Materials in orthodontics

Removable appliances

- Acrylic plate
- Metal wire (stainless steel)
  - active for realignment
  - passive for retention
- Screws

Space maintainer

- assist normal tooth eruption after premature loss, injury or other problem

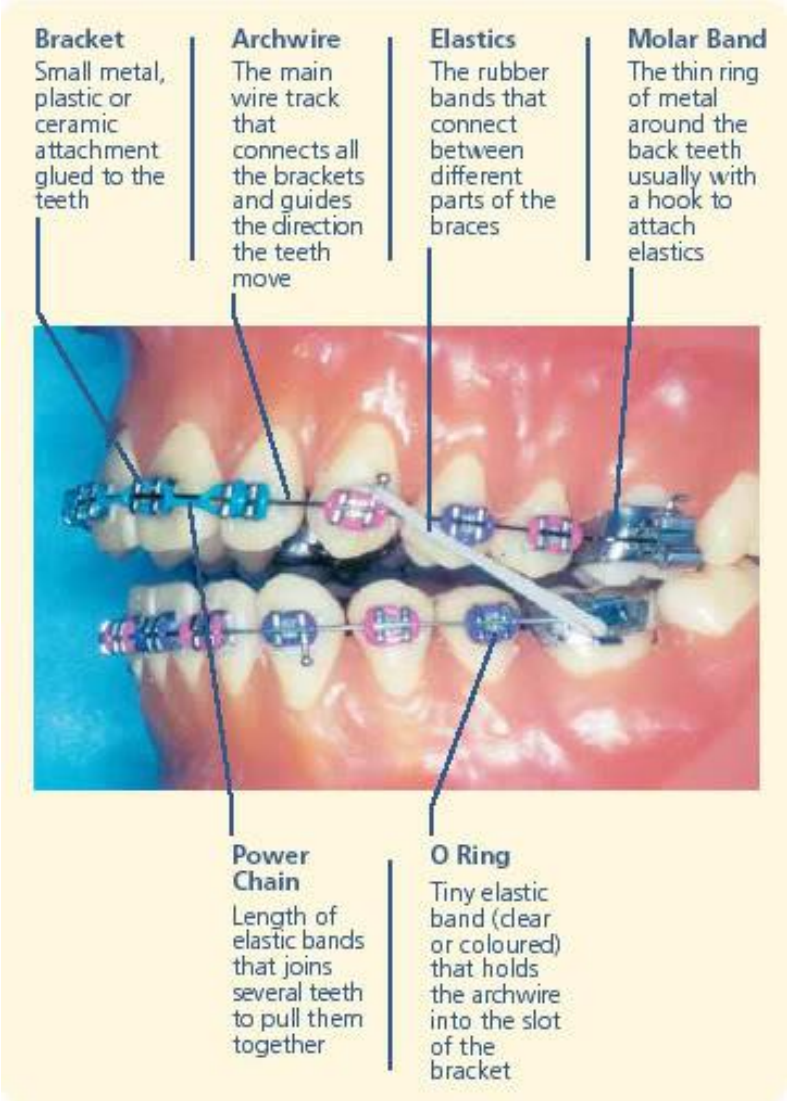
Retainer

- prevent relapse of teeth or jaws to their original positions after completion of the therapy

www.imedo.de/practice/provider/show/450271-dr-michael-de-cassan

http://www.stratfordorthodontics.ca/Portals/0/partsofbraces.swf

Fixed appliances



www.nelsonortho.co.nz/newbracesguide.htm

www.bracesreview.com

www.archwired.com/Photos-Sherri.htm

Implant failure

Causes of implant failure

- Critical situations could not be anticipated in implant tests
- Design not appropriate (material combinations, stress distribution, ...)
- Defects or contaminants introduced during manufacture
- Inappropriate sterilisation method, packaging, shipping, ...
- Inappropriate handling by the surgeon (change of the original shape, drilling of holes, ...)
- Inflammation of the surrounding tissue -> loosening, foreign body reaction, allergy, untimely degradation of biodegradable implants, ...
- Insufficient corrosion resistance, wear resistance, fatigue strength, ...
- ...

