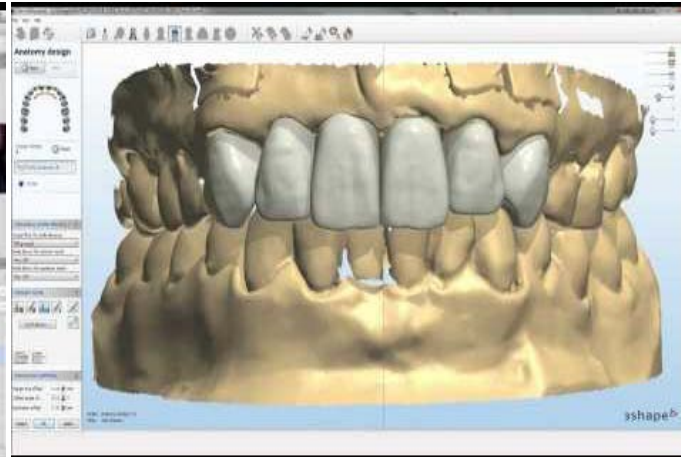
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# Digital smile designing i 2018- et enda mer imponerende visuelt inntrykk



**Digital Smile Design**



**Smile composer**



**CEREC Smile Design**



**Romexis Smile Design**

Product name	Manufacturer
<b>CEREC Smile Design</b>	Sirona, Germany
<b>Digital Dentist</b>	Digident, USA
<b>Digital Smile Design</b>	DSD, Spain
<b>Digital Smile System</b>	DSS, Italy
<b>Envisionasmile</b>	EnvisionASmile, USA
<b>G Design / D Pack</b>	HackDental, Romania
<b>GPS Digital Smile Design</b>	Dental GPS, Canada
<b>Insignia Advanced Smile Design</b>	Ormco, USA
<b>Romexis Smile Design</b>	Planmeca, Finland
<b>Smile Composer</b>	3Shape, Denmark
<b>Smile Designer Pro</b>	Tasty Tech, Canada
<b>Smile-Vision System</b>	Smile-Vision, USA
<b>SNAP Instant Dental Imaging</b>	SNAP Imaging Systems, USA