

SCIENTIFIC REPORT

Futurabond M+ – Adhesion to zirconium dioxide

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Dental adhesives were originally developed to guarantee the security and marginal integrity of the bond between the hydrophilic dental hard tissue and the hydrophobic composite. As the use of additional dental materials such as metals, metal alloys and different types of ceramics becomes ever more commonplace in modern dentistry, the indications of conventional dental adhesives have been expanded following intensive research and development work. The result is that the newly developed universal adhesives produce a reliable bond with long-term marginal integrity not only on composites, but also on all other dental materials. The compatibility of the universal adhesives with all dental materials allows the treating dentist to skip individual work steps in his daily treatments to an extent never before possible.

With their advanced monomer technology, universal adhesives are, among other things, also indicated for sealing cavities or glass ionomer cement fillings and the treatment of hypersensitive tooth necks. In addition, they can be used as a primer on different indirect restoratives. Due to the innovation of the universal adhesives with their considerably expanded indication spectrum, some users remain sceptical of the reliability of the new materials in the different application possibilities. Consequently, the use of universal adhesives as a primer on oxide ceramics is still viewed critically by some experts. For this reason, Amaral et al. investigated the efficacy of a range of universal adhesives and conventional primers in bonding composites to zirconium dioxide at the University Hospital Erlangen.^[1]

This scientific report investigates the extent to which Futurabond M+, the new universal adhesive from VOCO, is suitable for the conditioning of a zirconium dioxide ceramic interface.

Zirconium dioxide is an important dental material and has a broad spectrum of application, for example in prosthetic restorations in the form of crowns and bridges. The permanent luting of this type of indirect restoration is traditionally performed in several stages: Roughening the inner surface of the crown by means of sandblasting, application of a primer and the application of a luting cement (GI cement or composite based). Etching of the bonding surface of the crown with hydrofluoric acid is not necessary on zirconium oxide and would also not improve the bonding.

The tooth stump is also pre-treated in the classic style with an adhesive, which must be compatible with the luting cement. In accordance with their innovative indications, today's universal adhesives can be used as a primer for both zirconium dioxide and for tooth stumps and thus save the dentist from having to use a separate material.

In their study Amaral et al. investigated the two universal adhesives Scotchbond Universal (3M ESPE) and Futurabond M+ (VOCO) as well as the conventional primers Z-Prime Plus (Bisco), AZ Primer (Shofu) and Monobond Plus (Ivoclar Vivadent) with regard to their efficacy as a bonding agent to zirconium dioxide.

Study design

This *in-vitro* investigation used 225 blocks of zirconium dioxide (Vita In-Ceram, VITA Zahnfabrik, H x W x L = 3.0 x 3.0 x 9.3 mm), which were sintered at 1,530°C for 2 hours prior to being measured. The zirconium dioxide was prepared in four different ways and divided into 15 subgroups (n = 15) in total.

- A: No pre-treatment, conditioning, 6 subgroups
- B: Air abrasion (Al_2O_3 , ø 35 µm), subsequent conditioning, 6 subgroups
- C: Silicate coating (SiO_2 , ø 30 µm), Rocatec Soft (3M ESPE), SilJet (Danville Materials), subsequent silanisation, 2 subgroups
- D: Porcelain glaze (VITA AKZENT), subsequent silanisation, 1 group

The materials employed for the conditioning following the pre-treatment corresponding to groups A, B, C and D are listed in Table 1. The antagonist to the indirect restoration was simulated using a lithium disilicate ceramic (IPS e.max Press, Ivoclar Vivadent). Variolink II (Ivoclar Vivadent) was used as the luting composite in all cases. Pre-treatment with the Rocatec / SilJet system is currently the gold standard and can thus be viewed as the control for the results of this study.

Following luting, the restorations were stored in water (37 °C) for 24 hours and then aged artificially by means of thermocycling (2,500 cycles). The adhesion values were then determined.

Table 1: Overview of the pre-treatments and the materials used

Group	Pre-treatment	Conditioning	Luting composite	Test specimen / antagonist
A	No pre-treatment	- Futurabond M+ * - Scotchbond Universal * - Z-Prime Plus ** - Monobond Plus ** - AZ Primer ** - Without primer	Variolink II	IPS e.max Press
B	Air abrasion	- Futurabond M+ - Scotchbond Universal - Z-Prime Plus - Monobond Plus - AZ Primer - Without primer	Variolink II	IPS e.max Press
C	1: Rocatec Soft 2: SilJet	- Porcelain Primer ** - S-Bond **	Variolink II	IPS e.max Press
D	Porcelain glaze (VITA AKZENT)	- Porcelain Primer **	Variolink II	IPS e.max Press

*Universal adhesive **Primer

Results

Figure 1 shows the results of Group A. In this group the zirconium dioxide ceramic was not pre-treated, but instead used in the condition in which it was directly after the sintering.