Protrusion of the ceramic head through the PE cup and the acetabular shell in total hip replacement

Radiograph before revision surgery (Prosthesis implanted 3 years ago)

The polyethylene cup had worn off and was broken. The ceramic head was intact. It was duller and blackened on its superior aspect in comparison to its non-contact surface (A). The head had fully penetrated the acetabular shell (B)

http://www.orthosupersite.com/print.aspx?rid=29622

Mechanical heart valve

- Increased risk of blood clotting (anti-coagulants needed)

http://cape.uwaterloo.ca/che100projects/heart/files/testing.htm

Cast 316 L femoral stem

- Fatigue failure of metal parts

C. D'Antonio in Handbook of case histories in failure analysis, Vol. 2, 1999, pp. 448-450

Failure of a ceramic acetabular insert

Failure of a Ceramic Cup Insert

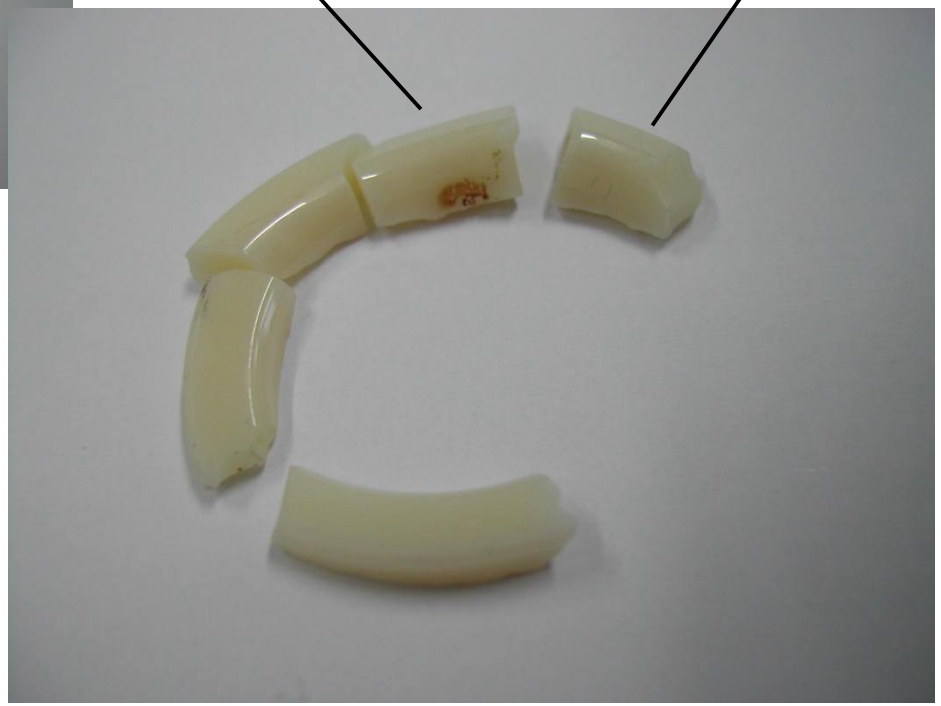
The two biggest fragments are from the upper side of the insert

8 fragments are related to the lower part of the insert; one of these fragments should be the failure initiating one

A multitude of small fragments and shivers that are produced during removal of the insert

