EuroCondenser

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In this issue:

EDITORIAL

Pace of Change

With the exponential increase in new knowledge and understanding, change is not only inevitable, it is relentless and rapid. Keeping abreast of change in Operative Dentistry, let alone the wider field of Conservative Dentistry, is a challenge for practitioners, teachers and researchers alike, but one that must be met in the interests of patients, students and the future of the profession. Meeting the challenge involves active participation in continuing profession development, including self-directed learning from periodicals, books, the internet and other information sources, and through interaction with colleagues at conferences and courses. Given that 60-70% of the provision of dental care comprises some aspect of Operative/Conservative Dentistry, membership and participation in the activities of the Academy of Operative Dentistry (AOD), its European section (AODES) and, in turn, the European Federation of Conservative Dentistry, of which AODES is a founder member, can pay great dividends in terms of keeping pace with change. Read on into this issue of EuroCondenser to learn more about AOD, AODES and EFCD. Details of how to apply for membership are included near the end of the newsletter. Immediate action is recommended. Where else will you have access to and be part of so much knowledge and understanding in the field.

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PRESIDENT'S MESSAGE

Goals

It is a great honour and privilege for me to be President of the Academy of Operative Dentistry European Section (AODES) for the next two years.

On behalf of the AODES, I would wish to express our sincere thanks to the Section's Immediate-past President – Ivo Krejci, and all the members of the Board of the Section for their commitment and efforts in enhancing the standing of AODES across Europe.

The first goal of my presidency is to establish contact and encourage dialogue with all individuals involved in teaching and research in Operative Dentistry across Europe. This will hopefully facilitate harmonization of academic endeavour in Operative/Conservative Dentistry across Europe and, in the process, allow AODES to further develop as an important forum for the exchange of views and data amongst all those with special interest and expertise in the field. Such action is necessary to strengthen, and have others appreciate the considerable importance of Operative/Conservative

Dentistry in dental education and the clinical practice of dentistry.

My second goal is to expand the membership of AODES, to include many more colleagues with roles and interests in Operative/Conservative Dentistry. Greater awareness of AODES and the benefits of membership will be achieved through an increased circulation of EuroCondenser free of charge, open access to the AODES website (www.aodes.be) and holding meetings around Europe of interest to practitioners and academics alike.

To achieve my two goals, I am looking forward to the continuing, invaluable support of all the Past Presidents of the Section – Nairn Wilson, Alphons Plasschaert, Guido Vanherle and Ivo Krejci, the other members of the Board – Paul Lambrechts (Secretary), Yo Gullentops (Assistant Secretary) and Ann Shearer (Treasurer) who recently succeeded Paul Brunton and, of course, the growing membership of the Section. Together we can make AODES a substantial part of the Academy and a major driving force for Operative/Conservative Dentistry in Europe.

Your President,
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AODES Leuven 2004 Revisited: Selected Reports

In vitro testing of restorative materials.

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Introduction

The use of resin-based particulate, reinforced composites, in combination with adhesives, has turned the restoration of teeth into tooth repair and reinforcement, assuming adhesive bonding can be achieved between remaining tooth tissues and the restorative material. The average life expectancy of adhesively bonded composite fillings is, however, somewhere in the range of six years, thereby necessitating frequent replacement, repair or refurbishment of the filling (Mjör et al. 2000). The ever increasing demand for improvements in restorative materials, together with the continuing demand for optimal aesthetics fuels a quick turn-over of available materials and the frequent introduction of new ones, often with little, if any, clinical validation. One of the main reasons for this unsatisfactory set of affairs is the cost and time taken to conduct good quality clinical trials, which are widely regarded to be the ultimate test of a material.

In vitro studies, in contrast to clinical investigations, are relatively inexpensive and quick to conduct. The laboratory screening of new materials should, in the absence of clinical data, be an essential requirement prior to the release of a new material for clinical use. Such screening may be used to identify those materials for which clinical testing is important if not essential. Over the last 30-40 years sustained efforts have been made to identify properties of materials, such as composites, which may predict, or at least help explain clinical performance. This paper considers the properties of materials which have been found helpful in understanding behaviour in the oral environment.

Ideal properties

Prior to considering which properties of a material need improving, it is of the utmost importance to define the ideal properties for that type of restorative system. First and foremost, a restorative material should be self-adhesive to both enamel and dentine, or, failing that, capable of being bonded to remaining tooth tissues using a simple, one step etch and prime approach. Such materials should be capable of being cured to any depth with a single application of light, or be of a dual-cure formulation.

In curing, the material should suffer little, if any shrinkage and thereby give rise to minimal, if any, stresses in the restored tooth unit which, under normal circumstances, may give rise to marginal and interfacial gap formation. Other ideal properties include good biocompatibility, an anticariogenic effect and a high level of conversion on curing, giving low water sorption, colour stability and the absence of the release of any leachants which may give rise to unacceptable side-effects. From a mechanical point of view, a composite should be highly filled for strength and favourable stiffness and toughness, while, at one and the same time, have the capacity to handle well and maintain its shape during placement. Given all these properties, the material should have a high resistance to wear and marginal breakdown with good polishability and aesthetic qualities.

Unfortunately, clinical studies indicate that no one material is ideal and that there is quite some way to go to obtain the "perfect" material. The main reason for the replacement of restorations, irrespective of the type of material used, is secondary caries as diagnosed clinically, followed by fracture of the restoration and/or the remaining tooth tissues. To understand these latter phenomena , it is necessary to look at what happens during the functional loading of a restored tooth unit. Occlusal loading directly, or indirectly through a food bolus creates tensile, compressive and shear stresses at different locations with the structure. Based on this understanding, the most relevant mechanical properties may be considered to be strength, fracture toughness, wear and fatigue, followed by others including the elastic modulus.

Elastic modulus

Since the type of test will influence the magnitude of the measured value, it seems most appropriate to look at the relative ranking of the different types of material available. From these results, it becomes clear that classifying materials into groups or generic types, eg, 'posterior composite', does not reflect behavior in terms of elastic modulus, given the wide spread in the magnitude of measured values. The same holds for other types of materials. To understand the influence of the elastic modulus on marginal behavior, think of a Class V cavity that should be restored. In such a situation a low elastic modulus could be of importance given the flexure of the tooth at its fulcrum (Lambrechts et al., 1995). A low elastic modulus material such as a microfilled composite could be hypothesized to survive the stresses exerted on the margins and the adhesive interface better than a highly filled hybrid material. Although an appealing concept, the clinical reality is different (Browning et al., 2000): after two years the same percentage retention was observed for Z100 and Silux Plus suggesting that elastic modulus, which is about three times greater for Z100, did not influence the success of the Class V restorations. So, exit the elastic modulus as a predictor of clinical success.

Flexural strength and Fracture toughness

Almost identical predictor outcomes hold true for elastic modulus and strength properties. Given the mix of strength values for artificially grouped materials, the prediction is not sustained by clinical evidence, although it has been suggested that flexure strength and modulus of resilience may be correlated with clinical wear (Peutzfeld and Asmussen, 1992).
The story starts to be a little different once fracture toughness is studied. It would appear that fracture related failures in Class IV restorations show a relative high correlation with fracture toughness - microfilled materials not performing as well as hybrid materials in such situations. A relationship with clinical wear was hypothesized, and later confirmed using experimental formulations where filler fraction, degree of conversion and quality of silanisation was studied: flexural strength and fracture toughness showing the best correlation with clinical wear (Truong and Tyas, 1988).
For microfilled materials which show a high degree of marginal breakdown (Tyas, 1990), fracture toughness could well be an indicator of this susceptibility (Ferracane et al., 1997). Elastic modulus fails to contribute to a significant relationship in the tooth flexure concept.

Fatigue

Fatigue and wear are complex properties which other properties and environmental factors will influence in determining the behavior of a material under clinical circumstances. The oral environment is a challenging one. Masticatory forces range from 1 kg up to 150 kg under peak loading conditions. These forces result in tensile, compressive and shear stresses (McCabe et al., 2000). At the same time there are chemical challenges by acids, esterases and alcohol to name only a few. Temperature changes from 0°C to 50°C are possible, and last, but not least, bacterial exposure may be important. In spite of all this, relatively few fatigue studies have been carried out clinically.
Available date indicates that there is a distinct difference between the results from dynamic testing such as fatigue testing and those obtained from quasi-static testing. Fatigue resistance cannot be estimated from laboratory findings for elastic modulus and strength properties. Fatigue resistance is also not possible to estimate from structural material properties such as filler fraction (Braem et al., 1994a, b; Braem et al., 1995).
It is therefore necessary to undertake fatigue testing to be able to understand a material's resistance to fatigue. One way to do this is to apply alternating or cyclic loads to a material to study bulk fatigue behaviour. Ideally this is performed at a clinically relevant test frequency, in a wet environment at oral temperatures and, of course, at clinically relevant loads. A relatively quick way to achieve this is to apply the so-called staircase approach in which one is able to decrease the applied load on a sample when the previous one has failed, or increase the load when the previous sample has survived the test conditions. This results in the so-called fatigue limit, with a 50 percent probability of failure or survival for an untested sample.
The results show that any relationship that existed between structure and mechanical quasi-static property is not duplicated into cyclic testing results: the fatigue limit shows a completely different story. It can sharply discriminate between and within groups of materials, thereby emphasizing that classification such as "flowable" composites is not translated into a group behavior as far as fatigue resistance is concerned. The results also indicate that laboratory processed composites, as opposed to direct filling materials, do not benefit from optimized curing procedures, as this is not translated into an improved fatigue resistance. It turns out that fatigue resistance, which in fact is a crack-growth related phenomenon, accurately reflects the degree of internal disarrangement of loose filler particles, acting as stress concentrators and eventually causing loss of the filling.

