Futurabond® U · M+

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1. Introduction

The adhesive technique has had a profound effect on conserva-
tive dentistry. Since it was introduced and, for the first time, the adhesive and thus also the restorative material no longer merely provided the mechanical retention required for the necessary hold, but in addition formed a chemical bond with the dental hard tissue, the preparation guidelines and proce-
dures for replacing dental hard tissue damaged by caries have changed dramatically. “Minimally invasive” became the most important keyword. This could only be achieved by employing state-of-the-art adhesives and restorative composites.

The adhesive has the most important and most difficult task: establishing both a close connection with the dental hard tissue and a secure, insoluble bond with the restorative composite. And the difference between the components to be bonded – hydrophilic dental hard tissue and hydrophobic “resins”– couldn’t be much greater. The adhesives deal with this balancing act so efficiently that you do not even notice it during the application. The broad range of indications, clinically proven high adhesive strength, reliability and ease of application make these products perfect for daily use without restrictions, and that not only in conservative dentistry.

In the meantime, state-of-the-art research and the developed products are breaking down the boundaries between the different types of adhesive systems and, at the same time, dissolving the strict application conventions which formerly applied. Nowadays, total etch, selective etch and self-etch merely describe application options available to dentists and are no longer mutually incompatible individual philosophies.

Modern adhesives give you the option of placing your composite filling or composite build-up or luting a root post with or without an additional etching stage and with or without light polymerisation in accordance with the indications. They are compatible with all the methacrylate-based composites that you might wish to use for the various applications in your practice. However, modern adhesives nowadays can do much more than “just” bond composites to dental hard tissue. They are compatible with the materials used by dental technicians to produce fixed restorations and thus play an important role as a bonding agent for restorations made of (precious) metal and a wide range of ceramics. Acid-free repair of ceramic veneers directly in the mouth is also possible.

Futurabond U and Futurabond M+ give you the choice between the various methods of conditioning the dental hard tissue and do not impose any material restrictions when it comes to selecting the restorative, build-up or luting composite. Optimal compatibility and maximum integration in your treatment pro-
cedure make Futurabond U and Futurabond M+ truly universal adhesives.
1.1 VOCO’s universal adhesives

In recent years, research into adhesives has made enormous advances. VOCO has followed this course with great meticulousness and innovative capacity. The introductions of Futurabond U in 2013 and Futurabond M+ in 2014 made two universal adhesives available to users at the same time: one in the SingleDose and one in a bottle. As such, every dentist now has a universal adhesive available in his / her preferred pharmaceutical form. The two products are the result of a long development process with one principal objective: to create a universal adhesive offering users nothing but advantages and reliability, and making all other adhesive systems redundant in the practice. The universal Futurabonds set new standards in terms of their adhesion values and above all in how flexibly and diversely they can be employed.

Universal adhesives are one of the latest developments available on the market. In addition to their wide range of possible applications, they display considerably less “technique sensitivity” in comparison with conventional etch&rinse and self-etch systems. Their advantages are possible thanks to the specially coordinated formulation of the adhesives (see Table 1).

Table 1: General formulation of VOCO universal adhesives

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Designation</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidic adhesive monomers</td>
<td>Organic acids</td>
<td>Formation of the etching pattern, bond to dental hard tissue, improvement of flow properties</td>
</tr>
<tr>
<td>Cross-linking monomers</td>
<td>Functionalised methacrylates</td>
<td>Formation of the three-dimensional network, bond to methacrylate materials</td>
</tr>
<tr>
<td>Catalysts</td>
<td>Organic amine compound</td>
<td>Co-catalyst for the dual-curing</td>
</tr>
<tr>
<td>Initiators</td>
<td>Camphorquinone</td>
<td>Photoinitiator for the light curing</td>
</tr>
<tr>
<td>Stabilisers</td>
<td>BHT</td>
<td>Increasing monomer stability during storage</td>
</tr>
<tr>
<td>Solvent</td>
<td>Ethanol and water</td>
<td>Maintaining the constituents in a solution, improvement of flow and penetration properties</td>
</tr>
</tbody>
</table>

Particular attention must be paid to the acidic adhesive monomers / their different spheres of action. Organic acids are used which have a methacrylate function in addition to the acidic function. The reaction of the phosphoric acid group with the dental hard tissue results in demineralisation, a ruggedness, which creates a retention pattern. In a subsequent step, the abreacted organic acid forms a bond with the dental hard tissue, or to put it more precisely, with the calcium ions in the hydroxyapatite. The methacrylate function of the acidic adhesive monomers joins to the cross-linking monomers during the polymerisation, forming a very stable, three-dimensional network. Another benefit of the acidic adhesive monomers is
that they reduce the surface tension of the entire liquid, which decreases the viscosity of the adhesive solution considerably. The enormous advantage here can be found in the improved wetting property of the adhesive system. Complete covering of the retentive surface, homogeneous penetration of the collagen fibre network and optimal sealing of the dentinal tubules are only possible with the aid of this lower viscosity.

The excellent wetting behaviour also makes it possible to use the adhesive systems with different etching modes. The adhesive solution can penetrate a retention pattern created with concentrated phosphoric acid prior to the application, despite its own acidic pH value. For this reason, despite prior etching with phosphoric acid, the universal adhesives are able to create a hybrid layer and penetrate deep into the dentinal tubules in order to minimise postoperative sensitivity and ensure an excellent adhesive bond.

In addition, the perfect flow properties result in good adhesion to a variety of dental materials and to dental hard tissue. This permits secure bonding to various materials such as metal, zirconium dioxide, aluminium oxide and glass ceramics without an additional primer. Viewed in more detail taking zirconium dioxide as an example: On the one hand, the adhesive flows onto the ceramic part excellently and, on the other, the acid group of the intelligent monomers contained displays very high affinity to the surface of the oxide ceramic, making it possible to achieve an excellent adhesive bond.

And the functions of the solvent should not be forgotten: Basically, the solvent’s task is to maintain all of the constituents of the adhesive liquid in a solution. The use of monomers with different polarity is necessary to be able to create an optimal adhesive bond between the hydrophilic dental hard tissue and the hydrophobic composite. As such, it is advantageous to use a solvent mixture containing different polarities. In addition, the ethanol / water mixture prevents the liquid from evaporating too quickly, as can be the case with acetone-based adhesives, for example.

Figure 1: Dentine penetration of Futurabond U when using the total etch technique[1]

In addition, the perfect flow properties result in good adhesion to a variety of dental materials and to dental hard tissue. This permits secure bonding to various materials such as metal, zirconium dioxide, aluminium oxide and glass ceramics without an additional primer. Viewed in more detail taking zirconium dioxide as an example: On the one hand, the adhesive flows onto the ceramic part excellently and, on the other, the acid group of the intelligent monomers contained displays very high affinity to the surface of the oxide ceramic, making it possible to achieve an excellent adhesive bond.
1.2. Product descriptions

Futurabond U and Futurabond M+ are dental adhesives for use with methacrylate-based restorative, core build-up and luting materials. They can be applied with phosphoric acid etching (selective enamel etching or total-etch) of the dental hard tissue as well as without (self-etch).


