CHAPTER 1

Introduction
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Traumatic incidents, vast carious lesions and replacements of large infiltrated Class III resin composite restorations may result in a significant loss of substance in anterior teeth. In former days, crowns were usually the treatment of choice for such cases [1]. However, crown preparations often require a significant sacrifice of sound dental structure with the risk of pulpal complications, gingival recessions and mechanical failures [2]. Modern dentistry is evolving towards less invasive restorative procedures. One possible alternative is the use of ceramic veneers [3]. Their preparation is far less destructive in respect to full crown coverage and they are able to re-establish the strength of the restored tooth to almost 100% [4]. However, they still require removal of sound tooth structure. Another alternative is the use of direct adhesive composite restorations. They are truly minimally invasive. In fact, in most cases, no removal of sound tooth structure is required, except a marginal bevel [5, 6].

Due to the availability of tooth coloured restorations, the demand of patients for imperceptible and long-lasting aesthetic restorations is steadily increasing [1]. Besides the restorations’ shape [7] which is constantly thought to be one of the major elements, other factors such as colour, gloss, staining, ageing behaviour, mechanical structure and fatigue resistance have to be considered in order to achieve a complete and durable aesthetic success.

Nowadays, in fact, a large number of aesthetic resin composites are available in the market but scarce data are published on their behaviour with ageing. Once a resin composite material is used by the dentist for a dental restoration in a patient’s mouth, a complex sequence of events takes place that leads to the ageing of the material. Hydrolysis and temperature changes [8] may attack the resin matrix of both posterior and anterior composites, causing aesthetic changes such as colour variation. Furthermore, in literature no data are available yet, in order to evaluate the interchangeability of different brands of composites of equal colour shade immediately after curing and after ageing (Chapter 5).

In order to evaluate colour two approaches are possible: qualitative and quantitative. The qualitative way is based on the subjective comparison of the sample to a shade guide. In two studies (Chapters 7, 8) described in this thesis it was decided to use the quantitative approach by using a spectrophotometer to avoid bias due to human perception limitations. The parameters to take into account (according to CIE L*a*b*; 1976 colour space parameters) are L* (luminosity), a* (quantity of green-red) and b* (quantity of blue-yellow), CR (opacity) and opalescence (the ability to reflect blue wavelength when white light stroke the object perpendicularly) [9].
The same scientific approach should even be used in order to evaluate the staining capacity of the newly developed resin composites which are claimed by its manufacturers as designed for aesthetic anterior restorations.

Besides relatively satisfactory results observed in short term laboratory studies [10-12], some clinical trials [13-18] suggest a susceptibility of resin composite restoratives to discolouration over long periods of time.

This apparent discordance between in-vitro and in-vivo observations could be due to the relatively short immersion time of samples in staining solutions which do not replicate adequately long term in-vivo exposure to food and drink colourants. This hypothesis seems to be confirmed by two medium term laboratory reports [19, 20] which actually showed higher discolouration rates than other laboratory studies [10-12]. In absence of long term published in-vitro simulations of resin composite colour stability, a laboratory test should be developed which gives a more matching prediction of the clinical aesthetic longevity of resin composites (Chapter 4).

Anyway, not only “colour dimensions” including translucency and opalescence parameters, but also surface gloss is of paramount importance. It is well known that resin composite surfaces may be polished to a high lustre if appropriate polishing procedures are performed [21]. However, clinically, the high gloss level obtained immediately after polishing procedures is not preserved in the oral environment over a long time, leading to a matt surface. Mechanical wear as well as chemical degradation of resin composite may cause changes in surface gloss resulting in deteriorated aesthetics over time. This surface degradation can be due to several factors: wear of fillers, degradation of the resin matrix or weakening of resin-filler bonding. Clinically, this kind of superficial degradation can cause aesthetic problems especially in patients who present a high lip line. In this case, in fact, being upper front teeth free of saliva the different refraction index between natural tooth and resin composite can cause a severe aesthetic problem. A study concerning the evaluation of the influence of matrix nature and filler construction on changes of surface gloss of different resin composite materials immediately after polishing and after simulation of mechanical and chemical ageing should be suitable (Chapter 3).

