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BOND

NEWSLETTER FOR PROFESSIONALS IN DENTISTRY

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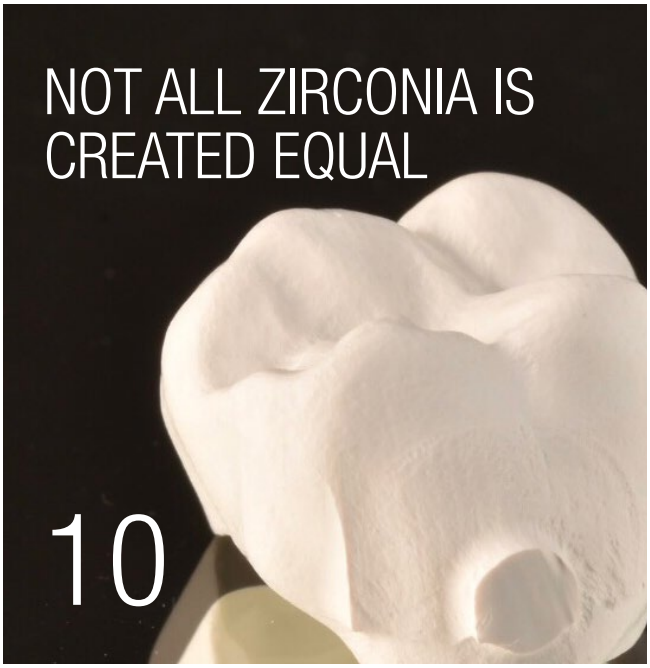

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COMPLEX CHEMISTRY FOR THE SIMPLIFICATION OF PROCESSES

MITSURU TAKEI,
Head of Scientific Marketing Europe

It is my pleasure to welcome you to Volume 6 of BOND, Kuraray Noritake Dental's newsletter for professionals in dentistry.

This edition of BOND coincides with the 20th anniversary of CLEARFIL™ SE BOND, still considered by many to represent the gold standard for dental bonding. To mark this occasion, we spoke with Kazumitsu Nakatsuka, one of the product developers and now Head of the Business Unit Medical at Kuraray Europe GmbH, about CLEARFIL™ SE BOND's invention and continued relevance in a crowded market.

Prof. Bart Van Meerbeek, Head of BIOMAT (Biomaterials Research Group) at KU Leuven, Belgium and co-editor-in-chief of the Journal of Adhesive Dentistry, and one of the most respected voices on the topic, discusses the history of dental bonding agents and why the MDP monomer is one of the best functional monomers available.

This issue also features an updated contemporary guide to that difficult restorative decision: conventional cementation or adhesive luting? For this topic, Prof. Dr. Florian Beuer, Chairman of Prosthodontic Department at Charité University in Berlin and Dr. Adham Elsayed, Clinical and Scientific Manager at Kuraray Europe GmbH, bring their expertise together to deliver their verdict.

Dr. Hendrik Zellerhoff, owner of Dr. Zellerhoff private practice in Germany, then outlines the differences between variants of zirconia and demonstrates why an informed opinion regarding these is essential for long-term restorative success. Dr. Zellerhoff presents a case that integrates the KATANA™ Zirconia STML Block into a CEREC workflow to create crowns with a natural aesthetic appearance in the aesthetic zone.

We round out the issue with an overview of PANAVIA™ SA Cement Universal, which renders the silanisation step of chemical bonding redundant. As with many solutions from Kuraray Noritake Dental, this self-adhesive resin cement has a chemical composition delicately refined by our scientific team to deliver simpler chairside product.

With my best regards,

Mitsuru Takei
Head of Scientific Marketing Europe

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ANNIVERSARY OF CLEARFIL™ SE BOND

20 YEARS OF SIMPLE AND DURABLE DENTAL BONDING

Many products in the dental industry are extremely short-lived, with alternatives that offer a better performance or simpler use replacing them after only a few years. CLEARFIL™ SE BOND from Kuraray Noritake Dental is different. The popular adhesive consisting of a single-bottle self-etching primer and a single-bottle light-curing bonding agent was launched 20 years ago and is still available today. As if this was not enough, universities around the world regard it as the gold standard in dental bonding.

We had a conversation with one of the product's developers, Kazumitsu Nakatsuka, about the invention, the challenges during its development and its position in the market today. Currently, Kazumitsu Nakatsuka is the Head of the Business Unit Medical at Kuraray Europe GmbH.