1.3. Method of use

Futurabond U and Futurabond M+ not only ensure a secure bond to natural dental hard tissue, but also to composites, metals and ceramics.

It is necessary to isolate the operating site from moisture. Any contamination of the cavity or material surface with blood or saliva must be avoided. The use of a rubber dam is recommended.

1.4. Indications


[D] Protective varnish for glass ionomer cement fillings.

[E1] Sealing of cavities prior to amalgam restorations.

[E2] Sealing of cavities and core preparations prior to the temporary luting of indirect restorations.


[F1] Adhesive for direct self-curing or dual-curing composite restorations of all classes of cavities and core build-ups.

[F2] Adhesive for indirect restorations using dual-curing or self-curing luting composites.


[B] Intraoral repair of composite, compomer or ORMOCER® restorations, ceramic veneers and all-ceramic restorations without an additional primer.

[G] Luting of root posts with dual-curing or self-curing luting composites.

[C] Treatment of hypersensitive tooth necks.
Table 2: Overview of VOCO’s universal adhesives

<table>
<thead>
<tr>
<th></th>
<th>Futurabond U</th>
<th>Futurabond M+ (+ DCA)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive classification</td>
<td>Universal</td>
<td>Universal</td>
</tr>
<tr>
<td>Curing</td>
<td>Dual-curing</td>
<td>Light-curing (dual-curing)</td>
</tr>
<tr>
<td>Pharmaceutical form</td>
<td>SingleDose</td>
<td>Bottle</td>
</tr>
<tr>
<td>Applied layers</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Work steps</th>
<th>3 Total-etch</th>
<th>2 Selective-etch</th>
<th>1 Self-etch</th>
<th>3 Total-etch</th>
<th>2 Selective-etch</th>
<th>1 Self-etch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enamel conditioning</td>
<td>Etching gel</td>
<td>Etching gel</td>
<td>Futurabond U</td>
<td>Etching gel</td>
<td>Etching gel</td>
<td>Futurabond M+</td>
</tr>
<tr>
<td>Dentine conditioning</td>
<td>Etching gel</td>
<td>Futurabond U</td>
<td>Futurabond U</td>
<td>Etching gel</td>
<td>Futurabond M+</td>
<td></td>
</tr>
<tr>
<td>Wetting</td>
<td>Futurabond U</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bond</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*DCA: Futurabond M+ DCA (Dual Cure Activator)*
2. In-vitro studies

2.1. Investigation of micro-shear bond strength on human enamel and dentine depending on etching technique


<table>
<thead>
<tr>
<th>Test specimens</th>
<th>Etching mode for adhesive</th>
<th>Curing mode for adhesive</th>
<th>Curing mode for composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human teeth</td>
<td>Self-etch</td>
<td>Light-curing</td>
<td>Light-curing</td>
</tr>
<tr>
<td>Enamel / dentine</td>
<td>and total-etch</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Aim
The in-vitro study reveals comparative micro-shear bond strengths for the two universal adhesives Futurabond U (VOCO) and Scotchbond Universal (3M ESPE), depending on the etching mode in connection with a light-curing composite (GrandioSO, VOCO).

Study design
Human teeth were used for the shear bond strength test. They were ground to remove the superficial occlusal enamel. The enamel surface was then polished with silicon carbide sandpaper (600 grain) to create a standardised smear layer. For the dentine test specimens, the occlusal enamel was also separated and the dentine surface prepared in the same way as the enamel preparation. The test compared two universal adhesives, Futurabond U (VOCO) and Scotchbond Universal (3M ESPE). The adhesive systems were applied on the prepared surfaces in accordance with the manufacturers’ instructions (in both the self-etch and the total etch mode) and a light-curing composite (GrandioSO, VOCO) applied (composite cylinder: diameter 0.8 mm and height 2 mm). 20 of each type of test specimen were produced, of which half were subjected to the thermocycling process to simulate artificial ageing (5,000 cycles, 5 °C / 55 °C). The micro-shear bond strength measurements were then taken with the universal testing machine (Instron).

Results
Futurabond U displays excellent micro-shear bond strength values on enamel and dentine both initially and following the thermocycling process, irrespective of whether the total etch or self-etch mode was used.
Figure 2: Micro-shear bond strength (MPa) on enamel and dentine, total-etch and self-etch mode, initially and following thermocycling, LC composite.
Aim
In this study, comparable shear bond strength measurements of universal and self-etch adhesives in combination with a light-curing composite were performed on bovine dentine / enamel.

Simulated indications


Study design
Bovine anterior teeth were prepared and embedded in an epoxy resin matrix. To create even surfaces, the surfaces of the teeth were processed with silicon carbide sandpaper (1,000 grain). The adhesive systems used are listed in Fig. 3. They were applied in self-etch mode and then light-cured in accordance with the manufacturers’ specifications. The light-curing composite GrandioSO (VOCO) was applied to the adhesive layer and light-cured in accordance with the manufacturer’s specifications. The shear bond strength measurements were then performed with a universal testing machine (Zwick Roell) as per ISO / TS 11405.

Results
Futurabond U and Futurabond M+ achieve excellent adhesion values in self-etch mode on enamel and dentine. With one exception, the high shear bond strengths of Futurabond U and Futurabond M+ on bovine dentine differ considerably from those of the other adhesive systems investigated.

### 2.2. Investigation of shear bond strength on bovine dentine / enamel in self-etch mode
(adhesive: LC, composite: LC)

R&D VOCO GmbH, Cuxhaven, Germany, 2013 - 2014, as per ISO / TS 11405.

<table>
<thead>
<tr>
<th>Test specimens</th>
<th>Etching mode for adhesive</th>
<th>Curing mode for adhesive</th>
<th>Curing mode for composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovine teeth</td>
<td>Self-etch</td>
<td>Light-curing</td>
<td>Light-curing</td>
</tr>
<tr>
<td>Enamel / dentine</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Figure 3: Shear bond strength [MPa] on bovine dentine / enamel in self-etch mode (LC), LC composite.
Aim
In this study, comparative shear bond strength measurements of universal and total etch adhesives in combination with a light-curing composite were performed on bovine dentine / enamel.

Simulated indications


Study design
Bovine anterior teeth were used as the test specimens for shear bond strength measurements. The teeth were prepared and embedded in an epoxy resin matrix. The surfaces of the teeth were then processed with silicon carbide sandpaper (1,000 grain) to achieve even surfaces. The adhesive systems used for the investigation are listed in Fig. 4. They were applied in total-etch mode and then light-cured in accordance with the manufacturers' specifications. The light-curing composite GrandioSO (VOCO) was applied to the adhesive layer and light-cured in accordance with the manufacturer’s specifications. The shear bond strength measurements were then performed with a universal testing machine (Zwick Roell) as per ISO / TS 11405.