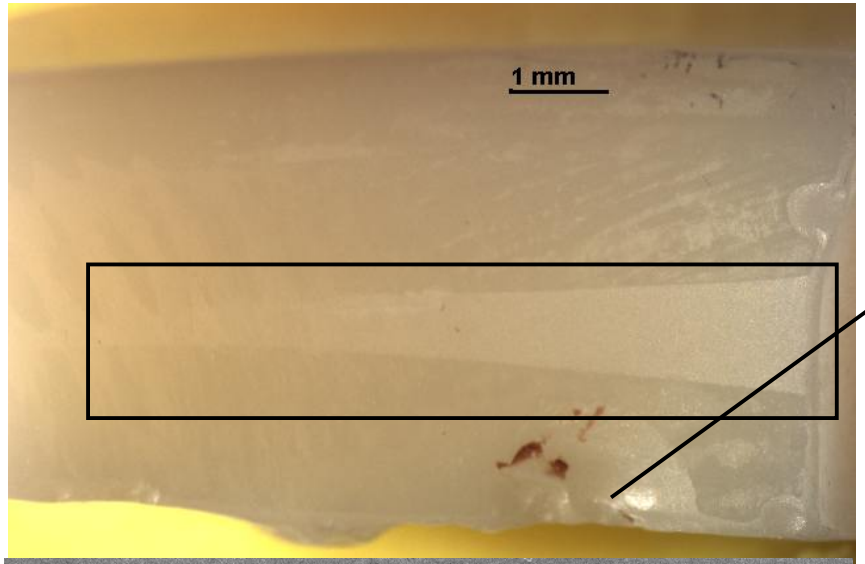
Failure of a Ceramic Cup Insert

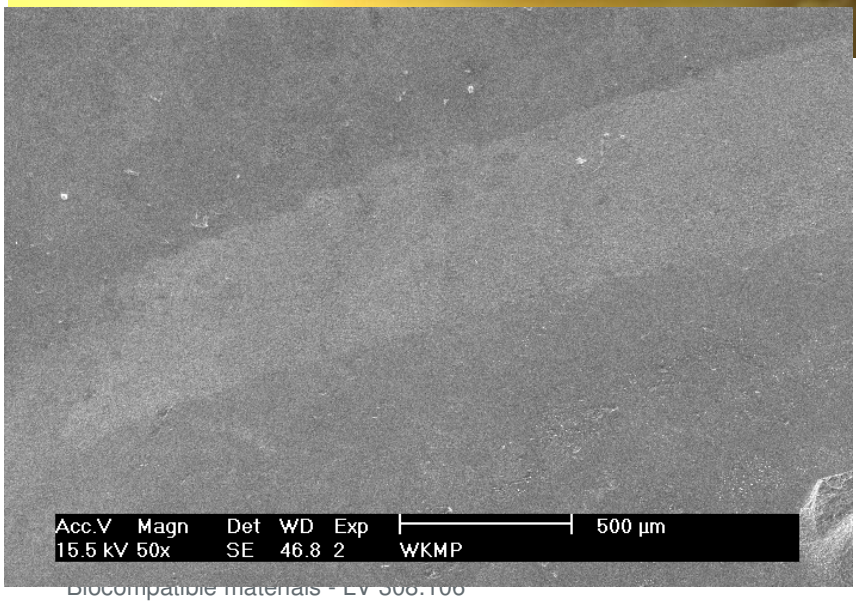
Arrangement of the fragments in the original cup shape



X-ray examination of the patient before removal indicates a failure initiation at a fragment with the dimension 9×4 mm^2