Since there is a pronounced effect of crack growth on fatigue resistance, it is not surprising that fracture toughness, which is a measure of the resistance to crack growth, can be correlated with fatigue limit. The link to the clinic is then reflected in the ranking of the materials according to their fatigue resistance, showing, for example, that conventional glass-ionomers have the least fatigue resistance, followed by the resin-modified glass-ionomers, the poly-acid modified composites and finally hybrid composites with the highest fatigue resistance.
It is of course not just the fatigue limit of the bulk material that will, in most cases, determine the life span

of a filling. More important will be the survival of the adhesive bond to, in particular, dentine. Almost no data are available on this subject. This may be studied using a microrotary fatigue test (De Munck et al., 2004) or a microshear test, both methods applying a cyclic load with alternating compressive and tensile stresses located at the interface. The results obtained with the micro-shear test again confirm clinical findings: the spontaneously adhering resin-modified glass-ionomers show the weakest fatigue resistance, followed by the self-etch adhesive and on top the classic etch/prime combination of adhesives. Sometimes dynamic tests yield results that cannot easily be understood; for example, on reusing dentin samples within test groups, it was found that for a resin-modified glass-ionomer there was a 50% increase in microshear fatigue limit. Further investigations are necessary to understand such outcomes.

Conclusions

Unfortunately, to date there is no single property capable of predicting the complexity of clinical behavior. Thanks to dynamic fatigue studies, however, some progress is being made. At the same time new understanding of what is going on when fillings and interfaces are dynamically stressed, is raising new questions which need to be addressed.

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Correlation between in vitro testing and clinical performance

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While there is no single property of a dental material capable of predicting the complexity of clinical behaviour, it is important to understand possible correlations between the findings of *in vitro* testing and clinical performance.

Bond strength

How can an adhesive restoration be tested to determine its fitness for clinical service? There have been countless studies on bond strength performed using different methodologies. A study by the group of Bernd Haller in Ulm, Germany indicated clearly that no bond strength measurement is able to predict clinical performance; no correlation was observed between bond strength and marginal adaptation.

Micromorphology

Micromorphology is able to describe the different features of the hybrid layer formed by different bonding systems on dental substrates. These features are mainly system dependent, indicating the importance of the nature of the interaction between the adhesive and the substrate. It is sometimes claimed that some of the features of the hybrid layer could be of help in predicting clinical effectiveness. Studies perfomed at the School of Dentistry, University of Geneva failed to demonstrate any such correlation. In fact, there was no evidence leading to a conclusion that features of the adhesive interface, such as the thickness of the hybrid layer or the presence or length of tags allow a prognosis in respect of marginal adaptation.[2]

Shrinkage
An important property of restorative materials is the volume change during hardening. All resin composites shrink during polymerisation, but distinction has to be made between different types of composites. Flowable composite resins develop about 50% more stress than conventional composite resins during hardening, as seen in Fig. 1[3].

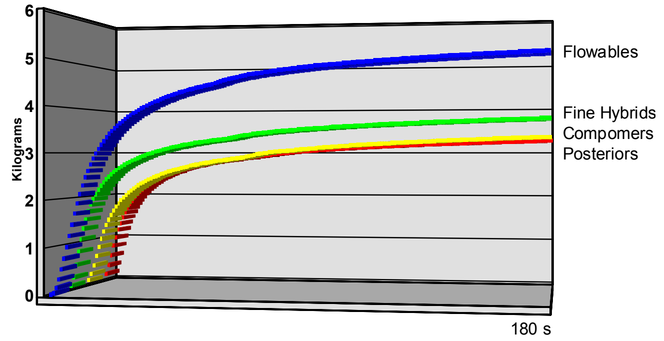


Fig. 1 Stresses developed by different resin composites

Marginal adaptation is dependent on many factors, including the nature of dimensional shrinkage, the shrinkage speed and the shrinkage stress. Testing the influence of these variables in shrinkage stress, it has been found that marginal adaptation is significantly better with a material with a low shrinkage stress. But after loaded this difference disappeared completely. Later investigations analysed the correlation between the shrinkage speed and subsequent marginal adaptation. Materials that polymerize rapidly show a lower tendency to flow, while chemical cured composite resins exhibit a greater capacity to flow. Comparing the marginal adaptation of materials with a high and low degree of flow it was found, after loading, that all significant differences in marginal adaptation disappeared.[4,5] Similar tests were performed to analyse differences in marginal adaptation with variations in shrinkage speed. Light curing composite resins can be polymerised either by a soft start or rapidly by exposure to the full intensity of the light source. A slow start polymerisation will diminish the shrinkage stress to approximately 10 - 15%. Marginal adaptation is slightly better following soft start polymerization, immediately after the filling procedure, but this difference in marginal adaptation disappears when the samples are loaded. These findings lead to the conclusion that properties of adhesive restorations are not able to predict clinical effectiveness.

The artificial mouth

In vitro testing, which may predict clinical effectiveness, must include all relevant factors that influence the clinical situation. These factors include:

- The substrate. Extracted human teeth should be preferred to bovine teeth. Although there is some correlation between substrates, the difference is too important to extrapolate results.
- Dentinal fluid simulation is necessary to test dentine adhesion. Fluid exchange within the dentine influences the bonding site, as has been reported in the literature. [6,7]
- The form and geometry of the cavity have an enormous influence on marginal adaptation. The survival of adhesion to the cavity walls is highly depended on the C-factor of the preparation. [8]
- Occlusal loading is important as most restorations are subjected to mechanical stresses. Direct loading by the antagonistic tooth is a risk factor for the integrity of dentine margins, in particular, in molars.[9] The loading must, however, remain within the clinical limits. In the artificial mouth samples are loaded sub-critically, <5kg for 1,200,000 cycles.
- Thermal loading is important as thermal conditions change constantly in the mouth. Furthermore, the thermal expansion coefficient of composite resin is also important. [10,11] In the artificial mouth loading is performed over 3,000 cycles, varying the temperature between 5 and 55 C°.
- Toothbrush-toothpaste abrasion will provide information in respect of the wear resistance of the filling material in contact free areas.
- Chemical disintegration can influence both the restorative material and the resin interface. As resin fillings and interfaces are subjected to chemical disintegration, this parameter should be included.

The realisation of true simulation is not an easy task. Over many years, the test methodology has been improved to a level at which good clinical approximation is possible. It is not possible, however, to mimic the clinical situation completely in an artificial mouth, but by combining all the relevant factors with correct values, the results are close to those obtained in the clinic. To date, good correlation is realised with clinical investigations spanning one year.

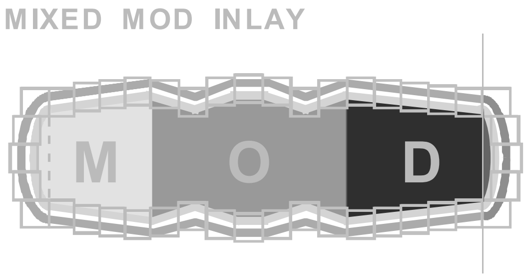


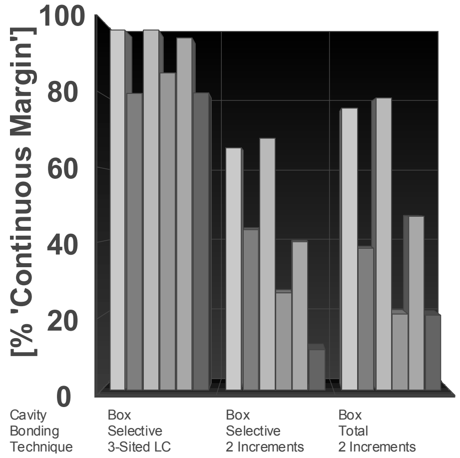
Fig. 2 Analysis of the margins of a mesio-occlusal-distal (MOD) by SEM pictures.

After the samples have been subjected to the tests conditions, an analysis of the margins is performed on SEM micrographs (x200). This examination is undertaken on replicas to make the test non-destructive. The effect of changing a variable during a second test can be subsequently analysed and compared with previous results on identical samples.
All margins are analysed as shown in Fig 2. The margins are characterized as continuous or faulty, once the following defects have been identified:

- marginal openings
- marginal tooth fractures

- marginal restoration fractures
- underfilled margins
- overfilled margins

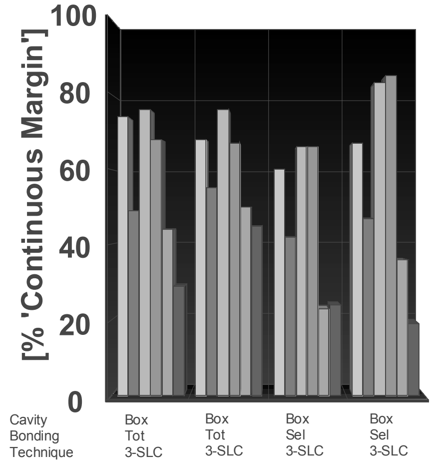
A



Mixed MOD Class II

1. total of continuous margins
2. total of continuous margins after loading
3. Cervical Enamel Before Loading
4. Cervical Enamel After Loading
5. Cervical Dentin Before Loading
6. Cervical Dentin After Loading

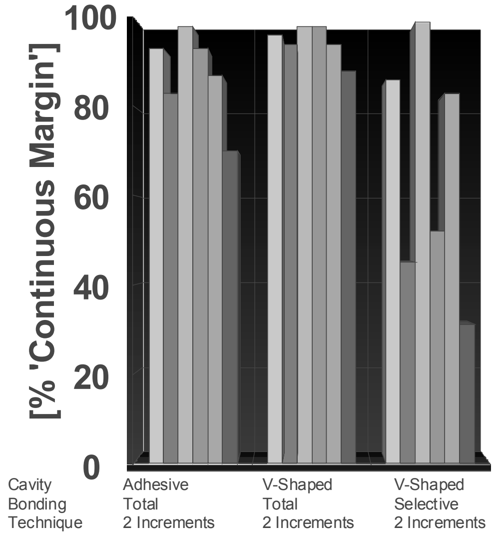
B



Mixed Class II Slot cavities

1. total of continuous margins
2. total of continuous margins after loading
3. Cervical Enamel Before Loading
4. Cervical Enamel After Loading
5. Cervical Dentin Before Loading
6. Cervical Dentin After Loading

C



Mixed Class V cavities

1. total % of continuous margins
2. total % of continuous margins after loading
3. Cervical Enamel Before Loading
4. Cervical Enamel After Loading
5. Cervical Dentin Before Loading
6. Cervical Dentin After Loading

Fig 3 A, B and C

Results % for continuous margins in different cavity forms. The results are expressed in six different bars. The order of the bars remains identical for all three tests.