Results
In total etch mode, Futurabond U and Futurabond M+ display high shear bond strength values on enamel and dentine. Additional etching of the dental hard tissue does not result in a noticeable change to the adhesion values on dentine, but does lead to an improved adhesive strength on enamel (see comparison of Figures 3 and 4).
Figure 4: Shear bond strength [MPa] on bovine dentine / enamel in total-etch mode (LC), LC composite.
2.4. Investigation of shear bond strength on bovine dentine / enamel in self-etch mode (adhesive: LC, composite: SC)


<table>
<thead>
<tr>
<th>Test specimens</th>
<th>Etching mode for adhesive</th>
<th>Curing mode for adhesive</th>
<th>Curing mode for composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovine teeth Enamel / dentine</td>
<td>Self-etch</td>
<td>Light-curing</td>
<td>Self-curing</td>
</tr>
</tbody>
</table>

**Aim**

**Simulated indications**
[F1]  Adhesive for direct self-curing or dual-curing composite restorations of all classes of cavities and core build-ups.

[F2]  Adhesive for indirect restorations using dual-curing or self-curing luting composites.

**Study design**
The bovine anterior teeth were prepared and embedded in an epoxy resin matrix. To create even surfaces, the surfaces of the teeth were processed with silicon carbide sandpaper (1,000 grain). Figure 5 shows the adhesive systems used in the investigation.

They were applied in self-etch mode and light-cured in accordance with the manufacturers' specifications. The dual-curing core build-up composite Grandio Core Dual Cure was applied to the adhesive layer and chemically cured in accordance with the manufacturer's specifications. The shear bond strength measurements were then performed with a universal testing machine (Zwick Roell) as per ISO / TS 11405.

**Results**
In our experience, lower adhesion values are measured in combination with a dual-curing composite, which is due to the chemical curing of the composite. The shear bond strengths of Futurabond U are higher than the other universal adhesives tested. Futurabond M+ was mixed together with Futurabond M+ DCA (Dual Cure Activator) prior to the application. The adhesion values achieved with the bottle version of the universal adhesive are almost identical to those with Futurabond U.
Figure 5: Shear bond strength [MPa] on bovine dentine / enamel in self-etch mode (LC), SC composite.

(*) The dual-cure or self-cure activator available from the respective company was used for these products in order to guarantee compatibility with the dual-curing composite.

(*) Clearfil S² Bond Plus was tested together with Clearfil DC Core Plus.
Aim
The test shows comparative shear bond strength measurements of universal and total etch adhesives in combination with a self-curing composite on bovine dentine / enamel.

Simulated indications
[F1] Adhesive for direct self-curing or dual-curing composite restorations of all classes of cavities and core build-ups.

[F2] Adhesive for indirect restorations using dual-curing or self-curing luting composites.

Study design
Bovine anterior teeth were used to measure the shear bond strength. They were prepared and embedded in an epoxy resin matrix. To ensure uniform conditions, the surfaces of the teeth were processed with silicon carbide sandpaper (1,000 grain). Figure 6 shows the results of the adhesive systems investigated in the measurement. They were applied in total-etch mode and then light-cured in accordance with the manufacturers’ specifications. The dual-curing core build-up composite Grandio Core Dual Cure was applied to the adhesive layer and chemically cured in accordance with the manufacturer’s specifications. The shear bond strength measurements were then performed with a universal testing machine (Zwick Roell) as per ISO / TS 11405.

Results
Compared with the other adhesive systems tested, Futurabond U displays considerably better adhesion values, particularly on dentine.

<table>
<thead>
<tr>
<th>Test specimens</th>
<th>Etching mode for adhesive</th>
<th>Curing mode for adhesive</th>
<th>Curing mode for composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovine teeth</td>
<td>Total-etch</td>
<td>Light-curing</td>
<td>Self-curing</td>
</tr>
<tr>
<td>Enamel / dentine</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 6: Shear bond strength [MPa] on bovine dentine / enamel in total-etch mode (LC), SC composite.

(*) The dual-cure or self-cure activator available from the respective company was used for these products in order to guarantee compatibility with the dual-curing composite.
In this study, comparative shear bond strength measurements of universal and self-etch adhesives in combination with a self-curing composite were performed.

**Simulated indication**

Luting of root posts with dual-curing or self-curing luting composites.

**Test design**

Bovine anterior teeth were used to measure the shear bond strength. The teeth were prepared and embedded in an epoxy resin matrix. To create even surfaces, the surfaces of the teeth were processed with silicon carbide sandpaper (1,000 grain). The adhesive systems used are listed in Fig. 7. They were applied in the self-etch mode in accordance with the manufacturers’ specifications. Then the dual-curing core build-up composite Grandio Core Dual Cure was applied to the adhesive layer and allowed to cure chemically in accordance with the manufacturer’s specifications. The shear bond strength measurements were then performed with a universal testing machine (Zwick Roell) as per ISO / TS 11405.

**Results**

The adhesion values for Futurabond U are considerably higher than those for the other adhesive systems tested.
Figure 7: Shear bond strength [MPa] on bovine dentine in self-etch mode (SC), SC composite.

(*) The dual-cure or self-cure activator available from the respective company was used for these products in order to guarantee compatibility with the dual-curing composite.
### 2.7. Investigation of tensile bond strength on bovine dentine / enamel (self-etch and total-etch mode)

Torres C.R.G., Influence of previous acid etching on bonding strength of self-etch adhesives to enamel and dentin, São José dos Campos, Brazil, report to VOCO, 2013.

<table>
<thead>
<tr>
<th>Test specimens</th>
<th>Etching mode for adhesive</th>
<th>Curing mode for adhesive</th>
<th>Curing mode for composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovine teeth (enamel / dentine)</td>
<td>Self-etch and total-etch</td>
<td>Light-curing</td>
<td>Light-curing</td>
</tr>
</tbody>
</table>

**Aim**

The investigation shows the effect of an earlier etching stage on the tensile bond strength of the universal adhesives Futurabond U (VOCO) and Scotchbond Universal (3M ESPE) on enamel and dentine in combination with a light-curing composite.

**Study design**

This study used 112 freshly extracted, undamaged bovine teeth. The teeth were divided into two groups (enamel and dentine). Following preparation and embedding in a resin matrix, the respective surfaces were then processed with silicon carbide sandpaper (600 grain) to create a standardised smear layer. The test specimens were then in turn divided into two groups for each substrate (Futurabond U, Scotchbond Universal). Finally, each group was further divided into four subgroups and the respective adhesive system applied in accordance with the instructions for use. GrandioSO (VOCO) in A2 was employed as the composite, applied in a 2 mm layer and then light-cured for 20 seconds. Following removal of the matrix, light curing was performed again from all sides.

**Results**

Futurabond U is a universal adhesive system, which can be used for all etching techniques. The high tensile bond strength values overall amaze across the board. It is possible to achieve outstanding adhesion values on enamel and dentine both in self-etch mode and in total etch mode.
Figure 8: Tensile bond strength values (MPa) on enamel and dentine. The graph shows the results in the self-etch and total-etch modes for Futurabond U and Scotchbond Universal in combination with a light-curing composite.
2.8. Investigation of cuspal deflection / marginal integrity


Aim
The study investigated cusp movement and marginal integrity for standardised MOD cavities. These were treated using the incremental technique with composites in combination with the adhesive system recommended by the manufacturer under total etch or self-etch conditions.