Failure of a Ceramic Cup Insert

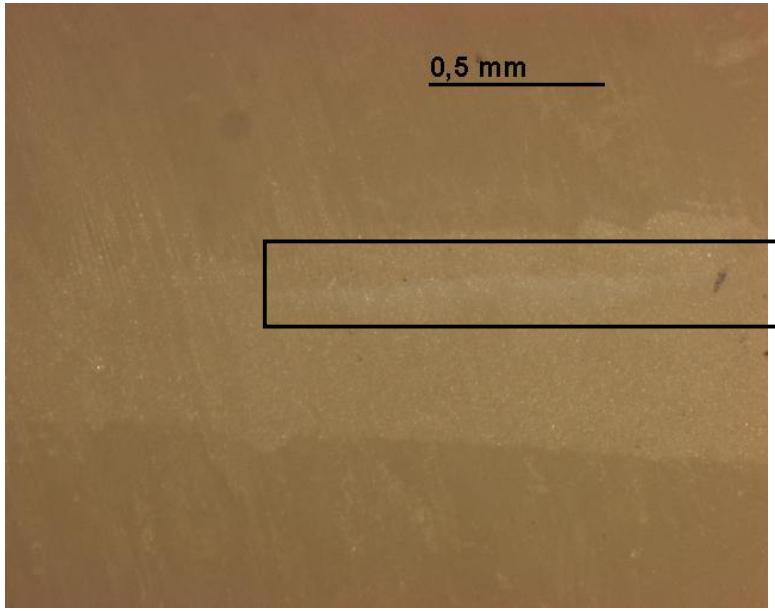




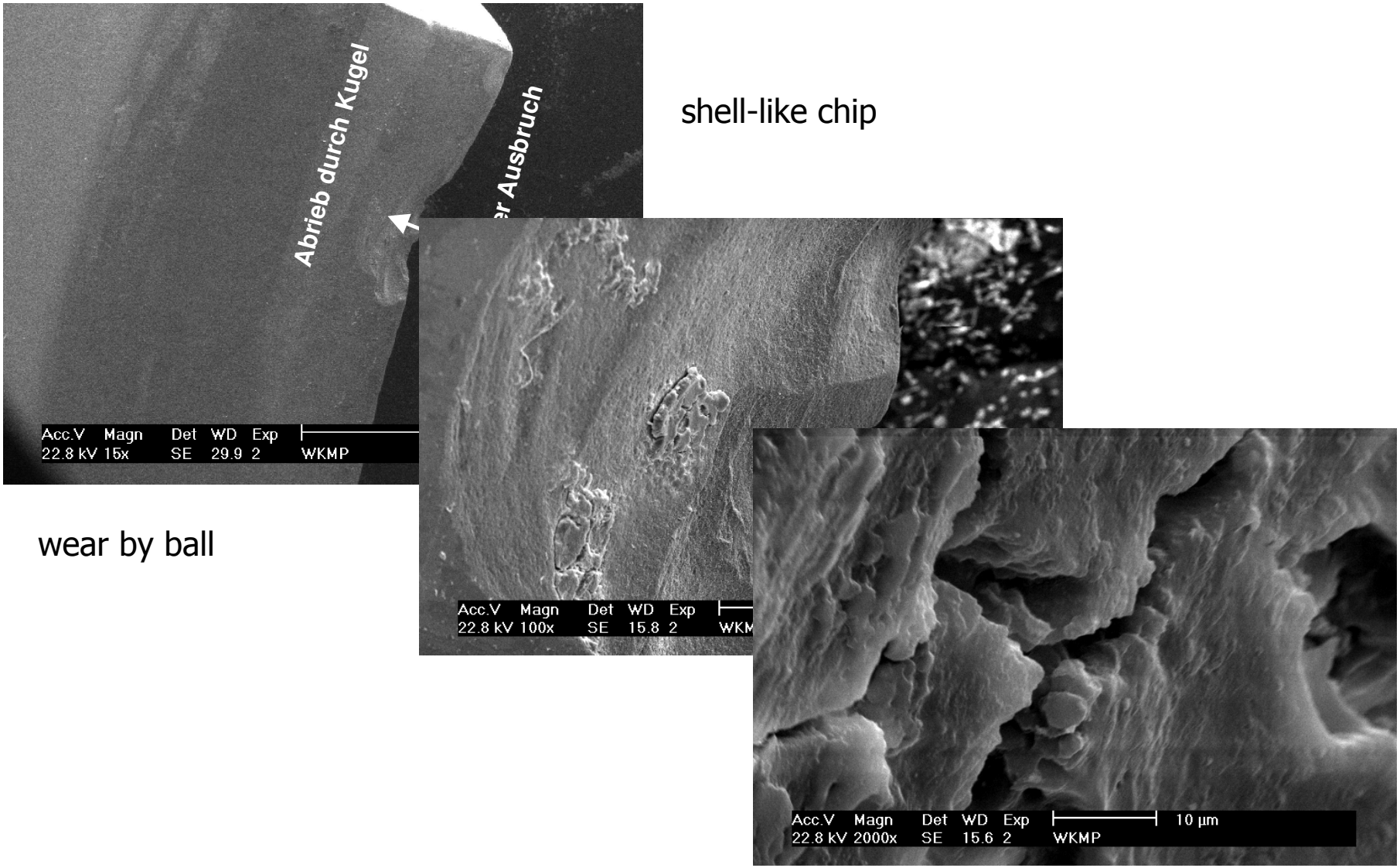
Fragment 1: Longish wear traces due to the friction head-cup

