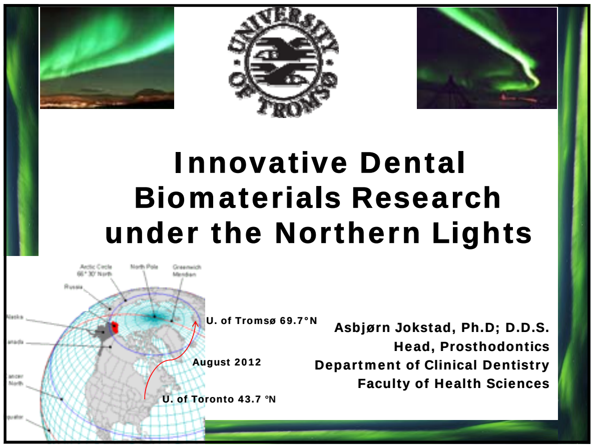
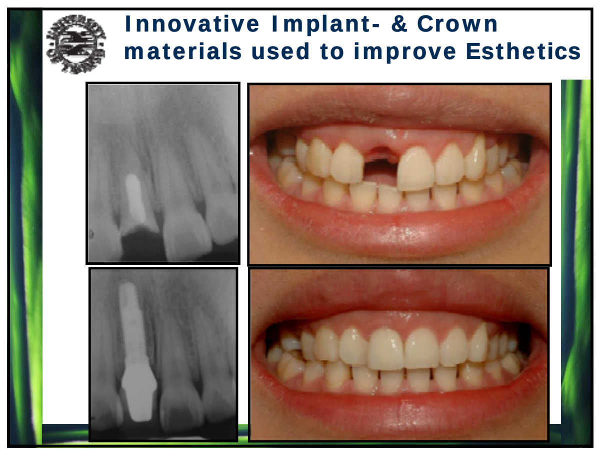

Innovative Dental Biomaterials Research under the Northern Lights
U. of Tromsø 69.7°N
August 2012
U. of Toronto 43.7 °N
Asbjørn Jokstad, Ph.D; D.D.S.
Head, Prosthodontics
Department of Clinical Dentistry
Faculty of Health Sciences


The average patients' teeth today
A Drive for Esthetics!
Innovative Restorative Materials
Combining Novel Materials

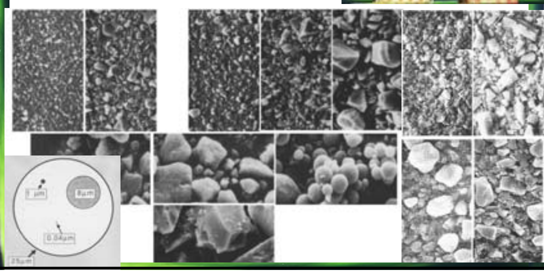

Innovative Composite Resin Materials used to improve Esthetics


Innovative Implant- & Crown materials used to improve Esthetics


Innovative Ceramic Materials used to improve Esthetics


Innovative Ceramic Materials used to repair Worn Teeth of Dentate Elders
Scandinavian solution vs North America solution

Abundance of commercial products. E.g. According to filler size



Unwanted Clinical performance

- Bulk Discoloration
- Margin Discoloration
- Surface Wear
- Margin Leakage
- Degradation

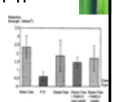
Laboratory tests vs clinical significance?

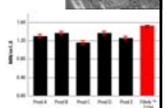
Static stresses

Compressive (crushing) strength, 1h & 24 h
Tensile strength, 15 min.
Transverse strength, 1h & 24 h
(Flexure/bending/modulus of rupture)
Modulus of elasticity (Young's Modulus)
Shear modulus

Dynamic tests

Compressive modulus
Tensile modulus
Bending modulus
Resilience
Fatigue
Fracture toughness





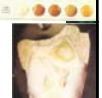
Laboratory tests vs clinical significance?

Other defined tests

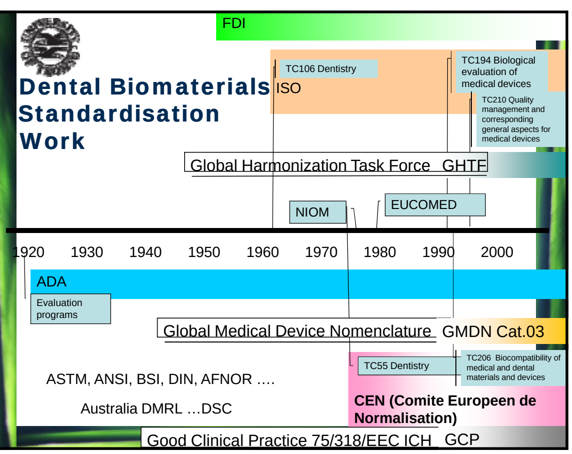
Flow (Creep) 3-24 h
Dimensional change 5 min -24 h
(Polymerization/setting contraction/expansion)
Hardness
Thermal Expansion Coefficient
Water solubility
Water sorption

Other undefined tests

Abrasion resistance (Wear)
Adhesion
Color stability
Surface roughness
Margin leakage