Study design
For this study 56 caries-free premolars were used, and large standardised MOD cavities prepared. They were divided into seven groups, see Table 3.

Cusp movement
Each composite increment inserted in the MOD cavity was light-cured for 20 seconds. The cusp movement was determined following the light polymerisation after 0, 30, 60 and 180 seconds, and then the total calculated.

<table>
<thead>
<tr>
<th>Test specimens</th>
<th>Etching mode for adhesive</th>
<th>Curing mode for adhesive</th>
<th>Curing mode for composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human teeth</td>
<td>Self-etch and total-etch</td>
<td>Light-curing</td>
<td>Light-curing</td>
</tr>
<tr>
<td>Enamel / dentine</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Group distribution of the test set-up

<table>
<thead>
<tr>
<th>Group</th>
<th>Composite</th>
<th>Adhesive</th>
<th>Etching mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Filtek Supreme XTE (3M ESPE)</td>
<td>Scotchbond Universal (3M ESPE)</td>
<td>Total-etch</td>
</tr>
<tr>
<td>B</td>
<td>Filtek Supreme XTE (3M ESPE)</td>
<td>Scotchbond Universal (3M ESPE)</td>
<td>Self-etch</td>
</tr>
<tr>
<td>C</td>
<td>GrandioSO (VOCO)</td>
<td>Futurabond U (VOCO)</td>
<td>Total-etch</td>
</tr>
<tr>
<td>D</td>
<td>Spectrum TPH 3 (Dentsply)</td>
<td>Prime&amp;Bond Elect (Dentsply)</td>
<td>Total-etch</td>
</tr>
<tr>
<td>E</td>
<td>GrandioSO (VOCO)</td>
<td>Futurabond U (VOCO)</td>
<td>Self-etch</td>
</tr>
<tr>
<td>F</td>
<td>Spectrum TPH 3 (Dentsply)</td>
<td>Prime&amp;Bond Elect (Dentsply)</td>
<td>Self-etch</td>
</tr>
<tr>
<td>G</td>
<td>Filtek Supreme XTE (3M ESPE)</td>
<td>Adper Prompt L-Pop (3M ESPE)</td>
<td>Self-etch</td>
</tr>
</tbody>
</table>
Figure 9: Cusp movement (µm), MOD cavities prepared teeth treated with adhesive / composite.

(*) Adper Prompt L-Pop is a purely self-etching adhesive.
Marginal integrity
Afterwards, the restorations were tested for their marginal integrity. To this end, the teeth were sealed. Wax was used for the apical seal and all the tooth surfaces were additionally coated with nail varnish. A 1-mm-wide strip around the restoration margins was left exposed. After thermocycling, the teeth were immersed in fuchsin for 24 hours (basic, 0.2 %), cut into, examined under a microscope to determine the penetration depth of the colourant and then classified using the marginal integrity factors specified in Table 4.

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>No penetration by the colourant</td>
<td>Superficial penetration (not beyond the enamel-dentine junction)</td>
<td>Penetration along the gingival floor</td>
<td>Penetration as far as the axial wall right up to the pulp</td>
<td>Penetration of the pulp chamber</td>
</tr>
</tbody>
</table>

![Diagram of tooth with marginal integrity factors]
Results
The treatment of MOD cavities using Futurabond U / GrandioSO impresses right across the board. The cusp movement which occurs during curing is minimal and does not depend on the etching technique used. The subsequent marginal integrity measurements show very impressive values, which likewise do not differ significantly depending on the etching technique used.
2.9. Investigation of dentine permeability of universal adhesives depending on etching technique

Torres C.R.G., Effects of universal adhesive systems using self-etch or total-etch mode on dentin permeability, São José dos Campos, Brazil, report to VOCO, 2013.

### Aim
The effectiveness of the two universal adhesives Futurabond U (VOCO) and Scotchbond Universal (3M ESPE) as desensitisers was compared with the specially developed desensitiser Admira Protect (VOCO). The effect of additional etching on dentine sealing was also examined.

### Study design
The study used 1-mm-thick dentine discs taken from the buccal wall of extracted bovine incisors. Grinding was carried out using silicone carbide sandpaper in order to ensure the standardised uniform thickness of all dentine bodies, which is important for measuring permeability. 6 % citric acid was used to open the dentinal tubules on the side of the pulp. The buccal tubules were opened by immersing the dentine bodies in water for 30 minutes. Finally, the test specimens were stored for a further 10 minutes in an ultrasonic bath in 70 % ethanol. Permeability was measured at a pressure of 10 psi (~ 0.7 bar) for 2 minutes, with the maximum permeability for each test specimen initially determined as a reference, i.e. permeability was determined without the previous use of a desensitiser. The test specimens were then divided into five groups and different versions of desensitising were applied which are set out in Table 5. The test specimens on which the tried and tested desensitiser, Admira Protect, was applied served as a control each time.

### Table 5: Overview of the materials and versions used

<table>
<thead>
<tr>
<th>Material</th>
<th>Etching mode</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admira Protect (Control / VOCO)</td>
<td>Self-etch and total etch</td>
<td>Apply and allow to act for 20 s, dry for 5 s, light cure for 10 s</td>
</tr>
<tr>
<td>Futurabond U (VOCO)</td>
<td>Self-etch</td>
<td>Apply and rub in for 20 s, dry for 5 s, light cure for 10 s</td>
</tr>
<tr>
<td>Futurabond U (VOCO)</td>
<td>Total-etch</td>
<td>Etch with 35 % phosphoric acid for 15 s, then rinse for 20 s, soak up excess water with paper</td>
</tr>
<tr>
<td>Scotchbond Universal (3M ESPE)</td>
<td>Self-etch</td>
<td>Apply and rub in for 20 s, dry for 5 s, light cure for 10 s</td>
</tr>
<tr>
<td>Scotchbond Universal (3M ESPE)</td>
<td>Total-etch</td>
<td>Etch with 35 % phosphoric acid for 15 s, then rinse for 20 s, soak up excess water with paper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Apply and rub in for 20 s, dry for 5 s, light cure for 10 s</td>
</tr>
</tbody>
</table>
Results
Futurabond U can be used as a safe and reliable desensitiser in cases of exposed tooth necks. Practically identical results are achieved in both the self-etch and total etch mode. The universal adhesive delivers comparable results for the sealing of the dentinal tubules to the specially developed desensitiser Admira Protect.

Figure 11: Sealing of the dentinal tubules [%] following application of the different desensitisers Admira Protect, Futurabond U and Scotchbond Universal.
2.10. Measurement of shear bond strength following repairs on different materials

R&D VOCO GmbH, Cuxhaven, Germany, 2013 - 2014, as per ISO / TS 11405.

<table>
<thead>
<tr>
<th>Test specimens</th>
<th>Etching mode for adhesive</th>
<th>Curing mode for adhesive</th>
<th>Curing mode for composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic, metal, composite</td>
<td>Self-etch</td>
<td>Light-curing</td>
<td>Light-curing</td>
</tr>
</tbody>
</table>

**Aim**
This study performed comparative shear bond strength measurements on universal adhesives on different dental materials. The universal adhesives were applied in the self-etch mode in combination with a light-curing composite.

