Aesthetic analysis of natural anterior teeth and their restoration with resin composites
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CHAPTER 10

Summary, conclusions and future perspectives
Resin composite materials are widely used in today’s dental practice due to their relatively good bio-compatibility, handling properties and acceptable low price especially when compared to ceramic materials. Furthermore they permit a minimal invasive treatment approach allowing a maximum conservation of sound tissues. This treatment philosophy represents one of the biggest advancements in modern operative and restorative dentistry which is, nowadays, able to furnish highly aesthetic resin composite materials which have an acceptable behaviour in oral mouth.

The present thesis deals with the aesthetic analysis of natural anterior teeth and their restorations with resin composites. The focus is on colour of natural teeth which are faced with the ones present in today’s resin composite restorative materials.

Chapter 2 describes a laboratory study on the marginal adaptation of Class IV restorations made of different resin composite materials designed for anterior use. The restorations were submitted to cyclic incisal stress and thermal loading, under simulation of dentinal simulation fluid pressure.

Two working hypotheses were present in this article: the first, which had to be accepted, was that marginal adaptation could been significantly and negatively influenced by loading. The second one, which had to be rejected, was that no significant difference in marginal adaptation can be seen within the tested materials when used with their respective adhesive system.

The positive results of the fine-hybrid composite materials used in this in vitro study (Miris, Point4, Esthet-X and Clearfil) at enamel margins give a quite favourable prediction for the long term clinical behaviour of marginal adaptation on enamel of these materials.

In conclusion, although an enormous progress has been made in the field of dentin adhesion, the quality of marginal adaptation on dentin was lower than that on enamel and showed a large variability. Within the limitations of this study caution is thus recommended for the use of direct resin composite restoratives for Class IV restorations if the margins are located in dentin.

Chapter 3 deals with the changes in surface gloss of different resin composite materials after simulation of mechanical and chemical ageing mechanisms. The working hypothesis, which had to be accepted, was that mechanical and chemical agents are able to decrease surface gloss of resin composite materials.

In this study significant differences between surface gloss of the resin composite materials tested were detected after simulated brushing. With the exception of Filtek Silorane, all tested resin composite materials were significantly affected by immersion in Elmex gelée®. Immersion in 75% alcohol aqueous solution significantly affected surface gloss except natural enamel and Durafill.
It can be concluded that no artificial material has shown behaviour comparable to that of natural enamel which demonstrated to be the best material in respect to optical properties and behaviour throughout mechanical (i.e. toothbrushing) and chemical (i.e. acidic and alcoholic attack) degradation.

**Chapter 4** evaluates the colour stability of different resin composites types designed for aesthetic anterior restorations when continuously exposed to various staining agents. The working hypothesis stating that resin composites are not susceptible to staining by different food and drink colorants had to be rejected.

Wine proved to have the highest staining potential followed by coffee, tea, orange and cola which had the lowest staining potential. The highest colour change measured against white background was observed for Durafill in wine ($\Delta E=62.3$), while the least staining was found for Enamel HFO in cola ($\Delta E=3.5$). The highest colour change measured against a black background was observed for Esthet-X in wine ($\Delta E=46.0$), while the least staining was observed for Enamel HFO in cola ($\Delta E=2.5$).

The results obtained from the present study inform clinicians about the staining susceptibility of the restorative materials tested taking into account patient's dietary habits. For instance, Durafill with its high susceptibility to staining by red wine or Enamel HFO susceptible to staining by tea, might not be the materials of choice for patients who are heavy consumers of these substances.

In conclusion it can be supposed that the colour of aesthetic restorations can be maintained over a longer period of time in the oral environment either by introducing some restrictions to patient's dietary habits or by carefully choosing the type of material best compatible with their dietary lifestyle.

**Chapter 5** evaluates the influence of 1 week water storage on colour stability of A2 enamel and dentin shade of 13 resin composites intended for anterior restorations and to evaluate the interchangeability of different brands of resin composites of equal colour shade. Two working hypotheses were present in this article: the first, which had to be partially accepted, was that 1 week water storage does not change the colour of a resin composite. The second one, which had to be rejected, was that all resin composites of equal shade do not have a visible colour difference.

In this study 6 samples per shade were prepared as 1 mm thick discs of 10 mm diameter. $L^*a^*b^*$ and contrast ratio (CR) were measured immediately after light curing and after 1 week in water at $37 \, ^\circ\mathrm{C}$ in the dark. Then all samples were compared against each other. The greatest colour change was found for Enamel A2 Artemis ($\Delta E$
3.14) with white background while the smallest was observed for Dentin A2 Filtek ($\Delta E$ 0.29) with black background.

In conclusion this study showed in general a good colour stability of the composites tested after water hydrolysis test while huge differences were detected when the $L^*a^*b^*$ values of A2 shade of different manufacturers were compared.