Dental Biomaterials Standardisation Work



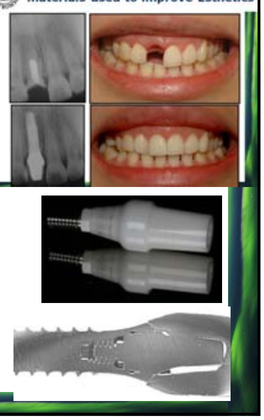
Our In-house Universal Testing Machine (Zwick)

Innovative Implant- & Crown materials used to improve Esthetics

Dental Implant ("Implant Body")

Customised implant abutment ("Implant transmucosal component")

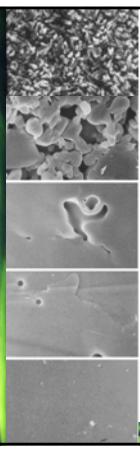
Implant supra-construction



Prefabricated ceramic blanks for customised implant abutments

ESSENTIALS

- Control of the chain of materials and fabrication methods
- Fabrication processes and material choices as they may be incompatible
- Which concept is validated regarding modern material properties
- Which concept is validated regarding subtractive manufacturing methods



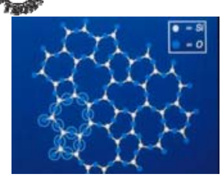
Innovative Ceramic Materials used to improve Esthetics

Traditional vs novel:
Chemistry
Fabrication methods
Surface treatment

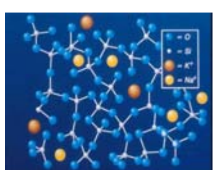
Ceramic types used in dentistry

- Traditional feldtspatic ceramics
  - With or without aluminium-oxide crystals
- Feldtspatic glas
  - With leucite crystals
- Tetra-silico-mica glas
- Lithium-disilicate glas
- Pre-Sintered Aluminium-oxide Glas-infiltrated
- High pressure sintered Aluminium-oxide
- Zirkonium-oxide

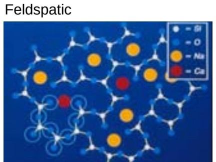
Novel Ceramics



Quartz glas
Feldspatic

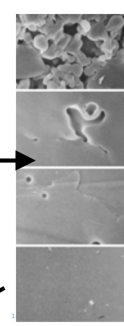


Normal glas
Low-fusing Ceramic



Principles for fabrication- 1

Sintering
e.g.
Biodent
Cerinate
Ducera Pluss
Hi-Ceram
IPS Corum
Microbond
Mirage II
Optec HSP
Vitadur-N



Principles for fabrication- 2

Pressforming & sintering

e.g. Empress

Principles for fabrication- 3

Casting & sintering

e.g.
CeraPearl
Dicor

20

Principles for fabrication- 4

Slip-sintering
e.g.
In-Ceram

+ Veneering ceram

21

Principles for fabrication- 5

High pressure sintering on enlarged model
e.g.
Procera

+ Veneering ceram

22

Principles for fabrication- 6

Pre- Sintered/ Sintered and machined
e.g.
cad-esthetics® /DECIM
Cercon smart ceramics®
Cerec® 3 / InLab®
DCS Precident®
Digident®
KaVo Everest®
Lava® system
+++

+ Veneering ceram

Prefabricated blanks

examples

Sirona

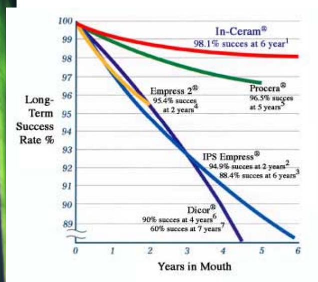
ø99 mm x 10 - 25mm

DCS (Hip)

KaVo Everest

E4D

Clinical Performance of Ceramics



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2.Lehner et al. J Prosthodontics, 6:20-30, 1997
3.Lehner et al. IADR, Nice, France 1998
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6.Ellison et al. J Dent Res, 71:207, 1992
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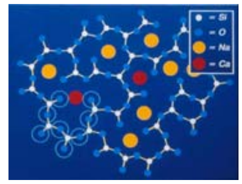
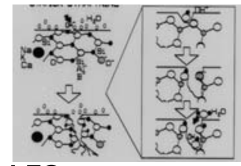
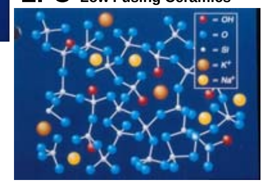
9.Seghi, Sorensen. Int J of Prosthodont, 1995

Ceramics undergoes Corrosion

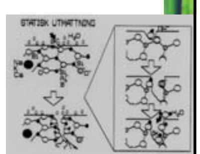
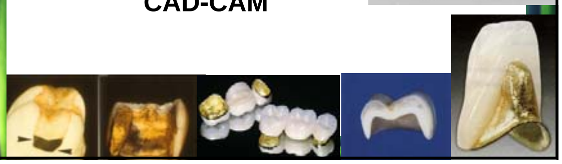

LFC=Low Fusing Ceramics



Strategies to reduce effects of Corrosion

Low Fusing Ceramic

Inner core strengthening
- Alloy, cast or other
- High strength ceramic
- CAD-CAM