Bonding, Selective adhesion is confined to the margins of the restoration; total adhesion involves the entire surface of the cavity, including the margins; Technique, 3-SLC; Three-sited light curing technique.

The analysis can be partial or selective for part of the restoration. Different options are available, including enamel versus dentine margins, occlusal versus proximal margins. The software program gives results for all margins or part of the restoration. To illustrate the importance of the cavity form, different results will be explained by reference to Fig 3. In these tests the composite resin and the adhesive system were identical. Only the cavity form and the restorative technique changed, according to the different tests and groups.

Mixed Class II MOD (Fig 3A)
In the first experiment a MOD cavity was filled after the bonding system had been applied selectively. The composite resin was light cured from three directions. The continuous margins value was 95% but was reduced to 82% after loading. Marginal adaptation was better in enamel than in dentine. An inferior result, in terms of marginal adaptation, was observed when the technique was changed to a "two increment filling procedure".

Slot cavity (Fig 3B)
The results were much worse than those for the MOD cavity. The results were better in enamel than in dentine. Direct occlusal loading (DL) had a mixed effect. The best results were obtained in the experiment in which three sited light curing was performed together with total adhesives.
In explaining these results, it is assumed that a MOD cavity is more flexible then a slot cavity, thereby avoiding more marginal defects. With a slot cavity the tooth structure is more rigid. As a consequence, stress is induced in the slot cavity, resulting in marginal defects.

Class V cavity - adhesive vs "V" shaped form (Fig 3C)
Best results in respect of continuous margins were observed in the "V" shaped cavity. Again, in this set of experiments marginal adaptation was significantly better in enamel than in dentine.
The "V" shaped cavity performed better because of a more favourable C factor, allowing plastic deformation, [12] and reducing the shrinking stress on the margins. The total application of the bonding system contributed to a more positive result.

Conclusions

Testing restorative materials *in vitro* should be undertaken in conditions that are close to clinical circumstances. It is very difficult to correlate single material properties with clinical effectiveness. Different parameters determine the longevity of dental restorations. Of these parameters marginal adaptation and seal of the restoration seem to be very important. Testing seal has to be done with consideration of all the clinical factors affecting this parameter.
In vitro testing in an artificial mouth, under clinical related parameters, has revealed that minor changes in clinical handling can substantially affect the results. The method is capable of determining optimum operative technique, thereby saving time, resources and patients discomfort.

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Adhesion to enamel and dentin: simple and effective?

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Adhesives strategies

Today, bonding to dental hard structures can be achieved by three adhesive strategies:[1]

1. Etch and rinse approach (E&R). This strategy involves etching of the tooth structure with an acid etchant (also called conditioner), such as phosphoric acid (H_3PO_4), which needs to rinsed off. In addition to conventional three-step E&R systems, simplified 2-step systems also exist.
2. In the self-etch (SE) approach, the application of a separate conditioner that needs to be rinsed away is omitted. In this approach, a two-step or one-step technique is possible.
3. The glass-ionomer cement (GIC) approach is important as glass-ionomers are capable of self (auto) adhesion. Adhesion to hard tooth structures by glass-ionomer materials is realised without the use of a bonding agent.

Bonding to enamel

In the E&R approach, the enamel surface is etched with an acid, usually H_3PO_4, which is immediately followed by rinsing. Microscopically, the etched surface displays a typical etch pattern characterised by the formation of retentive pits extending to a depth of 30 to 50 µm. These retentive pits are subsequently filled with the bonding agent, forming both macro- and microtags. Macrotags are formed between the enamel prism peripheries. Microtags are formed by the curing of the resin in pits at the core of the enamel prisms. Retention is obtained by micromechanical interlocking through tag formation.

The etch and rinse technique remains the most reliable approach to bonding a resin to enamel[2]. To measure the effectiveness of direct bonding strategies, the microtensile bond strength technique was developed.[3,4,5] E&R adhesives can be further subdivided into three-step and two-step adhesives. In the later, the procedure is shortened by having the primer and adhesive in one bottle. Both three-step and two-step systems produced (Fig. 1) high bond strength values to enamel. Although a small variation is noted among the different systems, no statistical differences were noticed in respect of enamel. Pooling all the data revealed an average bond strength of 42 MPa.

Bonding to enamel can also be realised by the SE approach in which the tooth structure is etched by an acidic primer. As the acid is not rinsed off, the dissolved minerals are incorporated in the interface. A frequently asked question is: Is enamel etched profoundly enough by SE systems? To answer this question a distinction has to be made between the different subgroups of SE approach systems.[6-x]

The President of AODES together with Frank Caughman, 34th President of the Academy at the 2006 AODES meeting in Rome. From left to right: Guido Vanherle, Alphons Plasschaert, George Vougiouklakis, Frank Caughman, Ivo Krejci, Nairn Wilson

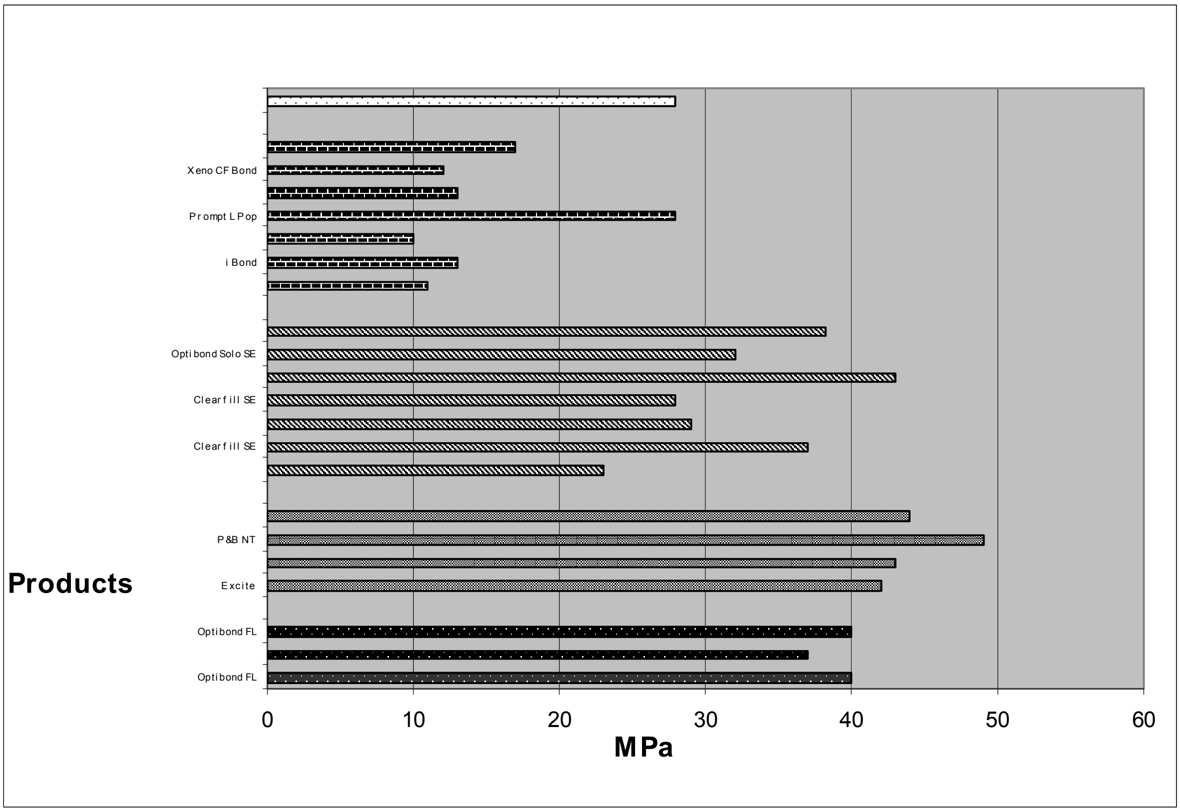


Fig. 1 Results of microtensile bond testing for different materials

3-step E&R 2-stepE&R 2-step SE 1-step SE RMGI

E & R, etch and rinse ; SE, self-etch ; RMGI, resin-modified glass ionomer cement

SE systems can be classified into three groups, based on the pH of the acidic primer:

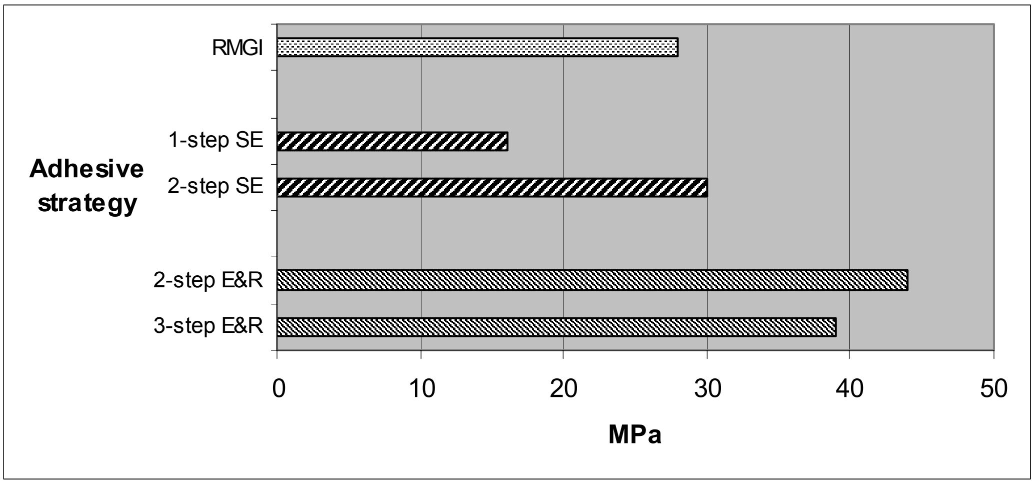
- strong SE systems with a pH < 1
- mild SE systems with a pH +/- = 2
- intermediary systems with a pH of 1.5

While in the strong subgroup an interaction of 4-5 µm occurs on the enamel surface, mild SE systems have little, if any, interaction. With the intermediary systems, the interaction is limited. Strong SE systems exhibit evident resin tags in SEM pictures, whereas with mild SE systems, only microtags can be identified at the interface.