**Simulated indication**
Intraoral repair of composite, compomer or ORMOCER® restorations, ceramic veneers and all-ceramic restorations without an additional primer.

**Study design**
Test specimens of the corresponding materials were used to measure the shear bond strength (see Table 6). They were mechanically roughened by means of blasting with aluminium oxide (50 µm). Once the test specimens had been cleaned, the respective universal adhesive was applied in accordance with the manufacturer’s specifications. The light-curing composite GrandioSO (VOCO) was then applied in accordance with the manufacturer’s specifications. After that, the shear bond strength was determined with a universal testing machine (Zwick Roell).

**Table 6: Materials used**

<table>
<thead>
<tr>
<th>Material name</th>
<th>Base material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium oxide</td>
<td>Ceramic</td>
</tr>
<tr>
<td>Zirconium dioxide</td>
<td>Ceramic</td>
</tr>
<tr>
<td>Silicate ceramic</td>
<td>Ceramic</td>
</tr>
<tr>
<td>Degunorm “precious metal” (Degudent)</td>
<td>Metal alloy</td>
</tr>
<tr>
<td>Wirobond C “non-precious metal” (Bego)</td>
<td>Metal alloy</td>
</tr>
<tr>
<td>GrandioSO “nanohybrid composite” (VOCO)</td>
<td>Resin</td>
</tr>
</tbody>
</table>
Results
The restoratives investigated here display differences in the adhesion values achieved following repairs with composite, although it was possible to achieve adhesion values which are more than sufficiently high for permanent adhesion for all substances. Futurabond M+ and Futurabond U displayed the highest adhesive strengths on zirconium dioxide. Nevertheless, aluminium oxide, composite and NPM alloys are also very well suited to repairs with composite, as they displayed very high adhesion values in the test. Despite the somewhat lower adhesion values for the silicate ceramics and precious metal alloys in comparison, sufficiently high adhesion values for Futurabond U and Futurabond M+ as adhesives were also achieved for these material categories.
2.11. Investigation of the adhesion of zirconium dioxide to different core build-up materials

Torres C.R.G., Bond strength of zirconia to core materials, São José dos Campos, Brazil, report to VOCO, 2013.

<table>
<thead>
<tr>
<th>Test specimens</th>
<th>Workpiece</th>
<th>Etching mode for adhesive</th>
<th>Curing mode for adhesive</th>
<th>Curing mode for composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovine teeth, metal, composite, zirconium dioxide</td>
<td>Zirconium dioxide</td>
<td>Self-etch</td>
<td>Light-curing</td>
<td>Dual-curing</td>
</tr>
</tbody>
</table>

**Aim**

The aim of this study was to analyse the adhesion between different dental materials, established by the application of Futurabond U (VOCO) and Bifix QM (VOCO), using shear bond strength measurements.

**Study design**

72 zirconium dioxide cylinders (2.2 × 2.0 mm) (e.max ZirCAD, Ivoclar Vivadent) were used, which had been sintered and blasted (Rocatec procedure, 3M ESPE) prior to the cementing.

Beside the actual bonding agent Futurabond U (VOCO), Bifix QM (VOCO) was used as a luting composite.

The attachment of the zirconium dioxide cylinders to enamel / dentine (freshly extracted and prepared bovine teeth) was used as a reference. In addition, adhesion to metal (alloys of silver / tin / copper, Technofix and copper / nickel / zinc / aluminium, Goldent LA), to a composite (Rebilda DC, VOCO) and to zirconium dioxide (e.max, Ivoclar Vivadent) was tested. All the

**Table 7: Overview of the materials and versions used**

<table>
<thead>
<tr>
<th>Available material</th>
<th>Bonding agent(*)</th>
<th>Luting composite</th>
<th>Indirect restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dentine (reference I)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enamel (reference II)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rebilda DC (core build-up, VOCO)</td>
<td>Futurabond U (VOCO)</td>
<td>Bifix QM (VOCO)</td>
<td>Zirconium dioxide (e.max ZirCAD, Ivoclar Vivadent)</td>
</tr>
<tr>
<td>Metal alloy (Cu / Ni / Zn / Al, Goldent LA)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal alloy (Ag / Sn / Cu, Technofix)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zirconium dioxide (e.max ZirCAD, Ivoclar Vivadent)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*) The bonding agent Futurabond U was used both as the bond between the luting composite and the respective test specimen and between the luting composite and the zirconium dioxide cylinder.
test specimens and the zirconium dioxide cylinders were treated with Futurabond U in accordance with the manufacturer’s specifications. Bifix QM was then applied to the surfaces of the zirconium dioxide cylinders and the respective test specimens attached. The number of test specimens in each of the six groups was n = 12. Table 7 offers an overview of the materials used, which were processed in accordance with the manufacturer’s specifications. The stability of the final restorations was determined based on shear bond strength as per ISO / TS 11405.

Results
Futurabond U can be used safely and reliably by dentists on all restoratives and natural dental hard tissue. It can be used both as a conventional adhesive system on dental hard tissue or as a conditioner for dental alloys – it makes no difference whatsoever! The excellent adhesion values on the zirconium dioxide ceramics are due to the high surface affinity of the acidic adhesive monomers contained in Futurabond U.

Figure 13: Shear bond strength (MPa) of Futurabond U in combination with Bifix QM and zirconium dioxide on different restoratives and natural dental hard tissue.
2.12. The potential of novel primers and universal adhesives to bond to zirconium dioxide


Aim
This study investigated the adhesion established by conditioning of zirconium dioxide ceramic surfaces with novel primers and universal adhesives.

Study design
This investigation used 225 blocks of zirconium dioxide (Vita In-Ceram, Vita Zahnfabrik) (H × W × L = 3.0 × 3.0 × 9.3 mm), which were sintered at 1,530 °C for 2 hours prior to the

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-treatment of the zirconium dioxide blocks (Vita in-Ceram, Vita Zahnfabrik)</th>
<th>Conditioning</th>
<th>Luting composite</th>
<th>Antagonist of indirect restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>No pre-treatment</td>
<td>Futurabond M+ * (VOCO)</td>
<td>Scotchbond Universal * (3M ESPE)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Z-Prime Plus ** (Bisco Inc.)</td>
<td>Monobond Plus ** (Ivoclar Vivadent)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>AZ Primer ** (Shofu Inc.)</td>
<td>Without primer</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Blasting (35 µm Al₂O₃)</td>
<td>Futurabond M+ (VOCO)</td>
<td>Scotchbond Universal (3M ESPE)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Z-Prime Plus (Bisco)</td>
<td>Monobond Plus (Ivoclar Vivadent)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>AZ Primer (Shofu)</td>
<td>Without primer</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Blasting (30 µm SiO₂) (Rocatec Soft, Rocatec system, 3M ESPE)</td>
<td>Porcelain Primer ** (Shofu Inc.)</td>
<td>S-Bond ** (Danville)</td>
<td></td>
</tr>
</tbody>
</table>

*Universal adhesive **Primer

Table 8: Overview of the materials and versions used
measurements. The zirconium dioxide was prepared in four
different ways and divided into 15 subgroups (n = 15) in total.
All the parameters are listed in Table 8. The antagonist to the
indirect restoration was simulated using a lithium disilicate
ceramic (IPS e.max Press, Ivoclar Vivadent). Variolink II (Ivo-
clar Vivadent) was used as the luting composite in all cases.
Pre-treatment with the Rocatec (3M ESPE) / SilJet system
(Danville) is viewed as the gold standard in this study and can
therefore be taken as the control for the results. Following
luting, the restorations were stored in water (37 °C) for
24 hours and then aged artificially by means of thermocycling
(5 °C / 55 °C, 2,500 cycles). The adhesion values were then
determined.