Kazumitsu Nakatsuka, what was your main aim when you started developing CLEARFIL™ SE BOND as a two-bottle adhesive system?
At the time the product was developed, dental bonding procedures were still complex. Although our first adhesive with a self-etching primer – e.g. CLEARFIL™ LINER BOND 2 – was already available, the total-etch approach was the standard procedure well established in dental offices all over the world. With the two-bottle self-etch primer in CLEARFIL™ LINER BOND 2, we had already eliminated the drawbacks associated with phosphoric acid etching, rinsing and drying of the tooth, but we still saw potential for improvement and further simplification.

What did you do to improve and simplify the self-etch bonding technology?
The idea was to develop a light-curing two-bottle bonding agent with a single-bottle, mild self-etching primer and a single-bottle adhesive. We wanted it to offer a bond strength higher than that of CLEARFIL™ LINER BOND 2 and equivalent to that of the dual-cure self-etching CLEARFIL™ LINER BOND 2V. Other aims were to shorten the application time of the primer and the irradiation time of the adhesive. Important measures that allowed us to reach our goals were the use of original MDP from Kuraray Noritake Dental – a Kuraray-invented adhesive monomer that establishes a chemical bond to enamel, dentin and metal oxides, modifications in the catalyst technology of the primer, and the development of a new initiator in the adhesive. Our last goal was to make sure that dental practitioners would accept the product and the simplified bonding technique coming with it across the Japanese borders.

What were the main challenges you encountered during the development process?
Thanks to a great team of passionate researchers, there were relatively few obstacles to overcome during the actual product development. A lot of testing and fine-tuning was necessary to ensure and verify a high initial bond strength as well as long-term stability of the adhesive interface. This laboratory testing, however, is not unusual for the development of any dental material. The biggest challenge came with the product's introduction to the global dental market in the year 2000. We really wanted to provide ideal conditions for dental practitioners all over the world to start using the product.

How did you achieve this?
In order to set the stage for market acceptance, we decided to collaborate with universities in Japan, Europe and the United States and asked them to test the product thoroughly.

Launched 20 years ago: CLEARFIL™ SE BOND consisting of a single-bottle self-etching primer and a single-bottle light-curing bonding agent.

They initiated independent in-vitro and in-vivo studies to evaluate the performance of CLEARFIL™ SE BOND. Meanwhile, reports are available that confirm a great clinical performance over a period of up to 13 years[1]. These clinical long-term results are the main pillars of our strong scientific evidence. And it is exactly this evidence we used to convince university professionals and dental practitioners with highest demands to select CLEARFIL™ SE BOND as their go-to adhesive.

You mentioned that the use of MDP as an adhesive monomer in CLEARFIL™ SE BOND was one of the strategies that enable the huge success. Is there a difference between the original MDP from Kuraray Noritake Dental and MDP used by other manufacturers?

In fact, there is a difference[2]. We believe that MDP is the best adhesive monomer available for dental bonding, and this is why so many dental manufacturers use it. However, high-quality synthetization of the monomer is very difficult to achieve. In addition, the composition is important, as it determines how the adhesive interacts with the tooth structure. The original MDP from Kuraray Noritake Dental is special in that it is very stable in water and therefore contributes to the long-term stability of the products containing it in the oral cavity.

In the last years, a number of additional dental bonding agents appeared on the dental market. What is the position of CLEARFIL™ SE BOND next to these products?

The demand for CLEARFIL™ SE BOND is still high across the globe. One reason for dentists to use the product is the long-term clinical evidence, which is not yet available for products launched more recently. While promising in-vitro data allows us to predict a great overall performance, this clinical evidence strongly supports such in-vitro results. The second reason for us to think that CLEARFIL™ SE BOND is still an important product in the portfolio is its slightly higher bond strength e.g. compared to most single-bottle universal adhesives. Hence, while the bond strength of these adhesives is high enough for many dental procedures, some users and indications might ask for more. This is what CLEARFIL™ SE BOND offers.

Please give an example of an indication requiring the highest possible bond strength.

Bulk filling of posterior cavities is a very good example. In this context, a higher shrinkage stress might develop, leading to an increased risk of microleakage at the adhesive interface. In order to minimize this risk and avoid clinical issues associated with this phenomenon, many experienced dental practitioners prefer an easy-to-use product that offers a low technique sensitivity and a very high bond strength independent on the skills of the operator – i.e. CLEARFIL™ SE BOND.