Concerning the bonding effectiveness of these systems, microtensile bond strength results indicate considerable variation between the tested systems (Fig. 2). An average assessment of the effectiveness of the bond with two-step SE systems can be made by pooling all microtensile bond strength data and was 30 MPa (Fig.2). Despite a relatively low average microtensile bond strength for some two-step SE adhesives, systems in this group realise on average results similar to systems in the E&R group (see Fig. 1).

Regarding the one-step SE systems, effectiveness is low compared to all previous systems. Resin-modified glass-ionomer systems have average microtensile bond strengths comparable to two-step SE systems. Resin-modified glass-ionomer systems are, however, brittle materials, making direct comparisons with resin adhesive systems questionable.

Fig. 2 Average microtensile bond strength values to enamel



RMGI: resin-modified glass-ionomer cement; SE: self-etch

Bonding to dentin

Adhesion to dentine can be achieved with an E&R approach. Etching dentine with H_3PO_4 results in demineralisation of the surface layer to a depth of 3 - 5 µm. Almost all hydroxyapatite is removed, leaving the collagen fibres without mineral support. Once the primer and adhesive resin are applied, the collagen web is infiltrated. After polymerisation, this will result in micromechanical interlocking through hybridization and tag formation. A frequently asked question is: What opportunities are there for a chemical bond in this approach? Some techniques (eg, energy dispersive X-ray spectroscopy) are able to produce images indicating mineral content.[7] E&R adhesives are found to leave no residual hydroxyapatite crystals after etching. A more complicated, sensitive technique is X-ray photoelectron spectroscopy (XPS). Using this technique, a spectrum displaying all the elements can be obtained before and after demineralisation. Before etching, elements of hydroxyapatite (minerals) and collagen (organic elements) are apparent. After demineralisation, all minerals are missing, leaving no possibility for primary chemical interaction with E&R adhesives.

The hybrid layer created by strong SE adhesives closely resembles those formed by E&R adhesives, with a thickness of approximately 4 µm. Intermediary SE adhesives (pH = 1.5) result in a thinner hybrid layer (1.5 to 2.5 µm) characterised by a top layer without any hydroxyapatite crystals and a bottom layer in which some crystals can be observed. With mild SE systems, a hybrid layer of around 1 µm (or smaller) is formed. This hybrid layer is not completely denuded of its mineral content as residual hydroxyapatite crystals can be observed. The presence of these crystals offers possibilities for chemical interaction between hydroxyapatite and some of the functional monomers present in the adhesive.

Regarding the bonding effectiveness of SE systems *in vitro,* two conclusions can be drawn. First, there is distinct variation in the results between the different systems. Second, the average microtensile bond strength for all two-step SE adhesives is 41 MPa. This is similar to the result for two-step E&R systems (Fig. 4).
One-step SE systems are the simplest systems, but exhibit considerable variation with an average microtensile bond strength of 24Mpa.

Chemical interaction at the interface.

Chemical interaction is typical of glass-ionomer cements. These materials are self-adhering, which means that no bonding agent is necessary to realise a bond to hard dental structures. Nevertheless, it is advisable to pre-treat or condition the substrate with a polyalkenoic acid for several reasons:[8]

- to clean the surface and removes surface smear.
- to create surface irregularities, thereby increasing the surface area.
- to create microporosities which enable micromechanical interaction and formation of a hybrid layer.
- to leave hydroxyapatite crystals available for chemical interaction.

The dentine surface layer in a transmission electron microscopic (TEM) section, following the application of a glass-ionomer material has a two layer appearance. The presence of hydroxyapatite crystals (HAP) is clearly seen in the hybrid layer (0.5 µm). On top of the hybrid layer a gel-like phase is present. The role of this structure will not be discussed here. The ultramorphological characteristics of the hybrid layer in a vertical section are similar, almost identical to those produced by a mild SE approach.[2]
To investigate chemical interaction at the interface between glass-ionomers and the tooth structure, an XPS study was performed in cooperation with the University

of Hiroshima.[9] This method analyses the binding energies on the surface of a sample. Changes in binding energies can be explained by chemical interaction taking place at the surface. Synthetic HAP was analysed before and after treatment with polyalkenoic acid. A comparison of these two spectra revealed a distinct change after the application of the acid, which indicated that a substance containing carbons was attached to that synthetic HAP surface. Further analysis of the spectra of polyalkenoic acid showed a double peak for the carbon. One represented the carbons forming the back bone of the polymer, the other peak the carbon present in the COOH group. As soon as polyalkenoic acid came into contact with the HAP sample, the second peak diminished in amplitude and changed its position in the spectrum. This drop in energy was caused by a change in binding energy between one of the oxygen atoms in the COOH group. Instead of pulling on the carbon, the oxygen atom diverted its action to a calcium atom at the HAP surface. An ionic bond was formed as a consequence. This caused a drop in the binding energy and a shift of the carbon peak in the spectrum. These results are proof of the chemical interaction between polyalkenoic acid and the HAP crystals present in the hard dental structures.[9] To conclude, it can be stated that glass-ionomer materials bond to dental hard tissues by a twofold mechanism. First, there is a micromechanical interlocking, and second, there is an ionic bond to the calcium present in the surface.

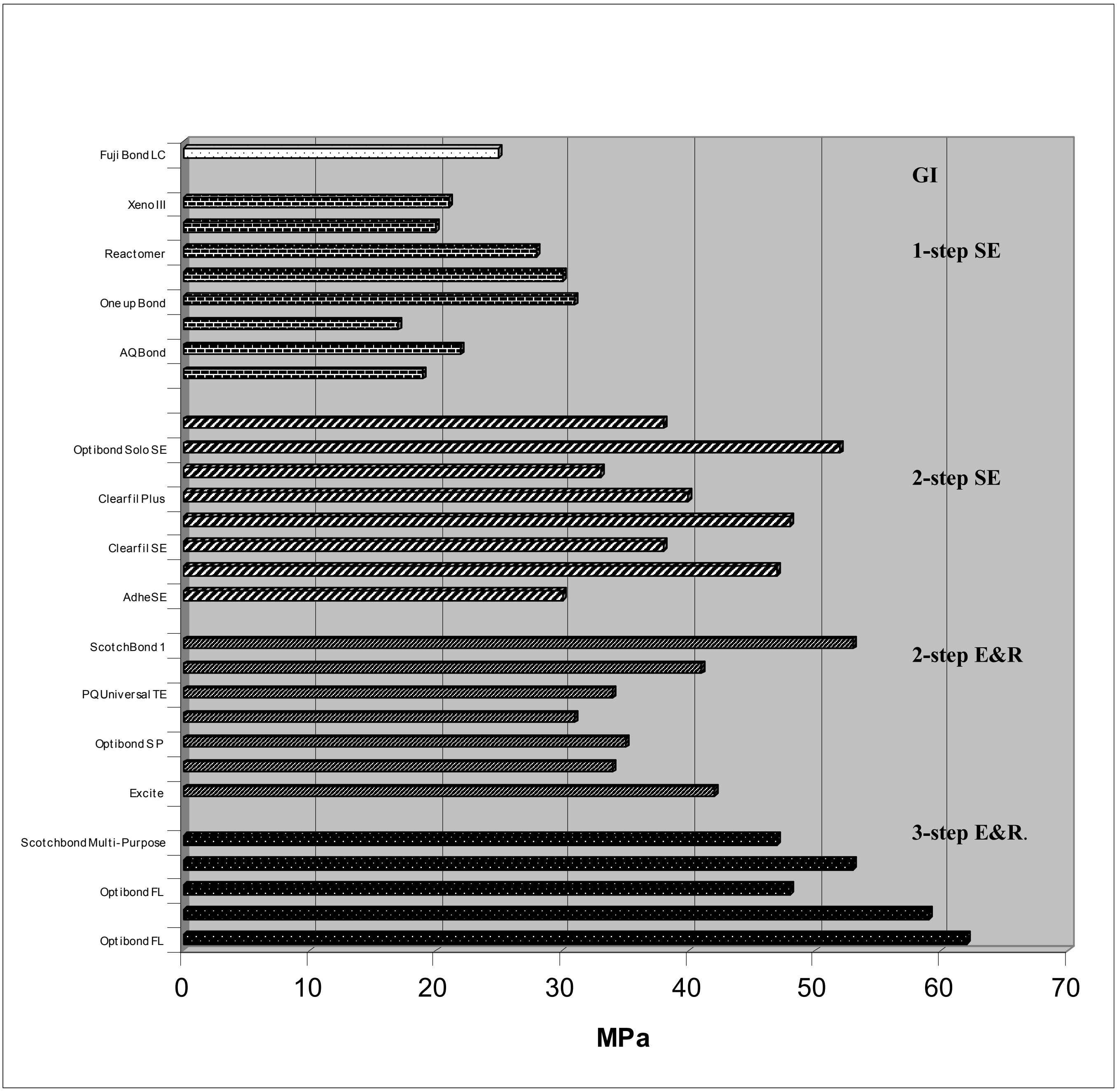


Fig 3 Microtensile bond strength of several systems to dentine[2] – SE, self-etech; E&R, etch and rinse

With mild SE systems, the ultramorphological features of dentine are very similar to those obtained with glass-ionomer materials. Most importantly, the hybrid layer still contains HAP crystals. To analyse the potential for chemical interaction between HAP and some functional monomers (4-META, 10-MDP, phenyl-P) present in commercial products, another XPS study was performed.[10] Similar results were found, proving that chemical interaction takes place. However, analysing the potential of chemical interaction in a relatively short time (clinically relevant time), it was noticed that some monomers are more effective than others. Indeed, some monomers can realise chemical interaction in 30seconds (clinically relevant time), others need much more time.