Results
Futurabond M+ creates a safe and reliable adhesive bond to
zirconium dioxide. The best results can be achieved when the
zirconium dioxide surface is blasted with aluminium oxide
particles in advance.

![Figure 14: Shear bond strength (MPa) of different conditioners to zirconium dioxide without pre-treatment and with pre-treatment of the ceramic.](image-url)
2.13. TEM investigations of the bonding layer between Futurabond U and dentine when using in self-etch and total-etch mode

Arantes-Oliveira S., TEM investigations of the bonding layer between Futurabond U and dentine when using in self-etch and total-etch mode, Faculty of Dentistry, Biomaterials Department, University of Lisbon, Portugal, report to VOCO, 2014.

<table>
<thead>
<tr>
<th>Test specimens</th>
<th>Etching mode for adhesive</th>
<th>Curing mode for adhesive</th>
<th>Curing mode for composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human teeth</td>
<td>Self-etch and total-etch</td>
<td>Light-curing</td>
<td>Light-curing</td>
</tr>
</tbody>
</table>

Aim

In this study, the adhesive / dentine bonding layer depending on various etching modes was investigated with the aid of transmission electron microscopy (TEM).

Study design

The study used 12 caries-free human teeth, from which 12 dentine discs were cut. Futurabond U (VOCO) was applied in accordance with the manufacturer’s specifications, once in the self-etch mode and once in the total-etch mode. The composite GrandioSO Flow (VOCO) was then applied and light-cured. The discs were divided into little rods with a cross section of 0.8 ± 0.2 mm² using a precision saw (IsoMet1000, Buehler). The test specimens were then prepared for the TEM analysis and examined using an analytical transmission electron microscope (H-8100, Hitachi) with an acceleration voltage of 100 KV.

Self-etch mode, Futurabond U / GrandioSO Flow

![TEM images](image1)

**Figure a:** 1,000× magnification.

**Figure b:** 2,000× magnification.

**Figure c:** 5,000× magnification.

**Figures a-c:** TEM images of the composite / adhesive / dentine bonding layer (1,000×, 2,000× and 5,000× magnification), Futurabond U (self-etch mode) / GrandioSO Flow (abbreviations employed: A: Adhesive, C: Composite, HL: Hybrid layer, D: Dentine)
Total etch mode, Futurabond U / GrandioSO Flow

Figures d and e: TEM images of the composite / adhesive / dentine bonding layer (2,000x and 5,000x magnification), Futurabond U (total-etch mode) / GrandioSO Flow (abbreviations employed: A: Adhesive, C: Composite, HL: Hybrid layer, D: Dentine)

Self-etch mode, Futurabond U / GrandioSO Flow

Figures f and g: TEM images of the composite / adhesive / dentine bonding layer (10,000x and 25,000x magnification), Futurabond U (self-etch mode) / GrandioSO Flow. The orange arrows indicate collagen fibres in Figure f and hydroxyapatite crystals in Figure g.

Results
The TEM analysis shows that a thicker adhesive / dentine bonding layer is achieved in total etch mode than in self-etch mode. Both hydroxyapatite crystals and collagen fibres were identified.
2.14. TEM investigations into nanoleakage on the contact surface between Futurabond U and dentine when using in self-etch and total-etch mode

Arantes-Oliveira S., TEM investigations into nanoleakage on the contact surface between Futurabond U and dentine when using in self-etch and total-etch mode, Faculty of Dentistry, Biomaterials Department, University of Lisbon, Portugal, report to VOCO, 2014.

<table>
<thead>
<tr>
<th>Test specimens</th>
<th>Etching mode for adhesive</th>
<th>Curing mode for adhesive</th>
<th>Curing mode for composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human teeth</td>
<td>Self-etch and total-etch</td>
<td>Light-curing</td>
<td>Light-curing</td>
</tr>
</tbody>
</table>

**Aim**

In this investigation, silver particles were detected by means of transmission electron microscopy, which provided information on the intensity of the nanoleakage at the contact surface between the adhesive and dentine.

**Study design**

The investigation used 12 caries-free human molars, from which 12 dentine discs were cut. Futurabond U (VOCO) was applied in accordance with the manufacturer’s specifications, once in the self-etch mode and once in the total-etch mode. The composite GrandioSO Flow (VOCO) was then applied and light-cured. The discs were divided into little rods with a cross section of 0.8 ± 0.2 mm² using a precision saw (IsoMet1000, Buehler). Half of the test specimens were sealed with 2 coats of quick-drying nail varnish, leaving a gap of 1 mm to the bonded boundary surface. The test specimens were then immersed in a 50 % silver nitrate solution (pH 9.5) for 24 hours, before being left in a photo development solution under fluorescent light for 8 hours. The silver penetration at the adhesive boundary surface was then examined using a transmission electron microscope (H-8100, Hitachi) with an acceleration voltage of 100 KV.
Self-etch mode, Futurabond U / GrandioSO Flow

Figures a and b: TEM images, Futurabond U (in the self-etch mode) / GrandioSO Flow. The test specimens were immersed in a silver nitrate solution for 24 hours and then developed. (Abbreviation used: Ag: Silver particles)

Total etch mode, Futurabond U / GrandioSO Flow

Figures c and d: TEM images, Futurabond U (in the total-etch mode) / GrandioSO Flow. The test specimens were immersed in a silver nitrate solution for 24 hours and then developed. (Abbreviations used: A: Adhesive, D: Dentine, HL: Hybrid layer, Ag: Silver particles)

Results

The TEM images show a homogeneously formed bonding layer for the self-etch mode. No relevant nanoleakage can be observed after immersion in a silver nitrate solution for 24 hours. More silver was detected for the total etch mode compared with the self-etch mode. Viewed overall, however, the two etching modes hardly differed.
2.15. Push-out bond strength tests on Rebilda Posts luted adhesively


Aim
In this study, push-out bond strength tests were performed in order to determine the adhesive strength of the root posts luted adhesively.

Study design
The study was performed on 80 human teeth (1 root). In an initial step, the teeth were treated endodontically. The roots were embedded in a cylinder of self-curing acrylic resin. The root canals were then prepared for the post insertion (8 - 9 mm), with the apical seal (4 - 5 mm) being preserved. The prepared test specimens were divided into four groups, which are shown in Table 9. A glass-fibre-reinforced composite root post (Rebilda Post, VOCO) was used for all of the tests.