What may dental practitioners expect from Kuraray Noritake Dental in the field of dental adhesive development in the next years?

Let me assure you that being a developer at Kuraray Noritake Dental means that you are never satisfied with the technology or product just launched. Like my team, which immediately start looking for possible new developments after introducing CLEARFIL™ SE BOND in the market, the developers behind our latest dental bonding agents are also constantly in search for better, simpler and more durable solutions. In this context, they are not focusing on bonding solutions alone, but on how to improve the quality of dental restorations without complicating the procedures. In the end, it is all about improving the patient's well-being, which should also be the ultimate goal of any dental practitioner choosing an adhesive.

Kazumitsu Nakatsuka, thank you very much for this conversation.

Kazumitsu Nakatsuka,
Head of the Business Unit Medical at Kuraray Europe GmbH.

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Interview with Prof. Bart Van Meerbeek

THE PAST, PRESENT AND FUTURE OF ADHESIVE DENTISTRY.

As co-editor-in-chief of the ***Journal of Adhesive Dentistry***, Prof. Bart Van Meerbeek is one of the most respected authorities on the topic of dental bonding agents. Here, he discusses how they have advanced over the last three decades and what the future of adhesive dentistry might look like.

> "I BELIEVE THAT THE GREAT PROGRESS DENTAL ADHESIVE TECHNOLOGY HAS UNDERGONE IN THE LAST 30 YEARS, AND THE PROGRESS IN BONDING AGENTS IN PARTICULAR, HAS HAD A GREAT IMPACT ON THE FIELD OF DENTISTRY AND PARTICULARLY ON RESTORATIVE DENTISTRY, OF COURSE."

Prof. Van Meerbeek, how have bonding agents changed and advanced since you first began studying them?
I believe that the great progress dental adhesive technology has undergone in the last 30 years, and the progress in bonding agents in particular, has had a great impact on the field of dentistry and particularly on restorative dentistry, of course. Many of the current restorative dental procedures make use of adhesive materials and techniques and have advanced greatly compared with when I wrote my dissertation more than two decades ago on the topic of adhesion to dentine. Adhesion to enamel is, of course, relatively easy to achieve in comparison with adhesion to dentine, and when I first started researching this topic, I was limited to conducting clinical trials in which we were confronted with a relatively high number of restoration losses in the short term. I was lucky to have been able to witness first-hand the fast advancements dental bonding has made, having conducted research in this field now for nearly 30 years.

At a certain point, the research community started to realise that there is a smear layer in-between, which is created through cavity preparation, and that this layer interferes with bonding. If you want to achieve successful micromechanical and chemical bonding to the substrate, you first need to do something with this smear layer.

> I DO SEE IT AS A POSITIVE THAT MANY OF THESE UNIVERSAL ADHESIVES INTEGRATE THE MDP MONOMER, WHICH SHOULD BE CONSIDERED TO BE ONE OF THE BEST FUNCTIONAL MONOMERS AVAILABLE TODAY, THOUGH IT NEEDS TO BE PRESENT AT A HIGH CONCENTRATION AND PURITY LEVEL.

After this, we entered the era of conditioners and primers. In the past, the restorative community had been a little bit afraid of using phosphoric acid owing to its potential for pulp irritation. More and more, however, dental professionals began to use etchants with this chemical in them, as well as primers that effectively promoted bonding between the adhesive resin and dentine. While having achieved excellent bonding performance with multistep adhesives in the laboratory, as was later confirmed in clinical studies, further design and development of adhesive materials next focused on simplification and shortening of bonding procedures.

Out of this, two kinds of adhesives, making use essentially of two different bonding modes, arose: the etch-and-rinse adhesives and the self-etch, or etch-and-dry, adhesives. The newest generation of universal adhesives now enables dental practitioners to choose which of the two bonding modes to apply with one single adhesive formulation.

What advantages do bonded restorations offer over more traditional methods?

Bonded restorations are minimally invasive—the dentist doesn't have to remove non-diseased tissue to create undercuts to keep the restoration in place, allowing for a more conservative approach. Keeping as much enamel as possible should be a goal of any restorative procedure, as it is simply the best tissue to bond to. Although bonding to dentine has always remained more challenging and has actually slowed down our adhesive endeavours for a long time, adhesively restoring teeth, involving also effective bonding to dentine, can today be achieved in a reliable, predictable and durable way.