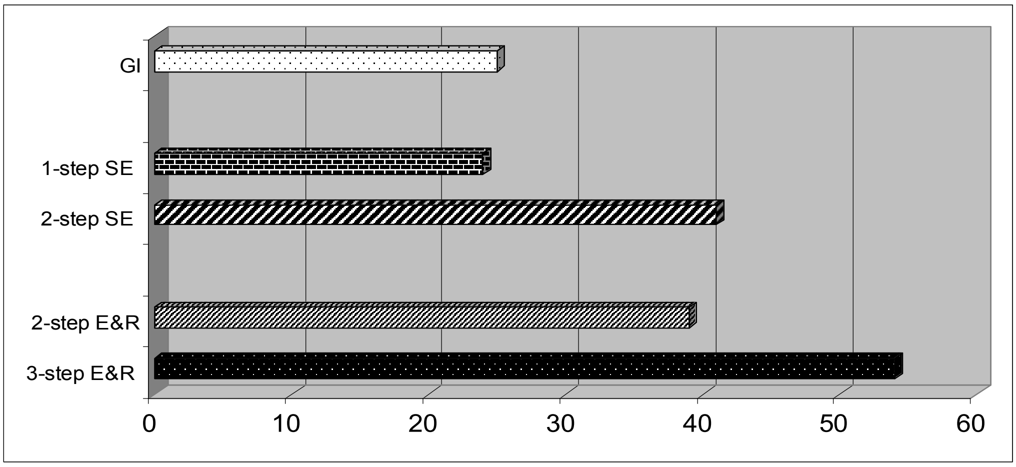


Fig. 4 Average microtensile bond strength to dentine for various adhesive strategies[2]
GI: glass-ionomer; SE: self-etch; E&R: etch and rinse.

These phenomena must be considered in a broader context. Many acids are able to interact with hard dental structures (demineralise the surface). Subsequently, two phenomena can occur.[11] If the salt formed between the acid and the dental minerals is highly soluble, it will be dissociate, leaving the surface decalcified. If the salt formed between the mineral and the acid is insoluble, it will remain attached to the surface, or bond to the surface. In other words, decalcification will take place, depending on the solubility of the salt formed. Analysing the solubility of the salts formed between calcium and the different functional monomers, it was found that those not able to adhere to the dental structure in a clinically relevant time, were those with the highest solubility. So, functional monomers in the SE systems have to be self-etching, and have to create a chemical interaction in a clinically relevant time. They require a specific chemical formula, enabling them to form a stable salt at the surface of the substrate, to ensure adhesion.[11]

One-step adhesives

To analyse the clinical potential of the one-step SE systems, a study was performed to compare the microtensile bond strength, before and after thermal cycling.[6] Three different products, each representing a particular group (E&R three-step, SE two-step, and SE one-step) were tested. An effective, comparable bond was obtained by the three-step E&R and two-step SE systems, while the one-step system showed a significantly lower value of microtensile bond strength and a number of pretesting failures. A similar trend was observed after thermocycling. What could be the reason for this difference in performance? Fracture analysis of some one-step, one-component SE specimens revealed porosities within the adhesive.[12] Further studies with experimental systems showed that these porosities were related to a phase-separation reaction between water and hydrophobic adhesive components. Air-drying these adhesives before light-curing removed droplets and prevented them from being trapped in the cured adhesive layer. HEMA plays an important role in the formation of the droplets, as it acts as a solvent, keeping the ingredients of these one-step adhesives in solution. Generally, two-step SE systems tend to obtain higher bond strengths than their one-step counterparts. However, the significance of trapped droplets in the adhesive layer needs further investigation. So far no significant differences between one-step SE adhesives with and without phase-separation have been found, nor could a difference be found between mild or strong air-blowing of the adhesive before light-curing. Finally, converting a one-step adhesive into a two-step system will lead to a droplet-free adhesive layer. Summarizing the results, it is concluded that HEMA-free one-step SE adhesives may undergo phase separation between water and the other adhesive ingredients and that this phenomenon is triggered by evaporation of the solvent. Strong air-blowing will remove that part of the residual water, thereby eliminating droplets.

Clinical performance

To investigate the clinical effectiveness of different adhesive systems, a review of the literature was undertaken to examine the retention rate of restorations placed in non-carious Class V lesions.[13] Eighty-five clinical studies performed between 1998 and 2004 in a university setting were included.
Analysing the results for three-step E&R systems, it was clear that most of these systems are able to meet the American Dental Association (ADA) guidelines for full acceptance.
Concerning the two-step E&R systems, which are the most popular materials in the U.S.A., a long list of studies was found. The results of these studies indicate that a lot of these systems do not meet the ADA guidelines.
As for the two-step SE systems, relatively few clinical studies have been published. Mild SE systems meet ADA guidelines.
Regarding one-step SE systems, a long list of studies is available. The results confirm that simplification of the clinical procedure results in a decrease of clinical performance.
All the studies performed with glass-ionomer materials showed that these materials comply with ADA guidelines.
The percentage failure rate and the maximum loss of retention per annum for the various systems is set out in Table 1.

From the table, it is clear that the worst performance was observed with the one-step SE systems, while the best results were obtained with three-step E&R and two-step SE systems. The best overall result was observed with the glass-ionomer materials with an average failure rate of 1.6%.

Objectives of the AODES

The AODES was founded as a section within the Academy of Operative Dentistry (USA) to:

- Promote excellence in operative dentistry within Europe.
- Share knowledge, information and experience with the Academy of Operative Dentistry (USA).
- Exchange knowledge and experience in the education of operative dentistry in the European schools through comparative studies of existing programs.
- Discuss new trends and evolutions in operative dentistry during the annual scientific meetings.
- Summarise and publish the conclusions in a newsletter EuroCondenser annually.
- Stimulate research in operative dentistry in Europe by rewarding the best poster presentation annually.

Activities

- ✓ Annual scientific meeting in Europe.
- ✓ Annual scientific meeting in Chicago with the AOD.
- ✓ Annual board – and annual business meetings.
- ✓ A newsletter ("EuroCondenser") published three times a year

Table 1 Annual failure rates for various adhesive systems

System	average loss/ year	maximum loss /year
• Three-step E&R	4.8%	16.0%
• Two-step E&R	6.2%	19.5%
• One-step SE	8.1%	48.0%
• Two-step SE	4.7%	19.3%
• Glass-ionomer materials	1.6%	7.6%

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Adherence to enamel and dentin, an addendum

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Adherence to enamel.

Conventional etching leaves enamel looking dull and opaque, with a typical etch pattern microscopically. When enamel is etched with a mild etching liquid, the picture in the microscope is different, presenting irregularities that are less pronounced than obtained after H_3PO_4 etching, but still important enough to realize micromechanical bonding.

Moisture influences bonding to enamel[1]. When etched and air-dried enamel is treated with ethanol, higher bond strength is obtained compared to enamel that is dried by a jet of air only. The difference in bond strength is statistically significant. A similar study was performed by Walls et al. in 2001.[2] They showed similar results in bond strength comparing dry versus wet enamel. In addition, they showed that moisture did not affect the bond strength in a negative way when bonding took place with modern adhesive systems, which are hydrophilic. The moisture is absorbed in the adhesive system and evaporated by the jet of air. This is reassuring because water will always be present, and with these systems it is possible to have an effective result.

A correlation was calculated between the bond strength values from Leuven[3] and those measured in Copenhagen. Although the values are higher in Leuven, where a microtensile bond strength is calculated, the correlation with those of Copenhagen was high ($r = 0.92$).

Adherence to dentine

Adherence to dentine is based on two concepts: hybridization and a possible chemical interaction between the adherent and the adhesive. Hybridization has for a long time been regarded as the main bonding mechanism, but recent work Van Meerbeek et al.[3] has focussed attention on chemical bonding. Many years ago a concept of chemical bonding was proposed.[4]

A methacrylate molecule with a reactive group X is so designed that it is able to react with the calcium ions in the dentine surface and/or with the organic components, (amino and hydroxyl groups) of the dentine.

MDP and 4-MET are potentially calcium binding molecules. Four-META as an anhydride is able to bond to the collagen.

To test the possibilities of chemical interaction, a dentine surface was prepared in different ways.[5] A normal dentine surface prepared by a sandpaper disc always has, in the infrared spectra, phosphate and an amide groups. The phosphate groups represent the mineral bonding sites, and the amides the bonding capacity of the collagen. The mineral and organic features can be

removed in separate steps. Etching the surface will eliminate, or considerably diminish the mineral content (the phosphate groups). Proteins can be removed by an 0.5 % NaOCl solution, reducing the amide groups, while at the same time the mineral groups are more pronounced. In this experiment, bond strength measurements were made on two surfaces, each time using an adhesive with a potential for chemical bonding either to the mineral content or to the organic part of the dentine.[6] The adhesives were used in different quantities, to establish their bonding capacities in relation to variations in concentration.
Using MDP (which is considered to bond very well with surface calcium) on etched dentine shows that with an increased content of MDP (in the adhesive) there is an increased bond strength to a demineralised dentine surface. When the same test is applied to a deproteinised surface, statistically no difference is apparent. The same bonding pattern was observed with 4-META.
The anhydride of 4-META, which is capable of bonding to the organic part of the dentine, shows an increased bond strength with an elevated 4-META content in the adhesive, but here again there is almost no difference between the two different dentine surfaces, either demineralised or deproteinised.
The effect of a possible chemical interaction is not clear, but these results are obtained with specimens that are broken after one day storage in water. Results after one year storage are not yet available.

Long-term bond strength: does nanoleakage play a role?