Following the corresponding cleaning stage, the post was coated completely with a coupling silane (Ceramic Bond, VOCO). The respective adhesive system and corresponding flowable luting composite were then applied (in accordance with the manufacturer’s specifications). The materials used are listed in Table 9. The post was inserted immediately after the filling of the luting composite. After 4 - 5 days immersed in water at 37 °C, the test specimens were prepared as follows: A low speed saw (Isomet, Buehler) was used to divide each test specimen into three segments (coronal, medial, apical) perpendicular to the longitudinal axis of the root under water cooling. The expulsion tests were performed with a universal testing machine (H5K-S, Hounsfield Test Equipment).

Table 9: Overview of the materials involved

<table>
<thead>
<tr>
<th>Group</th>
<th>Adhesive system</th>
<th>Luting composite</th>
<th>Root post</th>
<th>Silane</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Futurabond U (VOCO)</td>
<td>Grandio Core Dual Cure</td>
<td>Rebilda Post</td>
<td>Ceramic Bond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(VOCO)</td>
<td>(VOCO)</td>
<td>(VOCO)</td>
</tr>
<tr>
<td>2</td>
<td>LuxaBond (DMG)</td>
<td>Luxa Core Z-Dual (DMG)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Prime&amp;Bond Elect (Dentsply)</td>
<td>Core-X Flow (Dentsply)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Clearfil DC Bond (Kuraray)</td>
<td>Clearfil DC Core Plus (Kuraray)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results
The combination of the universal adhesive Futurabond U, Grandio Core Dual Cure, Rebilda Post and Ceramic Bond delivered the highest values for the push-out measurement on average in this study. Figure 15 shows the comparison to the other materials tested.

Figure 15: Values measured [N/mm²] in the push-out test.
3. In-vivo studies

3.1. Clinical results of class V restorations after 1 year


<table>
<thead>
<tr>
<th>Test subjects</th>
<th>Etching mode for adhesive</th>
<th>Curing mode for adhesive</th>
<th>Curing mode for composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>53 patients</td>
<td>Self-etch and total-etch</td>
<td>Light-curing</td>
<td>Light-curing</td>
</tr>
</tbody>
</table>

Aim

The 4-year study assesses class V restorations in accordance with selected USPHS criteria.\(^1\) Intermediate results after 12 months are presented.

Study design

53 patients between 18 and 55 years of age took part in the study. A total of 120 class V restorations were prepared and treated with the combination of Futurabond U / GrandioSO (VOCO) or Scotchbond Universal / Filtek Z 350 (3M ESPE).

Table 10: Overview of the materials used

<table>
<thead>
<tr>
<th>Group</th>
<th>Adhesive system</th>
<th>Etching mode</th>
<th>Composite</th>
<th>Abb. used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Futurabond U (VOCO)</td>
<td>Self-etch</td>
<td>GrandioSO (VOCO)</td>
<td>FB U SE mode</td>
</tr>
<tr>
<td>2</td>
<td>Futurabond U (VOCO)</td>
<td>Total-etch</td>
<td>GrandioSO (VOCO)</td>
<td>FB U TE mode</td>
</tr>
<tr>
<td>3</td>
<td>Scotchbond Universal (3M ESPE)</td>
<td>Self-etch</td>
<td>Filtek Z 350 (3M ESPE)</td>
<td>SB U SE mode</td>
</tr>
<tr>
<td>4</td>
<td>Scotchbond Universal (3M ESPE)</td>
<td>Total-etch</td>
<td>Filtek Z 350 (3M ESPE)</td>
<td>SB U TE mode</td>
</tr>
</tbody>
</table>

Only caries lesions in maxillary and mandibular premolars and maxillary anterior teeth were selected. Each patient was given at least two restorations which were filled with one of the tested material combinations. The teeth to be treated were cleaned with a fluoride-free prophylaxis paste using a rubber cup. In each case, the buccal surfaces of the class V restorations were prepared and standard cavity dimensions were selected: 3 - 4 mm occluso-gingival, 2 - 3 mm mesio-distal, 1 mm dentine depth. If a deeper caries had to be removed, a thin layer of a calcium hydroxide preparation was applied in advance to the bottom of the cavity.

Results

In the intermediate results after 12 months outlined here, the restorations of the class V cavities which were treated using Futurabond U / GrandioSO in total-etch mode had Alpha ratings, with the exception of two categories. In self-etch mode, all class V restorations were given Alpha ratings without exception.

Literature

[1] Cvar JF, 2005
Figure 16: Results after 12 months.
3.2. Clinical results of direct and indirect composite restorations after 6 and 12 months

Torres C.R.G., Clinical evaluation of direct and indirect composite restorations using the chairside technique, São José dos Campos, Brazil, reports to VOCO, 2013 - 2014.

### Aim

The 2-year clinical study investigates the quality of direct and indirect restorations produced using the chairside technique. The FDI criteria developed by Hickel et al. are taken as the basis for the evaluation. \(^{(1)}\)\(^{(2)}\) The initial results after 6 and 12 months are presented.

### Study design

30 patients were selected for the study; each test subject was treated with at least two restorations. The direct restorations were produced with the light-curing composite GrandioSO (VOCO) in accordance with the rules of the conventional adhesive technique in combination with Futurabond U (VOCO).

In the case of the indirect restorations, the composite inlays were produced in the chairside technique using GrandioSO (VOCO) and the Die Silicone (VOCO). They were then luted with the dual-curing luting composite (Bifix QM, VOCO) and Futurabond U (VOCO). The adhesive layer was light-cured on all restorations.

### Results

A total of 60 restorations were produced for 30 patients. Following the investigated periods of 6 and 12 months, all restorations displayed good clinical results for the parameters examined here. The results are shown in figures 17 - 19.

### Table 11: Overview of recall

<table>
<thead>
<tr>
<th>Test subjects</th>
<th>Etching mode for adhesive</th>
<th>Curing mode for adhesive</th>
<th>Direct: Curing mode for composite</th>
<th>Indirect: Curing mode for luting composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 patients</td>
<td>Selective-etch</td>
<td>Light-curing</td>
<td>Light-curing</td>
<td>Dual-curing</td>
</tr>
</tbody>
</table>

**Table 11: Overview of recall**

<table>
<thead>
<tr>
<th>Restorative technique</th>
<th>Initially (patients)</th>
<th>6 months (patients)</th>
<th>12 months (patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>30</td>
<td>30</td>
<td>27</td>
</tr>
<tr>
<td>Indirect</td>
<td>30</td>
<td>30</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>60</td>
<td>54</td>
</tr>
</tbody>
</table>

**Literature**

\(^{(1)}\) Hickel R, 2007

\(^{(2)}\) Hickel R, 2010
Figure 17: Functional properties of the direct (*) and indirect (**) restorations.

<table>
<thead>
<tr>
<th></th>
<th>Months</th>
<th>Retention of the restoration</th>
<th>Marginal adaptation</th>
<th>Approximal contacts</th>
<th>Patient satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

- **Retention of the restoration**
- **Marginal adaptation**
- **Approximal contacts**
- **Patient satisfaction**

- Excellent
- Good
- Satisfactory
- Unacceptable
- Inadequate
Figure 18: Aesthetic properties of the direct (*) and indirect (**) restorations.
Figure 19: Biological parameters following placement of direct (*) and indirect (**) restorations.
4. User survey / Clinical user tests

4.1. Futurabond U – Voted top 10 product in the USA 2014

Futurabond U was evaluated by a group of 13 testing dentists with a combined 283 years of practical experience.