It is immediately clear from the results that all the restorations in which the test specimen was applied to the untreated ceramic without primer failed and thus deliver adhesion values of 0 MPa. This indicates that it is not possible for the dentist to skip any pre-treatment or conditioning. The primers Z-Prime Plus, Monobond Plus and AZ-Primer achieve adhesion values of between 7 and 10 MPa. The two universal adhesives, Scotchbond Universal and Futurabond M+, in contrast, delivered significantly higher adhesion values of 19 MPa and 25 MPa. As such, Futurabond M+ achieves a bond which is approximately three times as strong as the adhesion strength of the three conventional primers. This result confirms the claim that the improved monomer technology in Futurabond M+ ensures significantly improved wetting behaviour and is thus in a position to guarantee that the material achieves particularly high adhesion values even on such important dental materials as zirconium dioxide, without any additional measures.

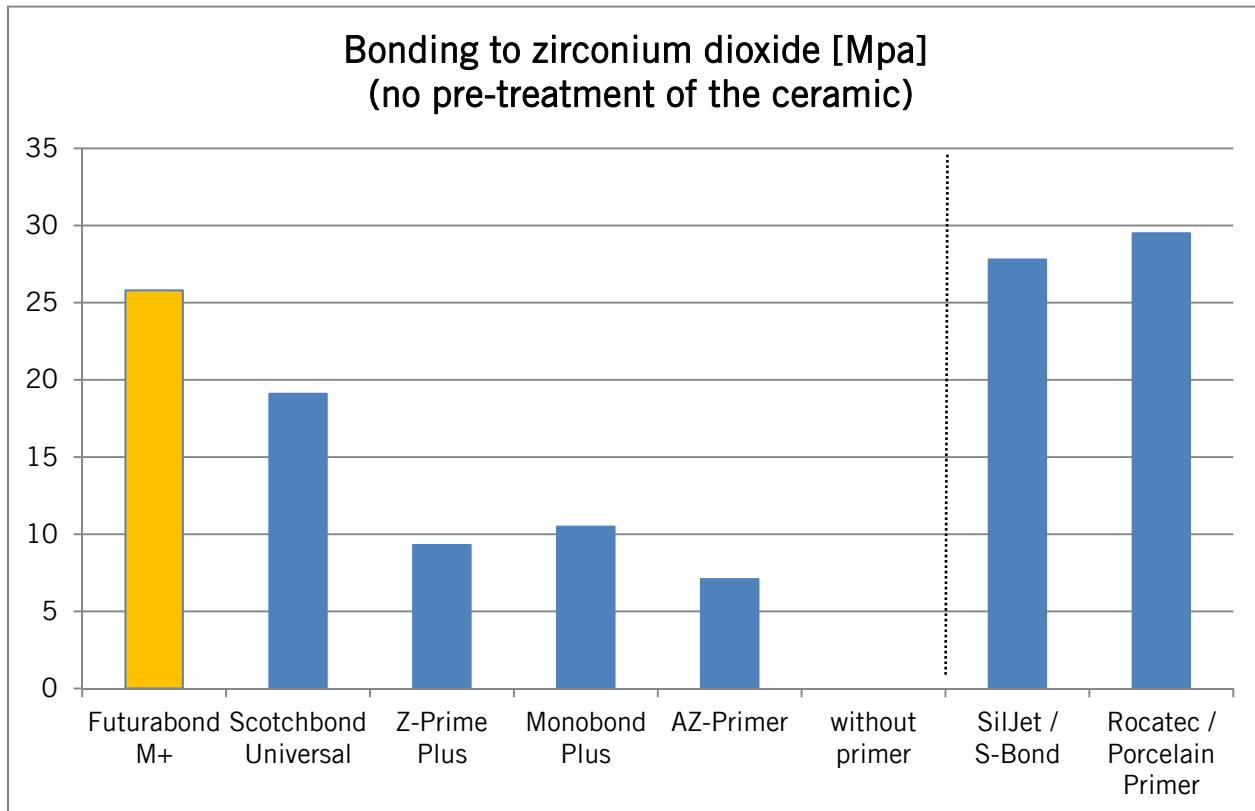


Figure 1: Bonding of different conditioners to zirconium dioxide without pre-treatment of the ceramic [MPa]

Figure 2 shows the adhesion values achieved following pre-treatment of the zirconium dioxide ceramic with sandblasting. Figure 1 showed clearly that Futurabond M+ displays results comparable with the gold standard (Rocatedec Soft and SilJet) without pre-treatment of the adhesive surface. Following pre-treatment with sandblasting (Fig. 2) Futurabond M+ even achieves adhesion values which are 15-20 % higher than with the gold standard.