The phenomenon of nanoleakage[7] may occur when the dentine surface has been demineralised to a depth which can not be infiltrated by resin. Resin penetration will not reach all the collagen in the deeper layers. This deep collagen layer is susceptible to degradation or degeneration.
Self-etching systems may have the advantage that etching and impregnation with adhesive monomers occurs at the same time. But there are no longterm studies proving this hypothesis. The data of Okuda et al.[8] showed a significant drop in bond strength with two total-etch systems after one year storage in water, indicating other findings. Some degeneration of the interface showed a drop in bond strength over one year, indicating a better result with a self-etch system.[9]
In another study, four commercial bonding systems[5] were compared:

OPTIBOND FL	(total etch three-step)
SCOTCH BOND 1	(total etch two-step)
CLEARFIL SE	(self etch two-step)
OPTIBOND S+SE	(self etch two-step)

Bond strengths were measured after one day storage in water and after one year. After one year, the bond strength results were almost the same as after one day. Only the CLEARFIL SE lost strength.

Comparison of bond strength measurements to dentine made in Leuven with those of Copenhagen show poor correlation (r=0.2). This is embarrassing because the message to the practitioners is unclear. Reasons to explain the lack of correlation centre around the method of measurement. In Leuven microtensile bond strength is used as compared to shear bond strength measurements in Copenhagen.[5] The general trend, however, is that two-step total etch systems do not work as well as three-step total etch systems. One-step self etching system have a lower bond strength than two-step self etching systems. A third reason might be technique sensitivity (in these tests) such as the dryness of the dentine surface. This is difficult to gauge between different laboratories.
A more important reason might be a chemical phenomenon at the bonding site. A given bonding system may not be equally effective with different composites. Indeed, when different composite resins are used with different adhesives systems the results vary. The differences are significant ($P<0.001$).

In order to find a reason to explain these differences, we analysed the surface energy. We placed small drops of water, glycerol, ethylene glycol and α-Br-naphtalene on the different composite resins. We did a similar study on the dentine surface treated with the two different adhesives systems. Measuring the contact angle and knowing certain elements, it was possible to calculate the adhesion: $W = \gamma_1 (1 + \cos \Theta)$.
Determination of the composite surfaces and the dentine treated surfaces allowed us to calculate the total surface free energy (mJ/m^2). The findings indicated significant differences in the base components.

Combining all the results, a correlation could be obtained, indicating that different results may be explained by different chemical interactions at the interface.

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Clinical testing of anterior filling materials

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Introduction

The randomised controlled clinical trial is regarded as the most appropriate means of evaluating new materials and treatment modes[1] of which there have been numerous examples in the last thirty years. This paper will describe the evaluation of anterior filling materials.

Study design

First and foremost the study must be carefully designed to provide clear answers to the questions which prompted the investigation. In a prospective clinical trial, the planning determines the extent and nature of the data to be collected. For the research questions to be answered, the data must be sufficient in terms of quality and quantity.

Second, the aims and objectives of the study must be determined. Is the study to determine the potential of a new filling material or the value of a new treatment procedure, or both? Once the aims and objective have been determined, the variables to be investigated can be established. Once the variables are known, a control group can be defined in such a way as to permit necessary comparisons. In most studies a well established, proven material or technique is chosen as the control.

Thirdly, the arrangements for randomisation must be established. Randomisation is important in eliminating unwanted influences that may distort the outcome of the study. Randomisation can be carried out at various levels. The assistance of a statistician is highly advisable in this and other stages of the planning of the study. If possible each patient in the study should receive similar treatment by a limited number of experienced operators trained to a high level of consistency. Very often a split mouth design is chose to satisfy statistical demands. For randomisation to be effective, the patient group must have a substantial degree of commonality as defined by the exclusion and inclusion criterias for the study.

Fourth, the clinical procedure has to be determined. The procedure must be described in great detail. The detail must include precise information on, for example, cavity preparation, including decisions in respect of the bevelling of margins, the nature of the margins – enamel or dentine and the finishing of the preparation, let alone cavity size, the use or otherwise of liners and bases, the bonding procedure, insertion and finishing techniques for the restoration, together with information on polymerisation and moisture isolation. For indirect restorations, impressions, laboratory and luting procedures need to be defined. Similarly, if impressions are to be taken for the construction of replicas for retrospective analyses, then the materials, technique and procedure to be used must be described, again in precise terms. Once the clinical procedure has been adopted, it cannot be changed without corrupting the study.

Fifth, the number of patients and, in turn, restorations to be included in the study must take account of the anticipated attrition rate, leaving sufficient patients and restorations in the study to undertake the intended analyses. This is another aspect of the planning of the study in which statistical expertise can be invaluable. The number of restorations in each patient should be restricted, ensuring that the patient group is of an appropriate size, and that the loss of any one patient will not compromise the study.

Sixth, the clinicians selected to undertake the operative procedures need to be prepared to a high degree of competence and consistency with the materials and techniques to be investigated. The operators need to be familiar with procedures such as the use of magnifying aids and the selected method of resin polymerisation. It is essential to have a small number of well trained and suitably experienced operators to give robustness to consistency in the study.

Experience in the clinical testing of resin composites in anterior teeth suggests that carefully controlled conditions offer the best opportunity of an early indication of the potential of the material and technique being investigated. For the testing of direct anterior filling materials, Class IV lesions are most demanding, with a tendency for a relatively high failure rate.[4,5]. Therefore, assuming sufficient numbers of Class IV defects can be found in suitable patients, there will be the prospect of an early indication of the potential of the filling material under investigation. In testing the clinical effectiveness of adhesives, non-carious cervical Class V lesions are the best option. Such lesions, apart from being located mainly in dentine and being commonplace in patients well suited for inclusion in prospective clinical trials, offer good access and the opportunity to test the most objective evaluation parameter – retention.[6]

Once the design of the study has been established, it must be subjected to scrutiny for ethical approval by an independent panel, comprising both clinicians and lay people.

Clinical assessments

Clinical assessments should be carried out at regular time intervals. A three year follow-up is advised with at least four assessments during the period. Longer observation periods are very useful especially when a new treatment mode is being tested. Nevertheless a long term clinical investigation has certain drawbacks. First the number of drop-outs will increase over the years. This number may become critical to the viability of the study. In certain respects, clinical judgement may change over time; for example, when a ten year observation period is planned. In such cases and, in particular, when the results of the study are published practitioners and manufactures must understand the context of the study and that its findings may find little, if any, application in respect of new replacement materials. As stated earlier, in an observation period of three years four recall sessions are necessary.

First the baseline review. This has to be carried out one week, or at the latest one month after the insertion of the filling. The following three recalls can have various timings. Either the recalls can take place after 6, 18 and 36 months, or alternatively follow a yearly recall, namely after 12, 24 and 36 months. An annual survival rate is readily calculated with the yearly recall approach.

The clinical assessments should be completed by experienced, suitably trained clinicians that were not involved in the restorative procedures. They should be blinded to the treatment conditions as far as possible. At least two investigators should assess the restorations, one after the other at the same appointment. If disagreement occurs it should be resolved by discussion. Clinical assessments are optimized when done with magnifying aids, the use of which is highly recommended.
Clinical assessments should be complemented by pulp testing, radiographic imaging where indicated clinically, photographs and in some cases by replicas for indirect observations and/or measurements. These assessments expand the clinical findings, and at the same time, capture information at defined time points.
Careful documentation of all the relevant patient records is mandatory. The data should be accessible for further study for at least 10 years.

Investigation of properties in anterior teeth

All clinical investigations in the anterior part of the dentition should analyse three different groups of properties, namely the aesthetic, functional and biological (local and general) properties of the restorations. Attention has also to be paid to the recurrence of the causes of the pathology (caries, erosion, attrition, trauma etc.) as they will codetermine the longevity of the restorations.

Regarding aesthetics, several aspects of the filling determine the aesthetic outcome. These include colour match and stability, translucency, surface staining, surface gloss and texture and the anatomical form. All these sub-properties have to be analysed separately and scored. Ultimately, all the scores will be taken into consideration to provide an overall assessment of the aesthetic behaviour of the filling. In such considerations, the lowest score always prevails.

Regarding the functional properties, the retention of the filling is critical. For restorations still in place, a careful assessment of the margins is undertaken. Different defects can occur such as gaps, under-filling or over-filling. Fractures at the margins, or in the body of the fillings (bulk fractures) must be observed. Chip fractures and cracks have to be identified. In a chip fracture material loss, small or severe is always present, while cracks exist without remarkable material loss.

The next step is to assess the seal of the margins. Leakage, observed as marginal discoloration, can occur in different ways.

Finally the functional form will be analysed, assessing whether there is normal or abnormal wear. Again, a combination of the different scores will determine the final score for functionality of the filling. Again the lowest score will prevail in the final score.

Finally, for the biological properties, it is necessary to investigate the occurrence of postoperative sensitivity and to examine for the presence of previous pathology at the margins, including caries recurrence, erosion, abrasion or trauma. Then a careful analysis of the hard tissues is done and all enamel and dentine cracks at the margins of the filling have to be noted. Next the vitality of the pulp tissues has to be checked. Then the response of the periodontal tissues, if they are adjacent to the filling, should be analysed. Most often the plaque index according to Silness and Löe and the sulcus bleeding index according to Mühleman and Son are used. Probing depth is also measured.[7] Finally a careful examination of the oral tissues and some questions concerning possible consequences of that dental treatment on the general health will complete this part of the assessment. Again all the scores contribute to the final biological score for each filling.
At the end of the assessment, the three final scores will determine the overall score of that particular filling. Again the lowest or most negative score will prevail.

Individual evaluation of properties or grading

When evaluating the different (sub)properties of the filling, each time a clear distinction has to be made between an acceptable and an unacceptable result in that particular property. In some cases that decision is an easy one, in others it is not. Indeed, there is not always a clear distinction between an acceptable and an unacceptable result. But in clinical circumstances, as a rule of thumb, one can state that the result becomes unacceptable whenever retreatment is necessary or highly advisable, despite all the negative effects associated with a re-intervention (see below). Even with such an approach, some decisions or judgements remain difficult. Only experienced examiners with sufficient training and a proper calibration will guarantee a reproducible result. If disagreement persists after discussion, preference must be given to the least favourable assessment.