Along with highly successful implantology to replace missing teeth, lessening the need for bridges, solitary tooth restorations have substantially increased in number. Bonding promoted the additional shift from conventional tissue-invasive crowns to tissue-preserving partial tooth restorations, as modern adhesives can hold such partial restorations in place on rather flat and even non-retentive surfaces. In addition, bonding procedures allow for more natural-appearing restorations to be achieved by techniques to adhesively lute aesthetic restorations made of glass-ceramics and even the strong zirconia ceramics that no longer can be considered non-bondable.

What is your opinion regarding the current generation of universal adhesive solutions?

I think that this generation is very good, but that they are still not always as good as the more traditional gold standard two-step self-etch and three-step etch-and-rinse adhesives when it comes to their intrinsic bonding potential to dental tissue. However, I do see it as a positive that many of these universal adhesives integrate the MDP monomer, which should be considered to be one of the best functional monomers available today, though it needs to be present at a high concentration and purity level.

The MDP monomer is, generally speaking, excellent at bonding to zirconia as well. When it comes to bonding to different kinds of ceramic as well as resin-based composite restorative materials, it is always helpful to know which universal adhesives contain silane and are claimed to no longer need further treatment of the restoration. This has the advantages of lower technique sensitivity and fewer procedural steps—provided that it does, of course, work. There is current scientific evidence that the silane incorporated in today's acidic aqueous universal adhesives is, however, insufficiently stable. Fortunately, research is underway to develop new universal adhesives that contain other silanes with higher stability in water at higher acidity.

Overall, I believe that a restoration primer that contains a high concentration of silane along with the MDP monomer is still more effective than many universal adhesives for bonding to restorative materials, since these universal adhesives can contain many other ingredients that create a kind of competition within the material to reach and interact with the substrate surface, leading to lesser bonds.

Another shortcoming of universal adhesives is their thin film thickness and relatively high hydrophilicity, promoting water uptake and hence making them sensitive to

hydrolytic degradation. In this light, it's important to note that, when a viscous and hydrophobic flowable composite is applied on top of a universal adhesive, it can make up for this somewhat and allow for durable bonding to take place.

Is the MDP monomer crucial to the ultimate success of universal adhesives? Are there other factors that can influence this?

Well, it's very clear that the MDP monomer is one of the most effective monomers available, given its primary chemical binding potential to hydroxyapatite. However, there are significant differences in the MDP monomer purity and concentration levels between these products, factors that are affected by whether or not the monomer is synthesised by the company itself or whether this process is outsourced. Essentially, a universal adhesive that contains a high concentration of very pure MDP monomer should perform the best.

Are there any specific advantages that a self-etch adhesive possesses?

The biggest advantage is that it doesn't remove all hydroxyapatite and minerals present in dentine and so keeps the weaker dentinal collagen protected. Phosphoric-acid etching results in relatively deep and complete demineralisation with collagen exposure, making the bond more prone to degradation. Partially maintaining minerals around collagen using a mild self-etch adhesive additionally allows for strong ionic bond formation to take place when the adhesive in particular contains the functional monomer MDP. In addition, one should be aware that, while chemical binding doesn't necessarily lead to higher bond strength, it can create better long-term bond durability.

What do you see as the next step in adhesive dentistry?

One possibility is to reduce the number of steps in the adhesion process with the final goal of having self-adhering restorative materials. There have been developments in this direction, including studies and commercial products, though the products haven't always proved to be very effective and their bond durability is unclear. Now, however, there are newer materials coming to market with claims that they can be used with no pretreatment. Their clinical effectiveness, nevertheless, still needs to be proved and guaranteed before such self-adhering restorative materials could be used as true amalgam alternatives in routine dental practice.

“SOME RESEARCHERS BELIEVE THAT THEY SHOULD HAVE ANTIBACTERIAL QUALITIES, WHEREAS OTHERS STATE THAT REMINERALISATION OF DENTINE AND PULPAL CELL INTERACTION ARE NEEDED TO QUALIFY FOR THE TERM “BIOACTIVE”. WE CERTAINLY NEED TO INVESTIGATE WHETHER WE CAN GIVE THESE MATERIALS THESE ADDITIONAL PROPERTIES, BUT ON ONE CONDITION: THAT THE ADHESIVE MATERIAL DOES NOT LOSE ANY OF ITS ORIGINAL BONDING ABILITIES.”