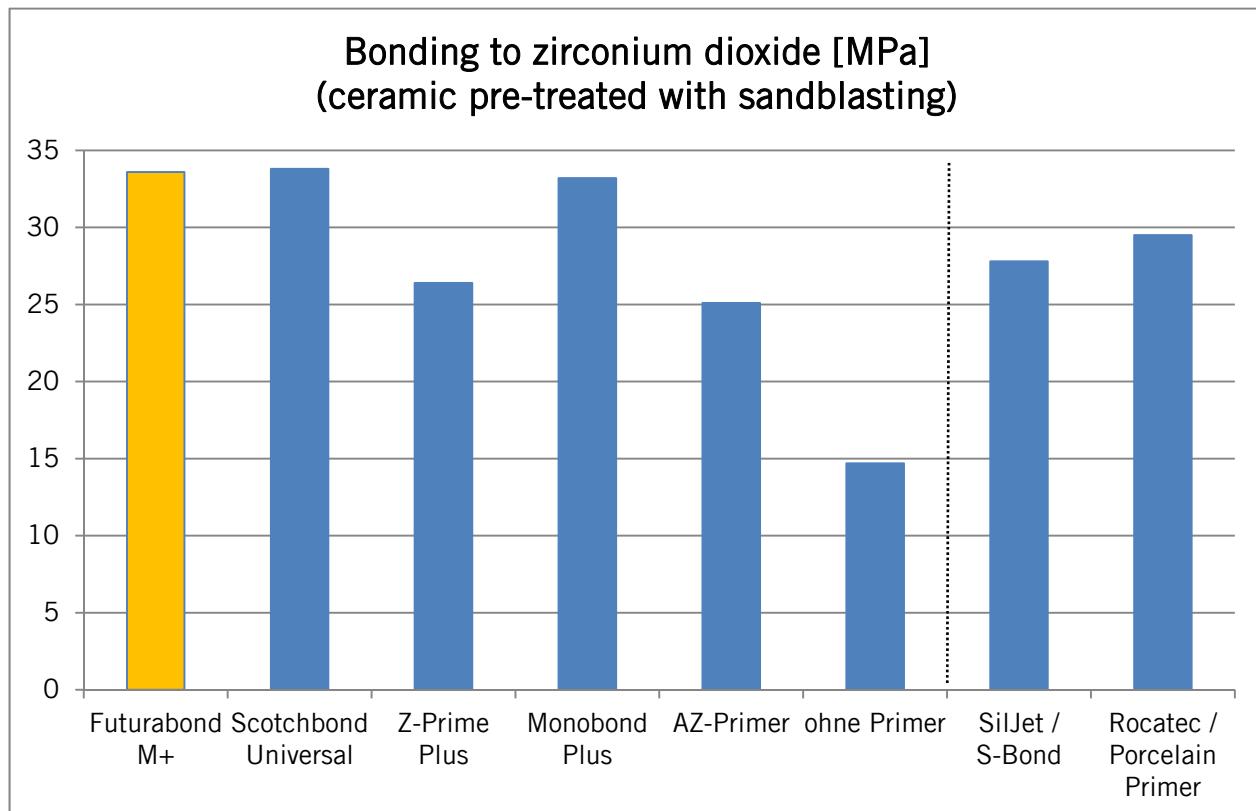


Figure 2: Bonding of different conditioners to zirconium dioxide following sandblasting of the ceramic [MPa]

Sandblasting the ceramic prior to the luting increases the adhesion of the different conditioners considerably. The reason for this can be found in the creation of additional mechanical retention on a roughened bonding surface. This means that an adhesion value of approx. 15 MPa can be achieved even without the use of a primer. The conventional coupling silanes Z-Prime Plus and AZ-Primer achieve adhesion values of approx. 25 MPa. Monobond Plus achieves an adhesion value of 32 MPa and as such is only slightly behind the adhesion values of Futurabond M+ and Scotchbond Universal (~34 MPa). The results show clearly that the innovative universal adhesives also possess significant advantages compared with the classic coupling silanes and primers following pre-treatment with sandblasting. This result in turn is proof of the excellent wetting behaviour of the universal adhesives. This ensures that the material also always achieves the largest possible coverage of the surface on which the universal adhesive is intended to give rise to a certain reaction.

One notable aspect of the results of Amaral *et al.*'s study is the fact that they showed that even **without** prior sandblasting, Futurabond M+ delivers identical results for the luting of zirconium dioxide crowns to those of classic primers **after** prior sandblasting. As such, it has been proven once again that the dentist can also rely on the universal adhesive Futurabond M+ for this indication without any hesitation and again save on the additional coupling silane and its time-consuming processing for the conditioning. Thanks to the latest generation of universal adhesives, the dentist now only requires one material for all clinical situations, regardless of whether for direct or indirect restorations, desensitisation, intraoral repair of chipping fractures or the sealing of cavities and temporary restorations.

Conclusion: Futurabond M+ is a safe and reliable bonding agent also when used for the luting of zirconium dioxide restorations. In this task, the universal adhesive achieves higher adhesion values than conventional coupling silanes even without pre-treatment of the ceramic, which is nevertheless still recommended. Futurabond M+ makes it possible to skip time-intensive additional steps and save on material costs without compromising on the quality of the restoration. As such, it has been possible to show once again that the dentist now only requires one material for all indications in day-to-day treatments in the dental practice.

Amaral M, Belli R, Cesar PF, Valandro LF, Petschelt A, Lohbauer U, *The potential of novel primers and universal adhesives to bond to zirconia*, Journal of Dentistry, 42, 90-98, 2014.