Within clinically acceptable results, a further distinction can additionally be made between an excellent, a good and an adequate result. Reporting over a very short period of clinical time, the excellent and good results will change more rapidly and may disclose a further trend in the behaviour of the fillings.
Within the group of the unacceptable results, a further distinction can be made between an inadequate and a bad result, according to the extent of the problem.
Regarding each unacceptable result it is helpful to indicate first the exact cause of failure and second the necessity for repair or retreatment. If a minor repair, with a limited intervention (only reshaping and limited sealing or polishing) can resolve the existing problem, then the clinical decision concerning that filling should be graded as acceptable. On the other hand, if a major intervention is needed then the restoration should be graded as unacceptable.

In some cases even an unacceptable result may survive several years without clinically significant deterioration, because a favourable (oral) environment prevents further breakdown or dental discomfort. Nevertheless, survival may not change the decision of an unacceptable result. Experience indicates that every unacceptable result will impede proper function of the tooth and, in most cases, will result in further dysfunction, breakdown, dental discomfort or pain. Unacceptable results are equal to a retreatment or to a major re-intervention.

After one year, the percentage of controlled fillings should exceed 95% acceptability and after three years at least 90% acceptability should be observed.

All the unacceptable results are taken into consideration. Therefore for anterior direct fillings, aesthetic, functional and biological properties may be responsible for an unacceptable outcome. In summarising the three scores (aesthetic, functional and biological) in one overall final score, again the lowest score prevails and dictates the final score. The annual failures rate will indicate the performance of the material or treatment mode, the failures rate within each group will indicate where the (main) problem lies.

Study outcomes

Outcomes will be explained with reference to two different studies conducted in the 1980s and 90s.

Microfilled composites

During the late seventies traditional resin composites gained a broad acceptance by practitioners. Some years later the microfilled composites were launched, claiming superior clinical characteristics. To analyse the benefits of these new composites a study was started. Materials of both groups, conventional and microfilled composites were placed in the same mouth to compare their behaviour. More than one thousand fillings were placed. An initial report of 455 fillings was published after 18 months.[8] A second report after 30 months, detailing the results of 1076 fillings, completed the initial findings.[9] From this study it was clear that aesthetic results were influenced by age, material and location of the filling. In the older fillings more failures were noticed. The conventional composites always displayed a slight inferior percentage of acceptable fillings and at the same time a higher rate of failures. It became clear that a Class IV filling is by far the most severe test for an aesthetic outcome in the anterior part of the dentition. Next to colour stability, loss of translucency was critical. The change was again more pronounced by material and age. The surface gloss of the fillings helped considerably in the aesthetic outcome and this became more dominant with age. Finally, anatomical form also played a role in the aesthetic result.

Concerning marginal adaptation, two outcomes were observed. First the conventional composites displayed a better result. With the newer materials mixed results were observed with the microfilled composites. Embarrassing defects in that group were chip fractures. These fractures were mostly located in Class IV restorations. An SEM investigation gave some indication of the aetiology of these failures.[10] It seemed that most probably, the effect was related to the adhesive strategy of the material. Most failures were present in restorations placed without an enamel bonding agent. Most fractures were therefore adhesive or cohesive-adhesive. All other failures in marginal adaptation were noticed more frequently in the Class IV fillings.
The combination of results of both parameters gave a 90% clinically acceptable finding after 30 months.

Adhesive system

In a second study 10 different adhesive systems or techniques were investigated.[6] After the enamel bonding technique was widely accepted, dentine bonding became the priority in clinical dentistry. As soon as new products or techniques were available, research was started to evaluate the merits of the proposed systems. At that time most of the *in vitro* data differed too widely to predict clinical effectiveness. Therefore, a clinical model was developed for a controlled investigation. In each trial, two groups of cervical restorations were placed, first a group in which the retention of the fillings was secured only by a dentine bond and second a group in which the dentine bond was assisted by an enamel bond. In the case of the latter group the enamel wall was bevelled and conditioned with phosphoric acid[11]. Ineffective bonding resulted in early loss of the restoration. In such studies, retention is the most objective evaluation parameter. In total, over a period of ten years, more than 1100 fillings were inserted in nearly 350 patients.

Only some highlight of the results are mentioned here. Clinical retention rates indicated the supervised clinical effectiveness of the newest dentine adhesive systems over the earlier ones. With regard to the adhesion strategy, adhesive systems that removed the smear layer and concurrently demineralised the dentine surface layer performed clinically better than systems that relied on chemical interaction or modified the smear layer, without complete removal. Six different systems involved dentine impregnation, but only two of them reached a retention rate capable of complying with the ADA provisional and full acceptance guidelines. The fact that equivalent adhesion strategies revealed different clinical results indicated that other factors contributed to the clinical effectiveness of a particular system.
A number of clinical studies assessing the effectiveness of dentine bonding systems revealed similar results (Table 2)

Table 2 Clinical studies on dentine bonding with similar results

Scotchbond 1	Ziemetiecki et al 1987 [13]
	Heymann et al 1988 [14]
	Tyas et al. 1989 [15]
	Van Dijken 1990 [16]
Scotchbond 2	Jordan et al. 1989 [17]
	Duke et al. 1991 [18]
	Powel et al. 1992 [19]
Tenure	Van Dijken 1992 [20]
	Jordan et al. 1989 [17]
Tripton	van Dijken 1992 [20]
	Tyas and Chandler 1993 [21]
Clearfil Liner Bond system	Barkmeyer et al. 1996 [22]
	Duke et al 1994 [23]
	Trevino et al [24]

In both examples of study outcomes, an RCT study was effective once the aim of the study was clearly defined. The variables were defined and proper randomization eliminated all unwanted influences. The number of experienced operators was limited and at the assessments two evaluators were assigned that were not involved in the restorative procedures. The results of both studies concurred with a number of studies carried out at the same period or at a later date[25] (Table 2). Composites resin in the anterior region will gradually loose their aesthetic properties and, at the same time, their function is impaired by progressive loss of marginal adaptation. Fractures and leakage are also noticed. A proper bonding technique and a high filler load of small particles offers the best chances of a durable result. Under these circumstances an acceptable result can be realized in normal clinical procedures with both groups of materials.

The effectiveness of a dentine bond has been improved over the last ten years. A proper hybridization of the dentine surface layer and the existence of an elastic layer at the interface improves clinical performance.

Discussion and Conclusion

The clinical testing of restorative materials remains an essential part of research in dentistry. Knowledge concerning the longevity of restorations is important as most of the treatment time in a dental practice is devoted to the repair/replacement of existing restorations. It is a multibillion dollar industry according to Mjor[26]. Many authors have confirmed that statement. [27 28 29]
How best to perform clinical tests remains an issue in the literature.[30] Diverging view exists, and will probably continue to exist in the future. A solution is only possible if standardisation emerges both in the testing methods and in the publications of the results with appropriate consideration to material, clinical and patient factors.[31 32]

Critics will argue that clinical trials are too academic and unrelated to the situation in general practice. This is correct, but the results of controlled clinical trials will inform us about the best materials and techniques.[33] A randomized controlled clinical trial is the first step in the long process to the acceptance of new materials and treatment modes. Once the new material or treatment mode has been found to have good potential, as determined by randomised clinical trials, other studies must follow to determine effectiveness when used by practitioners of variable skills in patients with diverse circumstances.

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Report of the 35th Annual Meeting of the Academy

Margaret Wilson, University Dental Hospital of Manchester

The end of February in Chicago heralds the arrival of several thousand dentists, technicians, dental nurses, and hygienists. It is the time for the Windy City to host a huge number of dental meetings including: Academy Meetings, the Mid-Winter Meeting and also one of the largest dental trade fairs in the world. If you can schedule a few days into your diary at the end of February, come to Chicago, support your Academy, boost your continuing professional development credits and have an unforgettable experience.

So, it is against this backdrop and amongst all the other dental meetings that our Academy holds its annual meeting. The AOD meeting is held in the luxurious Chicago Fairmont Hotel. In 2006 approximately 480 delegates attended the meeting. Nine new European members were enrolled into the Academy at the meeting.

The programme covered: aesthetic considerations including the orthodontic/restorative interface, tooth bleaching, tissue engineering, occlusion and TMD, digital dental photography and three dimensional dental imaging.

This is a personal report of my attendance at the 2006 Academy meeting. I hope you will find this report interesting and will be encouraged to attend in future years, if not 2007. The report does not represent the views of the AOD nor the European Section. I have only included comment on some of the presentations. There were 33 presentations at the meeting this year, including Table Clinics - so something to interest everyone.

The 25th M G Buonocore Memorial Lecture

The 25th M G Buonocore Memorial Lecture was given by Dr Jacques Nor. University of Michigan, School of Dentistry Ann Arbor, Michigan. The title of his lecture was: Tooth Tissue Engineering and Molecular Biology in Restorative Dentistry. This was a superb lecture, well presented and evidence-based. Dr Nor kept the audience spellbound as he led us through the human genome project, traced the recent developments in gene-based therapy and tooth tissue engineering. He gave us tantalizing glimpses into the future: the prospect of enamel, dentine and pulp regeneration, with the possibility of incorporating morphogenic signals into "intelligent" dental materials. He concluded his lecture with the comment that, in his opinion, it would be the practicality of developing tissue engineering techniques which would be the "make or break" factor. He emphasised the importance that all new procedures must be user friendly. This approach indicated that, despite being an eminent scientist, Dr Nor's experience and knowledge of practical dentistry ensure his feet are well and truly planted on firm ground.