Another possibility, and current R & D hype, is the development of bioactive adhesives. Many dental researchers and many companies want adhesives not only to deliver good bonding performance but also to have certain therapeutic benefits. What exactly a bioactive adhesive is depends on who you're talking to. Some researchers believe that they should have antibacterial qualities, whereas others state that remineralisation of dentine and pulpal cell interaction are needed to qualify for the term “bioactive”. We certainly need to investigate whether we can give these materials these additional properties, but on one condition: that the adhesive material does not lose any of its original bonding abilities. That, in my opinion, is the biggest challenge for the future of adhesive dentistry.

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ALL INDICATIONS. ONE BOND.

No waiting, No multiple layers, No extensive rubbing.

CLEARFIL™ UNIVERSAL BOND QUICK

Unlike traditional dental bonding agents that require waiting time, extensive rubbing and multiple layers in order to deliver an optimum result, with CLEARFIL™ Universal Bond Quick your restorative procedures are carried out to the exceptionally high standards. Exceptional levels of adhesion result in a bond that lasts with minimal risk of remedial work. And, because there's no need to wait before you proceed, procedures take less time than with most other available bondings, benefiting both patient and practitioner.

BORN IN JAPAN

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CONVENTIONAL CEMENTATION OR ADHESIVE LUTING

A GUIDELINE WITH REGARD TO CONTEMPORARY MATERIALS

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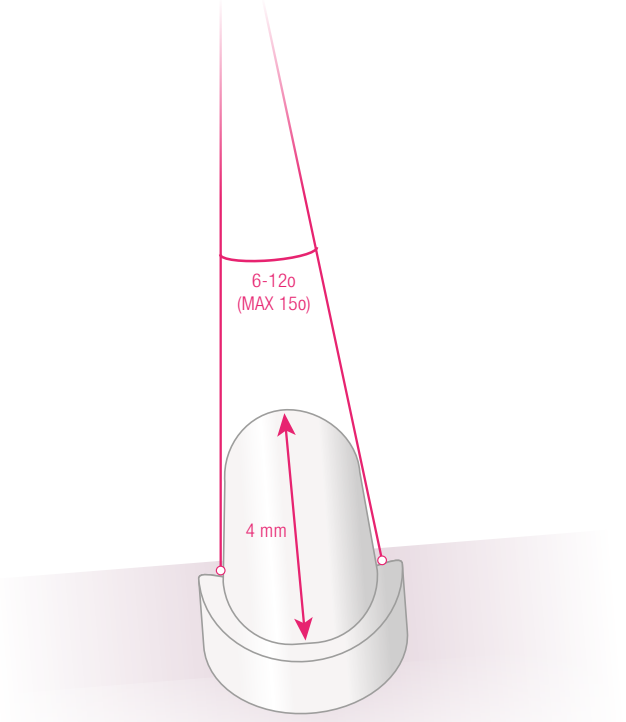
The retention of the fixed prosthodontic restorations is a critical factor for the long-term success, as the loss of crown retention is one of the main reasons for failure of crowns and fixed dental prosthesis (FDP) [1, 2]. There are three main elements that need to be considered to achieve proper retention of the restorations; the tooth preparation, the restorative material and the luting agent.

TOOTH PREPARATION

During tooth preparation there are some important features to be considered, such as the height, angle and surface texture of the abutment tooth, in order to achieve an adequate retention and resistance form which provide stability of the restorations to resist dislodgment and subsequent loss [3]. Retention form is responsible for counteracting tensile stresses, whereas resistance form counteracts shear stresses [4].

In order to achieve a sufficient retention and resistance form for full coverage crowns it is recommended that the height of the abutment tooth should be at least 4 mm and that the optimal convergence angle should range from 6 to 12 degrees with a maximum of 15 degrees [1, 5-8].



RESTORATIVE MATERIAL

With the continuous introduction of new restorative materials to the dental market it is important to take into consideration the different mechanical properties of the various materials. The composition and the surface properties of the material have a decisive role in the ability to accomplish mechanical and/or chemical attachment to the restoration and therefore achieving required retention.