Shell-like chip Ausbruch

Fragment 1: cracks under the surface due to high contact loads between insert and head



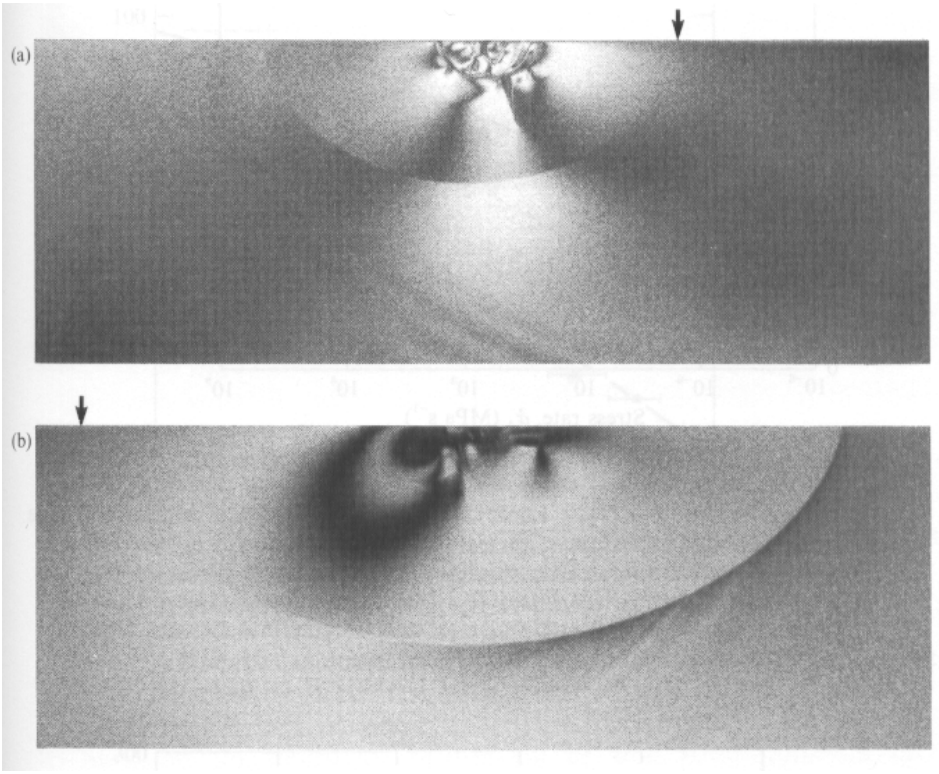
Failure of a Ceramic Cup Insert



shell-like chip

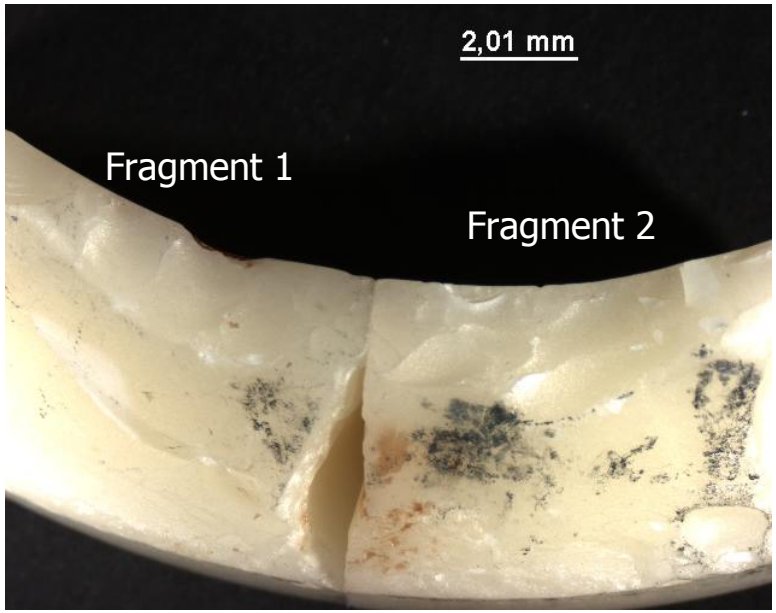