Furthermore $L^*a^*b^*$ and CR values could be, in the future, integrated into the software of dental spectrophotometers which, after a quick scanning of the concerned tooth, could then be able to suggest the best colour choice (brand and colour) that perfectly match with the sound enamel and dentin. This approach could finally lead to a quantitative and objective determination of the colour of natural teeth and the possibility to achieve predictable invisible restorations.

**Chapter 6** illustrates a new classification of resin-based aesthetic restorative materials based on the characterization of their matrix and their filler morphology. Four samples per material were prepared for SEM evaluation. Each sample was treated with chloroform to dissolve its matrix in order to evidence the filler morphology. A general scheme of four different matrix systems which characterize the material’s level of hydrophobicity can be put in evidence. The subsequent filler analysis enables the determination of a more complex scheme based on filler size and composition. A new classification based on matrix nature and filler morphology can then be proposed. This kind of systematic categorization, which takes in consideration not only filler’s size but also resin matrix nature, allows a better understanding of the clinical properties of resin composites as well as comompers, ormocers, and siloranes.

**Chapter 7** proposes a novel spectrophotometric approach to evaluate the aesthetic properties of incisors, which was developed and applied on a preliminary group of subjects. The aim of this study was therefore to develop a spectrophotometer and digital image-based quantitative method to measure CIE $L^*a^*b^*$, transparency (CR) and opalescence of incisor teeth (2mm pure enamel and 3mm enamel-dentin complex made of 1.5mm enamel and 1.5mm dentin) *in vivo* that is rapid enough to be suitable for a large group of subjects.

The mean values of $L^*$ of the enamel-dentin complex against black and white background were 79.6 and 75.4, respectively. The mean values of $a^*$ were 2.5 against black and 0.8 against white background, respectively. The mean values of $b^*$ were 17.4 against black and 13.0 against white background, respectively. The mean contrast ratio was 86.7%. Opalescence value was 4.8. The mean values of $L^*$ of enamel against black and white background were 79.0 and 64.2, respectively. The mean values of $a^*$ were 2.1 against black and -0.3 against white background, respectively. The mean
values of $b^*$ were 15.2 against black and 8.7 against white background, respectively. The mean contrast ratio was 60.5%. Opalescence value was 7.4.

The described methodology, applied on a larger group of subjects, may serve as a database for a more exact characterization of optical properties of natural enamel and dentin which may be useful for further developments of aesthetic restorative materials.

**Chapter 8** describes an *in vivo* study, applied on a Swiss Army recruits group, quantifying $L^*a^*b^*$ values of pure enamel as well as of enamel-dentin complex against black and white background together with CR. Two working hypotheses were present in this article: the first was to investigate the $L^*a^*b^*$ and the opacity (CR) of front teeth by means of an image spectrophotometer trying to evaluate the eventual influence of the background colour on the results. The second one, which had to be partially rejected, was that tea, coffee, red wine drinking habits or smoking habits of the tested subjects could influence tooth colour in a young population. The approach followed in this study is the one described in chapter 7.

When 2mm thick pure enamel was considered, the values obtained were (mean (SD)) $L^*(76.3 (3.4))$, $a^*(3.4 (1.2))$ and $b^*(17.2 (2.45))$ against white background and $L^*(63.5 (4.2))$, $a^*(0.8 (1.3))$ and $b^*(10.7 (2.7))$ against black background. The opacity (CR) of 2mm thick pure enamel was (64.4 (0.1)).

When 3mm thick enamel-dentin complex were considered, the values obtained were $L^*(79.0 (2.6))$, $a^*(3.9 (1.3))$ and $b^*(20.4 (3.0))$ against a white background and $L^*(74.9 (3.0))$, $a^*(1.8 (1.2))$ and $b^*(16.7 (3.1))$ against a black background. The opacity (CR) of 3 mm thick enamel-dentin complex was (87.4 (0.1)).

It is of evidence that the influence of the background on the results was highly significant, while only a marginal influence of the drinking habits (only tea showed to decrease $L^*$ values in pure enamel when analysed against black background) could be found.

**Chapter 9** describes an easy approach for managing small superficial defects in light to medium fluorosis. This technique is based on a selective abrasion of the superficial enamel and a re-creation of the superficial macro and micro morphology. The aesthetic appearance is then enhanced by a power or a home bleaching. Of course, the presented technique enables the management of enamel defects, which are confined in the most external enamel surface, with satisfying aesthetic results.

This combined chemo-mechanical approach may be considered an interesting alternative to more invasive prosthetic techniques based on resin composite reconstructions or ceramic veneers and even chair-time if compared to the classical micro-abrasion. Furthermore, this new minimal invasive approach allows good aesthetic results and a possible cost reduction for the patient.