Dental ceramics and their clinical drawback
Dental ceramics and their clinical drawback
(Resistance to crack propagation)

**Toughness (MPa\(\sqrt{\text{m}}\))**

- **Silicate (\(\text{SiO}_2\)) ceramics**
  - Feldspar, Leucite GC, F-Apatite GC

- **Dense Al2O3, AL-La glass, Al-ZR- La glass ALMg-La glass**

- **ZIRCONIA 3Y-TZP**

- **Feldspar + polymer**

**Ceramic materials overview**

**Flexure strength (MPa)**

- 100
- 200
- 400
- 600
- 800
- 1000
Ceramic materials overview

Flexure strength (MPa)

E (Young’s modul) (GPa)

- Dense Al2O3
- Al-La glass, Al-ZR-La glass
- AlMg-La glass
- Zirconia (3Y-TZP)
- Li2Si (GC)
- Feldspar + polymer
- Feldspar
- Leucite GC, F-Apatite GC,
Clinical problems

Mastication forces: high peak loads, cyclic loading (fatigue)

Powerfull jaw closer muscles (masseter, temporalis, pterigoid) can crack teeth, fracture ceramic and noble metal alloys (Au-Pd)

Guinness world record = 4000 N on molars

Mastication forces between 200 N - 800 N

forces are multidirectional
Clinical problems

Ceramic fractures (mechanics!!!!)

a) design issues
b) processing issues
c) mastication (force, multidirection)

Crown fracture / chipping  Implant fracture  Abutment fracture
Clinical problems

Ceramic fractures (mechanics!!!!)

1. veneer fractures (chips)
Clinical problems

Ceramic fractures (mechanics!!!!)

2. Bulk fracture (monolithic glass-ceramic)

- Lithium disilicate
- Mica glass ceramic
- Leucite glass ceramic
Clinical problems

Ceramic fractures (mechanics!!!!)

3. Bulk fracture (veneer + core)
Clinical problems

Ceramic fractures (mechanics!!!!)

4. Bulk fracture (zirconia implant)
Clinical problems

Ceramic fractures (mechanics!!!!)

5. Bulk fracture (zirconia abutment)
A material science approach for understanding clinical ceramic failures

Longitudinal clinical study all-ceramic restorations

Clinical failures

Material sciences

Microstructure & mechanical properties

Fracture mechanics ($K_{lc}$)

Fractographic failure analysis

Fatigue behavior

Clinical & lab recommendations
Standard Practice for Fractography and Characterization of Fracture Origins in Advanced Ceramics

V.D. Fréchette
2006

G.D. Quinn
2007

R. Morrell
2008

S.W. Freiman
J.J. Mecholsky Jr
2012

D. Hull (1999)
Fractography of clinically failed parts

Implant processing issues (surface texture) & design issues

- Crack propagation
- Failure origin
- Fracture surface
- Sandblasted surface
Fractography of clinically failed parts

Implant abutment processing (surface texture) & design issues
Fractography of clinically failed parts
Implant processing issues (surface texture)

premolar: failure after 3 months
Fractography of clinically failed parts
Occlusal contact damage, surface roughnesses, wear
Fractography of clinically failed parts
Fractography of clinically failed parts
Fractography of clinically failed parts
Fractography of clinically failed parts

Occlusal wear = origin

Acc.V Magn
20.0 kV 26x CONST24

1 mm
Fractography of clinically failed parts
Design weakness & processing

Lohbauer, Amberger, Quinn, Scherrer JMBBM; 2010
Origin

Secondary edge chip

Lohbauer U. (2010)
Grinding damage (opened during green state grinding)
Goals:

1. Train clinicians, researchers, industrials to use fractography as a regular tool for failure analysis of brittle materials

2. Identify failure modes in vivo and in vitro of dental ceramics and composites (create a data base)

3. Identify from the failure modes:
   a. weak designs
   b. processing errors
   c. material limitations

4. Dissemination of information / Symposium

Founders (dec. 2013):
U. Lohbauer, S. Scherrer
The oral environment

**Material**

- **Mechanical environment**
  - static load
  - fatigue load (cyclic)
    - fracture
      - chipping
      - total fracture
  - wear
    - abrasion
    - attrition

- **Chemical environment**
  - absorption
  - corrosion
  - chemic. degradation
    - hydrolysis
    - enzymatic degradation
      - discolorations
      - volume modif.
      - leaching
      - fracture

S. Scherrer