wear by ball

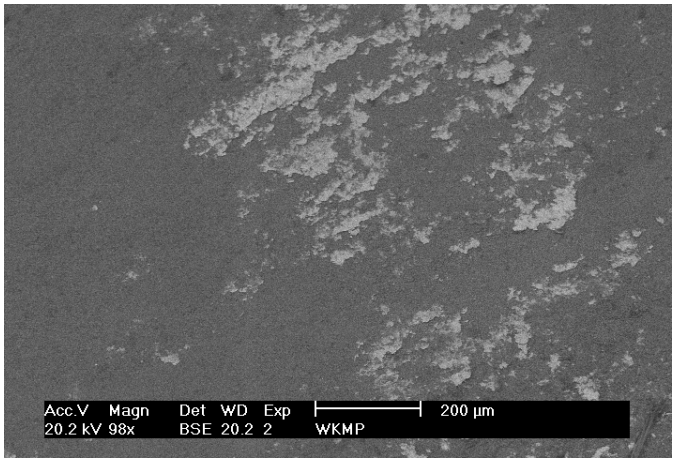
Shell-like Chip in a Glass Caused by Contact loading with a Diamond Tip

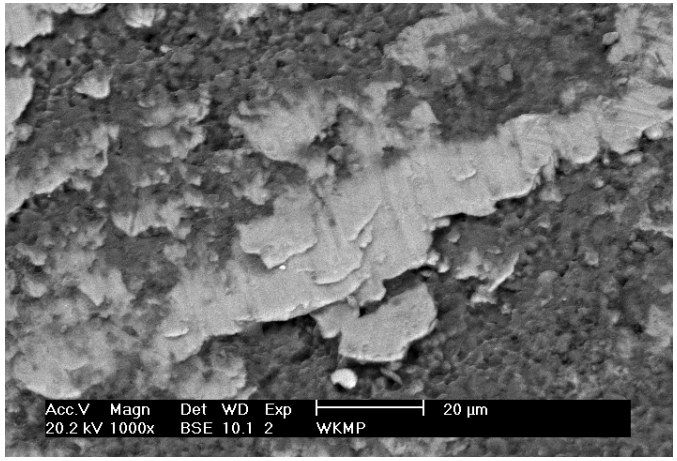


(B. Lawn, Fracture of brittle solids 1995)