Each of the surveyed criteria was assessed as very good (4 points) or excellent (5 points). The adhesive strength and the product behaviour in the total etch and self-etch modes were awarded the best scores.

The unrestricted compatibility with all methacrylate-based composites and the absence of postoperative sensitivity following placement of the fillings were given particular emphasis.

92% of the testing dentists would recommend Futurabond U to their colleagues.

Table 12: Overview of the results of the evaluated criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Average evaluation (1 to 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section A</strong></td>
<td></td>
</tr>
<tr>
<td>Simple to use</td>
<td>4.5</td>
</tr>
<tr>
<td>Adhesive strength</td>
<td>4.8</td>
</tr>
<tr>
<td>Speed</td>
<td>4.4</td>
</tr>
<tr>
<td>Convenience of use</td>
<td>4.2</td>
</tr>
<tr>
<td>Elasticity</td>
<td>4.3</td>
</tr>
<tr>
<td>Handling</td>
<td>4.5</td>
</tr>
<tr>
<td>Applicability</td>
<td>4.6</td>
</tr>
<tr>
<td>Product behaviour in TE mode</td>
<td>4.8</td>
</tr>
<tr>
<td>Product behaviour in SE mode</td>
<td>4.6</td>
</tr>
<tr>
<td>Postoperative sensitivity</td>
<td>4.8</td>
</tr>
<tr>
<td>Curing time</td>
<td>4.5</td>
</tr>
<tr>
<td>Working time</td>
<td>4.5</td>
</tr>
<tr>
<td>Average rating for section A</td>
<td>4.6</td>
</tr>
<tr>
<td><strong>Section B</strong></td>
<td></td>
</tr>
<tr>
<td>Overall satisfaction</td>
<td>4.5</td>
</tr>
<tr>
<td><strong>Overall result (average rating for sections A and B)</strong></td>
<td><strong>4.6</strong></td>
</tr>
</tbody>
</table>
4.2. Five stars out of five –
Futurabond M+ performs well in practical test

Futurabond M+ is a true all-rounder – a fact now given impressive confirmation by the outstanding verdict of the academic information service “Zahnmedizin Report”: The dentists awarded the universal adhesive offering users flexible solutions for all bonding situations five stars out of five and rated it “excellent” following a two-month test period.

The etching technique (total-etch, selective-etch or self-etch) can be freely selected and used depending on the indication or the dentist’s personal preference. Futurabond M+ can not only be reliably used for direct and indirect restorations, but also offers a secure adhesive bond to diverse materials such as metals, zirconium dioxide, aluminium oxide and silicate ceramic – and that without an additional primer. In combination with Futurabond M+ DCA, the Dual Cure Activator, the universal adhesive is also compatible with all self-curing and dual-curing methacrylate-based composites without any restrictions.

Outstanding application
These properties convinced practising dentists in the scope of the practical test to which they subjected Futurabond M+. Well over half of all the testers saw an enormous benefit in the freedom to select the etching mode. According to 92 % of the practices, Futurabond M+ covers all of the bonding indications which are relevant for work in the practice. The product was also assessed positively in terms of its use: The material scores highly for its viscosity and application. The low time requirements were even awarded the excellent average rating of 1.1.

A unanimous recommendation for the first time ever
And that’s not all: Every single one of the practice testers was so impressed by the product that they would recommend Futurabond M+ to their colleagues and employ it in their practices – the first time this type of result has ever been seen in the “Zahnmedizin Report” product test. The complete evaluation can be read in the 8/2014 issue of “Zahnmedizin Report”. [1]

Literature
5. Glossary

**Push-out test:**
Test to determine the adhesion strengths, used in root post luting.

**Dentine permeability:**
Describes the permeability of the dentine. This parameter is used to describe the sealing properties of adhesives and desensitisers among other products.

**Cuspal deflection:**
Movement of the cusps originating from the polymerization shrinkage of the composite material. This measurement method is usually employed for large MOD cavities.

**Marginal integrity:**
Describes the quality of the bond created by the adhesive between the dental hard tissue and the composite material.

**Shear bond strength:**
Adhesive strength offering information on the strength of the adhesive bond between the dental hard tissue (or similar) and composite (or similar). The force is exerted parallel to the bonded surface. The prefixes used, such as micro, describe the size of the surface of the bonded composite area.

**Tensile bond strength:**
Adhesive strength offering information on the strength of the adhesive bond between the dental hard tissue (or similar) and composite (or similar). The force is exerted perpendicular to the bonded surface. The prefixes used, such as micro, describe the size of the surface of the bonded composite area.

**Thermocycling:**
Contrast bath for simulating ageing of composite restorations (or similar); test specimens are subjected to this for a certain number of cycles.

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**The following materials named in the Scientific Compendium are not registered trademarks of VOCO:**

Adper Prompt L-Pop (3M ESPE); All-Bond Universal (Bisco), AZ Primer (Shofu Inc.), Clearfil DC Bond (Kuraray), Clearfil DC Core Plus (Kuraray), Clearfil SR Bond Plus (Kuraray), Clearfil SE Bond 2 (Kuraray), Clearfil Universal-Bond (Kuraray), Core-X Flow (Dentsply), Degunorm (Degudent), e.max ZirCAD (Ivoclar Vivadent), Filtek Supreme XTE (3M ESPE), Filtek Z 350 (3M ESPE), iBond SE (Heraeus), iBond TE (Heraeus), IPS e.max (Ivoclar Vivadent), LuxaBond (DMG), Luxa Core (DMG), Monobond Plus (Ivoclar Vivadent), Optibond All-in-One (Kerr), Optibond FL (Kerr), Optibond XTR (Kerr), Prime&Bond Elect (Dentsply), Prime&Bond NT (Dentsply), Scotchbond Universal (3M ESPE), Spectrum TPH 3 (Dentsply), Syntac (Ivoclar Vivadent), Variolink II (Ivoclar Vivadent), Vita In-Ceram (Vita Zahnfabrik), Wirobond C (Bego), Xeno Select (Dentsply), XP Bond (Dentsply), Z-Prime Plus (Bisco, Inc.)

(*) Prime&Bond Elect and Clearfil SE Bond 2 are not available in the EU.
6. Literature


Arantes-Oliveira S., *TEM investigations of the bonding layer between Futurabond U and dentine when using in self-etch and total-etch mode*, Faculty of Dentistry, Biomaterials Department, University of Lisbon, Portugal, report to VOCO, 2014.

Arantes-Oliveira S., *TEM investigations into nanoleakage on the contact surface between Futurabond U and dentine when using in self-etch and total-etch mode*, Faculty of Dentistry, Biomaterials Department, University of Lisbon, Portugal, report to VOCO, 2014.


Lohbauer U., University Hospital Erlangen, Dental Hospital 1 - Conservative Dentistry and Periodontology.