These two main components of resin composite, i.e. matrix and fillers, have dramatically changed in the last decades. In fact, from the early 1970’s on, adhesive materials, and especially resin composites, have been considerably improved by their manufacturers, with regard to mechanical and aesthetic behaviour. This is mainly achieved by continuous attempts to change their filler morphology. Particularly, the latest developments in nanotechnology have radically changed their particles’ size and behaviour. As a consequence contemporary resin composite materials are very
different from those of the 1970’s. Due to continuous changes from the 1980’s on, resin composite classifications based on average particle size, manufacturing techniques, and filler chemical composition have been introduced [22-26]. All these classifications show the dramatic changes that have been taken place: barium glass has been added for radiopacity, amorphous silica has been introduced for improved handling, ytterbium glass particles have been added for enhanced aesthetic effects, and particles have become spherical and smaller, reaching nano-dimensions [23]. On the other hand, not only fillers have changed with time, but even matrix components have been modified, becoming more hydrophobic. Therefore, current classifications do not sufficiently reflect the properties relevant for a clinical choice of a restorative material, as they are based only on fillers characterization. Consequently, a new classification in order to describe old and new resin composite materials on a morphological basis should be proposed. Chapter 6 thus, describes a new classification of aesthetic adhesive materials. Another factor such as marginal integrity is of main importance in aesthetic restorations. Marginal gaps, in fact, result in secondary caries, discolourations and tooth sensitivity. In order to achieve better homogeneity and higher marginal seal, manufacturers have created new resin composite materials with different elastic moduli. The influence of this variable, anyway, has not been yet investigated in-vitro or in-vivo. There is actually few information about long term behaviour of resin composite materials under function, especially in terms of marginal adaptation [27]. Clinical validation is definitely the most appropriate evaluation method of this parameter but it takes several years to get meaningful results. Besides some studies from the early nineties, no recent long term prospective controlled clinical trials on adhesive Class IV resin composite restorations are available in the literature. In Chapter 2 a study is described which evaluates in vitro the marginal adaptation of large Class IV adhesive composite restorations in enamel and in dentin, in a simulated clinical environment.

Restorative materials for imperceptible dental restorations must, anyway, perfectly match optical properties of teeth. Almost every aesthetic restorative material sticks to the Vita shade guide. Nevertheless, this scale is only a rough approximation of the clinical reality of tooth colours as shade selection is done by mixing the colour information of enamel and dentin. Due to this outdated concept, the majority of epidemiologic tooth colour studies have been done by measuring the colour of the entire tooth. This approach has already been criticized and shade selection based on the separate choice of enamel and dentin colour has been proposed [28-30]. Anyway, no study has, so far, tried to measure in vivo on a larger number of subjects, by means of a spectrophotometer, the optical properties of enamel and dentin. The only few data
in this field are, in fact, available from in vitro measurements [31, 32] and limited to a low number of samples. The investigation of the L*a*b*, opacity (CR) and opalescence of front teeth by means of an image spectrophotometer and the eventual influence of the background colour on the results could be useful in order to create a database of aesthetic parameters of teeth (Chapters 7, 8). These data might be useful for further developments of aesthetic restorative materials.

Not all aesthetic dischromies have to be treated by means of an adhesive approach. In recent decades, in fact, due to fluoridation of drinking water and the addition of fluoride into milk and salt, fluorosis has increased in western countries [33-35] causing aesthetic problems in certain populations. Teeth affected by fluorosis were, in the past, treated by conventional prosthodontics. Nowadays a more conservative approach based on cheaper and less chair time consuming treatments as bleaching techniques, micro-abrasive treatments and resin composites restorations is suited. Unlikely, even if micro-abrasion is less expensive than a prosthetic approach, it can still be expensive due to its high chair time, especially in cases of medium to severe fluorosis where the treatment has to be repeated several times.

Other inexpensive treatments should be investigated for managing small superficial defects as the ones present in medium to medium-severe fluorosis (Chapter 9). These methods should follow the criteria of minimal invasive restoration [36] and reduction of chair working time allowing a biological and economical advantage for patients.

In conclusion, in this thesis, chapter two compares the marginal adaptation of large Class IV adhesive composite restorations in enamel and in dentin, in simulated in vitro clinical environment, chapter three investigates the influence of mechanical and chemical degradation on surface gloss of resin composite materials, chapter four is based on a long-term laboratory test on staining susceptibility of “aesthetic” resin composite materials. Chapter 5 is about the evaluation of colour compatibility, colour stability and contrast ratio of resin composites, chapter six proposes a new classification of aesthetic adhesive materials and in chapter seven a quantitative clinical evaluation of aesthetic properties of incisors is described. This method is then used as base for an epidemiologic study on L*a*b* and opacity of central incisors of Swiss Army’s soldiers as described in chapter eight and a chemo-mechanical approach as a quick and easy technique for the aesthetic management of superficial enamel defects is proposed in chapter nine.
References

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