Black Disposal

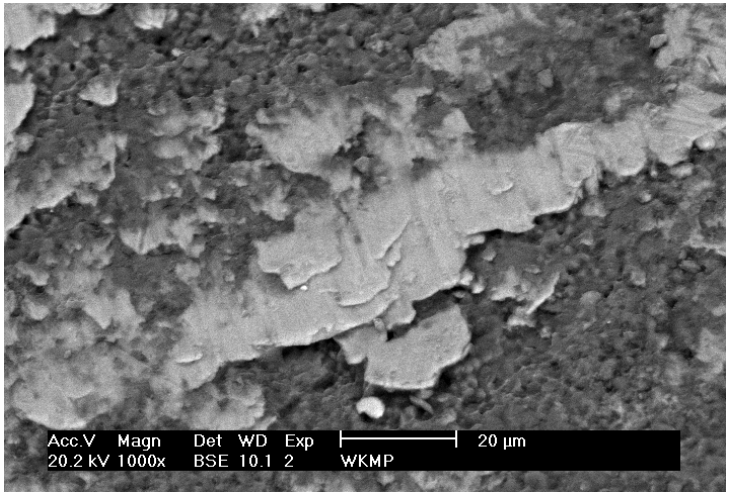






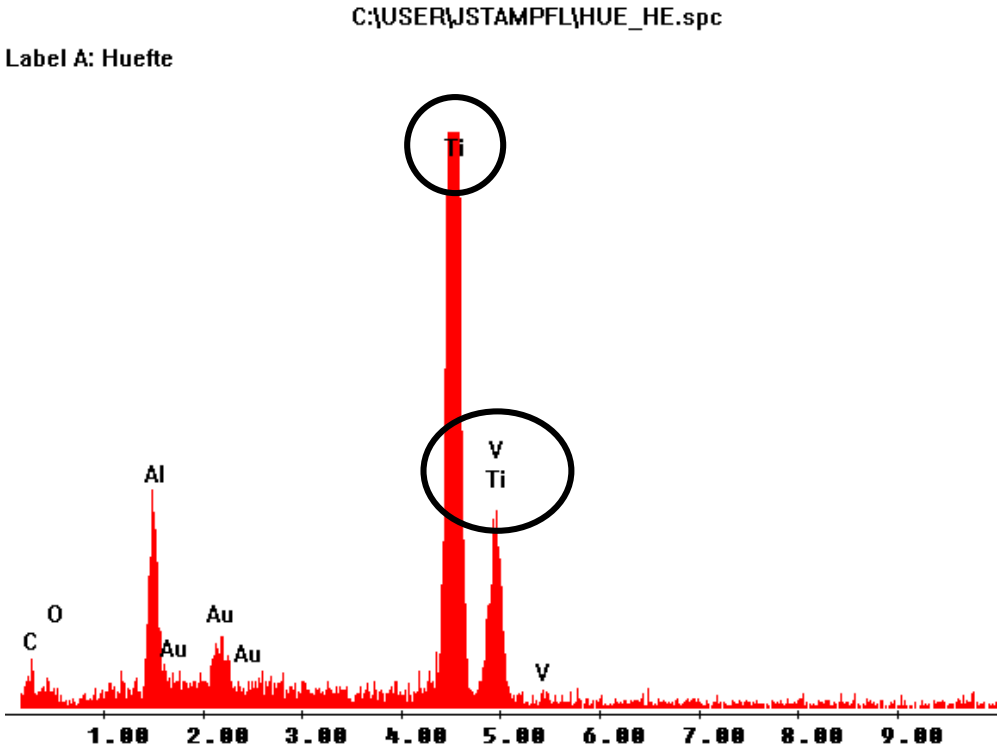
Platelet arrangement indicates mechanical loading of the surface after fracture

EDX of the Disposal



The disposal is caused by post-fracture clamping of the fragment between insert and Ti overlay.

The patient noticed „crashing"and „scrunching"



Al, O ... Elements of the ceramic

C, O ... Elements from the sputtering for electron conductivity

Why did the insert fail?

- Material defects in ceramics/glasses
  - Pores
  - Inclusions

-> No pores or inclusions could be found.

- Microstructure
  - Average grain size: 1.62 µm corresponds to the ISO 6474 (< 4.5 µm)
  - Bulk density: 3.975 g.cm^{-3} corresponds to to the ISO 6474 (≥ 3.94 g cm^{-3})

-> no evidence of inadequate microstructure

- Checking wear resistance and flexural strength on broken fragments is impossible

Probable cause: Wear and related effects given before.

Lessons learned

- Materials and medical devices in ophthalmology
  - Materials for prosthetic devices (contact lenses, IOL, ...) and corresponding requirements
  - Opportunities and limitations
- Materials and medical devices in dentistry
  - Materials used in dental applications (fillings, impression materials, dentures, implants, ...) and corresponding requirements
  - Opportunities and limitations
- Implant failure
  - Causes of implant failure
  - Failure of a ceramic hip cup insert