Contact Mechanics in Dentistry:
A systematic investigation of modern composite materials used for fillings

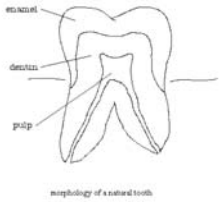
Dennis Heuer, Am Lehmberg 11, 04838 Eilenburg, Germany (dennis-heuer@freenet.de)
Norbert Schwarzer, SIO - Saxonian Institute of Surface Mechanics, Am Lauchberg 2, 04838 Eilenburg, Germany (n.schwarzer@esae.de)
Thomas Chudoba, ASMEC, Bautzner Landstr. 45, 01454 Radeberg OT Rossendorf, Germany (t.chudoba@asmec.de)

WHAT WE DID

Nowadays, high demands are made on filling materials in modern dentistry: Durability, Reliability & Aesthetic Requirements
Thus, a group of physicists and an independent practicing dentists investigated 11 different teeth fillings (composite materials) as used in modern dental practices according to their stability and ability to withstand contact loadings.

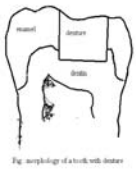
DIFFICULTY

The inhomogeneous natural teeth structure is unrivalled concerning its quality in material composition:

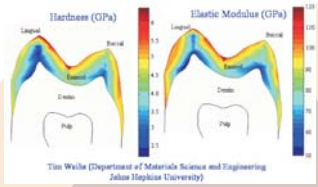


morphology of a natural tooth

Enamel: one of the hardest biological substances. Protects the tooth against weights and abrasion that occur during mastication.
Dentin: acts as a mechanical buffer between dead and live substances, and thus, between mechanical hard and mechanical soft material.
Pulp: sensitive and tender part. supplies the tooth, makes it alive and grow.



Studies show, that the characteristics of the natural "tooth layers" blend and adapt continuously. When a natural tooth is damaged (caries), a homogeneous, artificial material (filling) must replace the natural substance and imitate the natural characteristics.
But: the compound of the natural and artificial tooth material is not optimal!
Stresses within the filling due to polymerisation and hollow spaces can develop and lead to early loss of stability.



REALIZATION

Measurements: using an UMIS-2000 nanoindenter, we determined

- Hardness
- Young's Modulus
- Homogeneity
- Yield Strength*

[*by applying the "effectively shaped indenter model" (talk of N. Schwarzer, this conference)]

METHOD & RESULTS

Preparation of samples: practically orientated, close to real methods in dental practice

Results: Modern composite materials are still very limited in their ability to reproduce the mechanical strength of natural teeth.

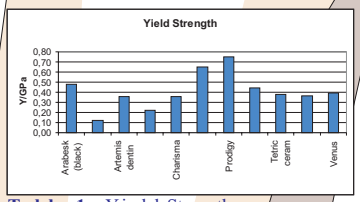


Table 1: Yield Strength

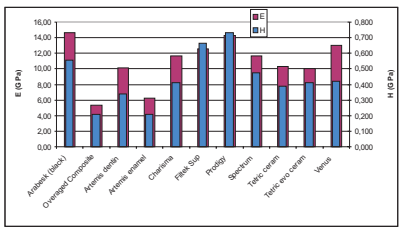


Table 2: Hardness H & Young's Modulus E

Comparison with natural teeth:
molar enamel: H= 4.0-6.5GPa and E= 80-120GPa
molar dentin: H= 0.82GPa and E= 23GPa

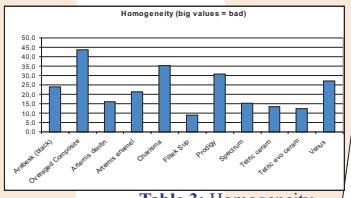


Table 3: Homogeneity

OUTLOOK

Further investigations should also consider other important parameters such aesthetics, processing properties and costs.

"Ranking list" for fillings

Material	Hardness	H/E	Homogeneity	Total	Position
Arabesk (black)	3	6	7	16	5
Overaged composite	11	5	10	26	11
Artemis dentin	9	10	5	24	8
Artemis enamel	10	9	4	23	7
Charisma	6	8	11	25	10
Filtek Sup	2	1	1	4	1
Prodigy	1	2	9	12	2
Spectrum	4	4	6	14	4
Tetric ceram	8	7	3	18	6
Tetric evo ceram	7	3	2	12	2
Venus	5	11	8	24	8

CONCLUSION

Future composite materials used for fillings should be harder.

The shrinking during the polymerisation process has to be reduced to diminish tensile stresses.

The compound between natural tooth & artificial filling must be improved in order to guarantee a higher reliability!

Long term aim: multilayered systems

AKNOWLEDGEMENT:
For the measurement services, the authors of this poster say thank you to Mr. P. Zubko from ASMEC, Germany.

Poster design:
P. Heuer-Schwarzer, ESAE