In Vivo. Abrasion of composites

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CHAPTER 8

SUMMARY

Abrasion of dental composites is supposed to be one important reason for failure and renewal of restorations. Because modern composites have excellent esthetic properties there is a tendency to use composites in the premolar/molar regions. Numerous publications have been published concerning qualitative composite restoration abrasion. Very few quantitative abrasion investigations have been carried out.

Some recent studies indicate that modern composites are unable to resist the occlusal forces as far as extreme loss of material in class I and class II restorations is concerned. Therefore a quantitative in vivo abrasion study was done with 6 different composite systems. The systems were unfilled, macro-filled, micro-filled and macro-micro-filled. Both cold curing and light curing composites were investigated.

In chapter 1 the aims are specified:

1. to quantify composite abrasion IN VIVO.
2. to compare differences in in vivo abrasion between unfilled, micro-filled and macro-filled composites as well as between cold and light cured systems.
3. to obtain information on the mechanism(s) influencing abrasion in vivo.
4. to compare some relevant mechanical and chemical properties of composites in vitro and in vivo.

A survey of the literature on composite abrasion in vivo and in vitro is given in chapter 2. The results of the few quantitative investigations are given. The method used in general was the linear prophilometer technique.

From the literature it is indicated that:
Micro-filled composites abrade less than the macro-filled types in vivo; restorations based on PMMA abrade more in vivo than the Bis-GMA based composites; there is NO relation between in vitro and in vivo abrasion results.

In chapter 3 methods and materials used in this work are described; they can be divided in two main parts:

1. *Clinical abrasion* on 18 patients with each 2 or 3 occlusal composite restorations. Patients, restorations, abrasion measuring technique, accuracy and reproducibility are presented in detail.
   The clinical abrasion was quantified after various periods up to 18 months.
2. *Laboratory investigations:* scanning electron microscopy (SEM), infra-red spectroscopy (IR), microhardness measurements and compressive strength measurements as well as water absorption measurements are described.
   SEM, IR and microhardness data were carried out on composites that had been 1½ years in the mouth as well as on *vitro* material.

Chapter 4 gives the individual and the average abrasion results for the 6 composite systems after 1½ years clinical use.

The main conclusions are:

a. Sevriton, Concise and Isopast (unfilled, macro-filled and micro-filled, resp.) show a measurable abrasion with respect to the starting situation after 5 months ($p < 0.05$), Concise even after 1 month ($p < 0.05$).
b. Miradapt, Heliosit and Heliomolar do NOT show a significant abrasion after 18 months.
c. The macro-filled type composite (Concise) abrades significantly more than the micro-filled types and the macro-micro-filled type Miradapt.
d. The unfilled PMMA type composite (Sevriton) abrades sig-

nificantly more than the micro-filled types Heliosit and Heliomolar.

e. There is NO statistically significant difference between the abrasion of Concise (macro-filled) and Sevriton (unfilled).

In chapter 5 mechanical and chemical properties of the composite systems investigated are compared.

The main conclusions are:

a. Hardness measurements:
   1. Microhardness values (KHN) of the composite systems after 18 months in vivo are significantly higher than the 24 hours data.
   2. The *ratio* of the in vivo KHN values with respect to the 24 hours values is about 2-3.
   3. Hardness increase in vivo is nearly independent of the composite system.

b. Infra-red spectroscopy: the C = C bond content is after 1½ years in vivo use comparable for all composite systems studied.

c. Compressive strength and compression data:
   1. The composite system determines the numerical maximum compressive strength; it does in vitro not measurably change in time over 1½ years. The light cured systems, however, increase substantially in compressive strength.
   2. Water uptake does not measurably influence compressive strength.
   3. Ranking the 6 composite systems according to their maximum compressive strength values:
      Heliosit > Miradapt ∿ Concise ∿ Heliomolar ∿ Isopast >> Sevriton.
   4. The compression module values for Concise (macro-filled) and Miradapt (macro-micro-filled) are comparable and about 2 times higher than the modules for unfilled or microfine-filled composites.

d. Water uptake experiments. They show that if we rank the 3 composite types according to water uptake:
   1. Unfilled polymer >> microfine-filled composites > macro-filled composites.
   2. Dimension increase caused by water uptake in all composites is always more than the dimension decrease caused by polymerization shrinkage.

In chapter 6 the main results and conclusions on the SEM investigated *in vivo* used composites are given. Investigated were in detail both the abraded surfaces as well as the composite surfaces previously in contact with dentine or enamel (not abraded).

Separately, SEM data are presented on the marginal integraty of the 6 composite systems after 1½ years in vivo.

The main conclusions are:

a. The in vivo abraded composite surface is VERY different from the composite surface previously in contact with dentine or enamel.
b. The structure of the abraded composite surface has changed in vivo strongly and shows numerous cracks and porosities (surface degradation).
c. The degradation mentioned above occurs in unfilled, macro-filled and in the micro-filled systems.
d. Marginal fracture in the 6 composite systems investigated was not a problem.

The surface degradation is most likely directly related to the occlusal abrasion. It is concluded that composite abrasion is due to the combination of: mechanical loading and chemical attack from the agressive oral environment and occurs as follows:

As a (first) possible step, mechanical forces loading the composite restorations numerous times a day at various points, cause micro cracks in the composite. Subsequently, as a second step, the oral environment (chemically) causes in and near these micro cracks a chemical breakdown of the composite surface resulting in local porosities penetrating in depth depending on the composite *type:*

1) microfine-filled < macro-filled < unfilled systems.

2) light cured < cold cured.

(In reality it is not known if the steps one and two occur in this sequence or that chemical attack preceeds mechanical damage).

As a third step, the mechanical forces remove the weak and porous surface layer and the cycle is repeated.

In chapter 7 an in vitro pilot study of chemical attack on composites *in vitro* is described; the influence of detergents, oxidising and alkaline agents on composites was checked and measured by means of SEM micrographs.

The preliminary conclusions are:
There is no significant difference between the degree of surface destruction (degradation) or destruction depth from 3 weeks upto 1 year in this mechanically unloaded situation. The fact that 1) in vitro chemical attack is limited to a thin surface layer and 2) in vivo abrasion of unloaded composites (e.g. cervically) is not measurable, substantiate both the abrasion model mentioned in chapter 6.

For the clinical practice the following results are important:

a. Abrasion (in class I situations) of modern composites is comparable to amalgam abrasion and in practice negligable.
b. Microfine composites show the least clinical abrasion.
c. Light cured composites abrade less than cold cured systems in vivo.
d. Marginal fracture of modern composites is not a limiting factor for use in vivo.
e. Composite fillings increase in hardness in vivo.
f. Abrasion in vivo is on one hand depending on the mechanical loading and on the other hand on chemical attack in the mouth.