Clinical performance is influenced by multiple variables

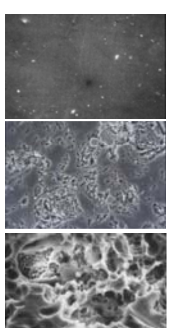
Key variables beyond material properties:
- **Corrosive & mechanical intra-oral environment**
- **Surface treatment**
- **Compatibility with combination material**
  - **Veneer ceramic (Expansion Coef.)**
  - **Cement**

28

Combining materials: The bond between ceramic:resin cement

1. Etching with HF acid

$SiO_2 + 4HF \text{ ----> } SiF_4 + 2H_2O$



not etched

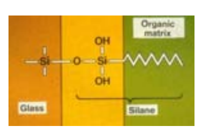
etched 15 sec. HF acid (10%)

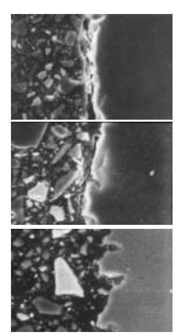
etched 60 sec. HF acid

29

Combining materials: The bond between ceramic:resin cement

1. Etching
2. Silanization



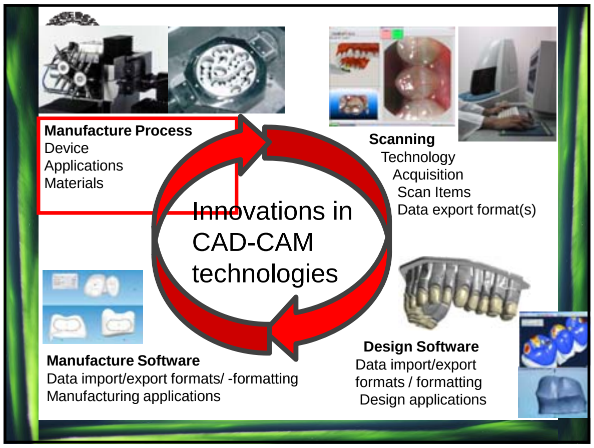


not etched & not silanized

etched & not silanized

etched & silanized

30

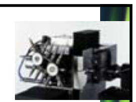
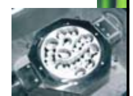


Milling - Parameters

Device
3/3.5/4/5/6-axis-milling

Applications
Wax-ups
In-/Onlays
Single-unit copings
Crowns
Monolithic Crowns
3 →16unit(/4 →7cm)-FDPs
Custom abutments
Implant-Bars
implant-suprastructure-Meso-structures
Partial Removable Prosthesis
Full Removable Prosthesis

Materials
Base alloys
Gold alloys
Non-precious alloys
Titanium / -alloys
Composite resins
Cast Resins / Wax
PMMA
In-Ceram (Porous Al_2O_3)
Al_2O_3 (sintered)
Feldtspathic
$Li_2Si_2O_5$
ZrO_2 (porous/green state)
ZrO_2 (pre-sintered state)
ZrO_2 (sintered)
ZrO_2 (sintered & HIP-ed state)
with / without Sintering-furnace

Zirconia milling substrates are not all alike!

		%
TZP*	ZrO_2 / Y_2O_3	95 / 5
TZP-A	ZrO_2 / Y_2O_3 / Al_2O_3	~95 / ~5 / 0.25
FSZ	ZrO_2 / Y_2O_3	90 / 10
PSZ	ZrO_2 / MgO	96.5 / 3.5
ATZ	ZrO_2 / Al_2O_3 / Y_2O_3	76 / 20 / 4

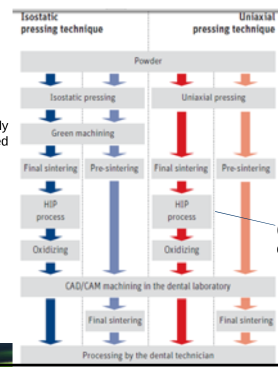
Great variations regarding:
Hardness — **Fracture resistance**, **Elasticity module** — **Grain size**, **Opacity** — **Tension strength**, **Sintering time**

Nobody checks:
Veneering ceramic compatibility
Optimal core-veneer layering thickness

*TZP=(tetragonal zirconia polycrystals)

Zirconia milling substrates are not all alike!

Partially sintered

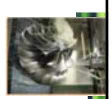


Isostatic
Uniaxial

(HIP process: hot isostatic post compaction

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

Errors introduced during milling processes require reliable software algorithm compensation



- 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

→ A robust industrial 5-axis machine is prerequisit to do proper materials research

Opportunity for collaboration

The Department of Clinical Dentistry
- **Organizes a unique dental educational school founded on a decentralized teaching model within the Dental Health Services**
- **New state-of-the-art:**
  - **5-axis industrial milling machine**
  - **Universal Testing Machine**
- **Faculty experienced in ISO standardization work**

Partnering Enterprises that desire to venture into:
- **the advancement of new dental biomaterials applicable to current trends in dentistry**

THANK YOU FOR KIND ATTENTION

&

WELCOME

to under the Northern Lights