The Hollenback Prize

The Hollenback Prize was presented to Dr William Douglas, University of Minnesota, School of Dentistry, and Minneapolis , Minnesota. The Prize was awarded in recognition of Bill's sustained commitment to dental research. Many will be familiar with Bill's work in clinically- simulated laboratory research leading to the development of the world famous Minnesota artificial mouth. It was an especially proud moment for those Europeans present as Bill's PhD in Chemistry was awarded by Queen's University Belfast. He subsequently went to Guy's to study Dentistry. The presentation of the Prize was accompanied by a standing ovation.

Long distance communication: Setting high aesthetic standards for the dental team
Dr Gerrard Chiche

Communication of the aesthetic requirements of your patient is important, in particular when you and your patient are in New Orleans and your technician is in Japan! This lecture was aimed at helping the dentist establish the aesthetic requirements of the patient and communicating these to the dental ceramist. The lecture was most useful in providing practical tips when establishing the position of the incisal edge of crowns and closing diastemas.

From a personal perspective, I accept that the cosmetic desire for white teeth of uniform shape is very powerful, but I keep asking myself if we as a profession have become too driven by patients' aesthetic desires and whether patients really understand the medium to long term consequences of certain cosmetic procedures.

White teeth or little white lies
Dr Van Haywood

Dr Haywood is probably the clinician with the foremost knowledge of bleaching. The lecture was illustrated with many images of the patients he has treated. He gave a scholarly review of current bleaching techniques and was able to support his lecture with a wealth of research data. He revealed early on in his lecture that the best technique in terms of cost, safety and efficiency is the use of night guard vital bleaching for approximately 2-6 weeks. He advocated 10 % carbomide peroxide in a non-scalloped tray without reservoirs. He reported the results of studies he had carried out using high concentration bleaching agents and power lights. He warned that use of high concentration bleaching agents could increase the risk of tooth sensitivity post bleaching and also result in a greater rebound of colour. So, from his vast experience, slow and steady wins the day. He emphasised the role of the dentist to ensure a correct diagnosis for discoloured teeth, and often the necessity of preoperative radiographs and vitality tests before embarking on any bleaching. He illustrated this point with a number of cases where the discoloration was caused by untreated non vital pulps and external resorption. His final message was "stop bleaching when the white of the teeth matches the whites of the eyes". He warned of the problems of trying to bleach roots, brown and white spots and nicotine stains. Whereas most teeth will bleach in 2-6 weeks, nicotine stains take 1-3 months and tetracycline stains 2-6 months. He estimated most bleaching will last 1.5-2 years prior to the possible need for top-up bleaching.

A pictorial retrospective of clinical dentistry by Dr Richard Tucker prepared and presented by Dr Terry Donovan and Dr Richard Simonsen

This was a video presentation of patients treated by DrTucker.

Dr Tucker is a living legend in cast gold restorations. His clinical technique, high standards and superlative expertise have amazed us lesser mortals for many a year. This was an assessment of patients he has treated over a continuing and very long dental career. One hundred and twenty patients with multiple gold restorations were identified and invited to attend for assessment. One hundred and fifteen patients turned up, four patients were deceased and one had moved away. Anyone who has ever carried out clinical research will recognise this as an outstanding recall rate.

In the patients examined, 90% of the restorations had been in place for >9years and 4 % for >25 years. Using USPHS codes and criteria, 96% of the cast gold restorations were graded as Alpha on all parameters. Of the restorations examined 73% were large onlays or partial veneer crowns, indicating Dr Tucker's preference for conserving tooth tissue. Using Weibull Characteristic Time, a Tucker gold restoration takes 45 years to fail. The video showed many of the patients who had been treated. The quality of the work was superb, illustrating the work of a truly gifted clinician. The beautifully produced video met with rapturous applause.

Gala Reception
The Gala reception was once again an opportunity to eat and drink in the company of old friends and new acquaintances. The Academy maintained its usual high standard for catering. The Gala dinner is not a time to start a diet, and I think every possible food preference or fad had been catered for by the hotel-a real culinary treat.

Occlusion, temporo-mandibular disorders and restorative dentistry
Dr Jeffrey Okeson

Not many people can make a lecture on TMD diagnosis and treatment both informative and entertaining. Dr Okeson could have another career in the media. He described how he differentiated between dental pain, TMD and non TMD pain. Quickly he moved on to the aetiology of TMD pain. There followed a discussion as to whether occlusion was related in any way or contributed to the overall pain experience. The wisdom of placing restorations within the adaptive range of the occlusion was discussed. There were excellent graphics and video sequences within the presentation.

Digital dental photography
Dr James Dunn

Dr Dunn gave a history of the move from film to digital cameras. The pros and cons of various cameras were discussed, together with techniques to achieve "glamour" photos of teeth and your patients. I felt slightly depressed after this presentation as I realised my patients do not come into the "glamour" category and that there is no point in rushing out to buy a new camera as it will be technically redundant before I take the wrapping off. I need to wait until the technology catches up with my lack of photography skills, or I start treating patients worthy of "glamour" photos.

Three dimensional imaging in dentistry
Dr Bruce Howerton

This lecture, despite its unassuming title was one of the best presentations of the meeting. Dr Howerton has a very gentle way of describing highly complex imaging techniques. His explanation of the physics involved in cone beam computer tomography and his review of 2D and 3D imaging, three dimensional concepts and X, Y and Z planes and multi-planar reconstructed images (MRI) was so good that for the whole of his lecture I almost forgot my lack of knowledge of this subject, let alone my general fear of physics. The presentation was illustrated with amazing images and video clips covering a wide range of subject areas, including endodontics, implant placement and TMD. How have we ever managed without this technique for diagnosis, visualisation of artefact and communication with radiologists? This was a superb lecture.

The Interdisciplinary management of anterior aesthetic dilemmas
Drs Kinzer and Kokich Jr
This was a lecture on the management of patients presenting with aesthetic problems requiring the input of both a restorative dentist and an orthodontist. The incisor relationship- overjet and overbite, were considered in patients with severe incisal wear, overeruption of teeth and loss of vertical dimension. The term "vertical bruxer" was used to describe these patients. The presentation looked at the problem of understanding a patient's anxiety about a selection of dental aesthetic problems and tried to identify the stage when the appearance becomes a problem to the patient and to the dentist.

In conclusion, the 35th Annual Meeting of the Academy was an excellent event. As in previous years this meeting exceeded expectations, with the prospect of future meetings being just as good.

The 2007 AODES meeting

Ivo Krejci has put together an outstanding programme for the 2007 meeting of the Section. This meeting is to be held in Geneva on Friday 12 October 2007. The details of the programme are as follows:

Advances in Conservative Dentistry

Morning session, Chairman Nairn Wilson

09.15-09.30 - I Krejci, Geneva – Welcome and opening remarks
09.30-10.15 – J F Roulet, Schaan – Future developments in conservative dentistry
10.15-11.00 – G Goffin, Geneva – Oral hygiene and bleaching of vital teeth
11.00-11.30 – Coffee break
11.30-12.15 – J J Lasfargues – Modern caries diagnosis and non-invasive caries management
12.15-13.00 – S Ardu, Geneva – Minimally invasive restorations of anterior and posterior teeth
13.00-14.30 – Lunch and poster presentations

Afternoon session, Chairman Guido Vanherle

14.30-15.15 – B Van Meerbeek, Leuven – Latest developments in dentinal adhesion
15.15-16.00 – Degrange, Paris – Are adhesive systems user-friendly under the conditions of a private office?

16.00-16.30 – Coffee Break

16.30-17.15 – S Bouillaguet, Geneva – Modern adhesive treatment of devitalised teeth
17.15-17.30 – G Vougiouklakis, Athens – Presentation of poster prize and closing remarks

Further details of the meeting may be found on the Section website or obtained from Ivo Krejci (ivo.krejci@medecine.unige.ch).

A side step

Having completed some eight years as Editor of EuroCondenser, it is time for me to step aside and assume a supporting role. In stepping aside, I am most pleased to pass the editorial baton to Chris Lynch, who is now based at the Dental School in Cardiff. In wishing Chris every success in taking EuroCondenser forward, I will be most pleased to assume the role of Consultant Editor and, in so doing, continue to play a role in the newsletter, albeit from the wings rather than centre stage.

It has been a great honour and pleasure to edit EuroCondenser. Look out for the next issue under new editorial control.

Chris, all power to your editorial pen!

Nairn Wilson
Editor

Contributions to EuroCondenser

The Editor wishes to encourage AODES members to make contributions to future issues of the EuroCondenser. Contributions may take the form of scientific papers, short communications, case reports, descriptions of clinical techniques, or other communications, including letters to the Editor, thesis details or details of forthcoming events. Further details are available on request from the new editor of EuroCondenser – Chris Lynch (lynchcd@cardiff.ac.uk).

Benefits of membership

From AOD (USA)
Annual meeting. The annual meeting (held each year in Chicago Illinois) is a carefully crafted two-day programme that includes outstanding scientific lectures and table clinic presentations. Many meals and social events are included, provided time to interact with other members, and making this one of the best values in continuing education.
The Academy's publication, *Operative Dentistry*, is one of the most widely read and highly respected journals in dentistry.

From AODES (Europe)
Annual scientific meeting in Europe. A substantial reduced registration fee for the members attending the annual scientific meeting.
The Newsletter. Free subscription to the EuroCondenser, the Newsletter of the Section.
Research Award. A prize for the two best poster presentations during the annual meeting.

Membership application form for The Academy of Operative Dentistry

Name____

Address______________________________________

Telephone: Home__________________________________

Office__________________________________

Fax____

Email_______________________________________

This application is for the following membership category:

____Active Membership
____Affiliate Membership (non-dentist)
____Student Membership ☐ Undergraduate ☐ Postgraduate
Presently attending the following dental school:
____

Projected graduation date:______________________________

Describe your practice of dentistry:

____Private Practice

____Military: ____Army ____Navy ____Air Force ____PHS

____Academic: ____Full-Time ____Part-Time

University______________________________________

Department_____________________________________

____Other_______________________________________

Study Club Affiliation_________________________________

Please tell us how you learned about the Academy:

____Professional colleague ___Dental school
____Website ___Operative Dentistry Journal

Other:____

Signature:____________________ Date:______________________

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