LUTING AGENT

The luting agent is the connection between the tooth and the restoration. Proper luting of indirect restoration is critical in achieving long-term success as it highly influences the retention of the restoration as well as tightly sealing the gap between the restoration and the tooth. Although there are several classifications for the definitive luting agents, they can be , however, classified into two main categories based on the ability to achieve chemical connection to different substrates; conventional (e.g. zinc phosphate, glass-ionomer and resin-modified glass-ionomer cements) and adhesives. Most commonly used and best documented adhesive luting agents are the adhesive composite resin cements.

Composite resin cements can be further classified according to the chemical composition into traditional full-adhesive resin cement and self-adhesive resin cements, both also differ in the bonding procedure. The full-adhesive resin cements require pre-treatment of the tooth structure and restorative material using separate adhesive systems. In this combination of the resin cement and the adhesive system, very durable chemical bonding can be reached.

To simplify the luting procedure and eliminate the need of using several components, the self-adhesive resin cements are a good choice for the daily busy practice, in which reliable bonding can be achieved in only one simple step of cement application, mostly without additional primers or bonding agents.

With the availability of different types of cements, the decision of choosing the suitable luting agent and method can be confusing for the practitioner. Especially with the wide use of contemporary restorative materials such as new generations of highly translucent zirconia as well as reinforced-composites, it is important to take into consideration that the properties of such materials differ highly from metal or earlier generations of zirconia. Subsequently the choice of the luting agent must be appropriate to achieve satisfying results and long-term success. Therefore, in this article, the authors aim to provide insights for the clinicians on choosing the correct luting agent that can help achieve satisfactory results for the dentist as well as the patients.

CONVENTIONAL CEMENTATION OR ADHESIVE LUTING?

The choice of whether to use a conventional cement or an adhesive resin cement depends on several factors, the key factors are:

1. Retention and resistance form of the abutment tooth.
2. Mechanical and optical properties of the restorative material (flexural strength and translucency).
3. Simplicity of the workflow and special requirements of the working environment.

1) RETENTION AND RESISTANCE FORM OF THE ABUTMENT TOOTH

Minimal-invasive restorations, such as resin-bonded FDP, labial and occlusal veneers and inlay-retained FDP are based on a non-retentive preparation form. In this case the only possible method to achieve retention is the adhesive luting [9-11].

Even though such preparations completely lack a retentive form, long-term success of the restorations is well-documented when using a durable resin cement (e.g. PANAVIA™ 21, Kuraray Noritake Dental Inc., Japan) and proper bonding procedure [10, 11].

For full-coverage restorations (e.g. crowns and FDPs), the guidelines for tooth preparation discussed before (minimum height of 4 mm and maximum convergence of 15 degrees) need to be applied in order to achieve the retention and resistance form required to make cementation with a conventional luting agent acceptable.

However, in reality this retention form is hard to realize due to several factors.

In cases of severe loss of tooth substance, achieving a minimum height of the abutment tooth is only possible with building up the tooth using a core build-up material which in some cases can be considered time consuming especially when the required build-up is minor (for example 1-2 mm). Moreover, increasing the height through core build-up is sometimes not possible, as in cases with short clinical crowns and insufficient occlusal clearance that is essential to provide the minimum thickness required for the restorative material. In such cases surgical crown lengthening is necessary to increase the height of the tooth without compromising the occlusal space required, which can be time consuming for the clinician and undesirable for the patient as it involves a surgical procedure and extends the treatment process.

Concerning the convergence angle, several studies showed that in reality and in daily practice of the dentist, the preparation angle is much higher than 15 degrees [5, 6, 12, 13]. For instance, preparations from general practitioners were evaluated digitally and compared to clinical recommendations and it was found that the mean convergence angle was 26.7 degree with the distopalatal angle being 31.7 degree [12].

Based on the previous concerns, it can be concluded that achieving a proper retention form during daily practice is hard to realize and thus conventional cementation in such cases can present clinical problems especially on the long term. Therefore, adhesive luting can be recommended in these cases as an alternative to conventional cementation [6, 14]. For full-coverage restorations with preparation designs featuring at least some mechanical retention, the use of self-adhesive resin cements can be considerate a good alternative as it provides high clinical success rates [9, 15].

Conclusion / Clinical Significance:

- For non-retentive minimal-invasive restorations, traditional full-adhesive luting is a must.
- For full-coverage restorations, full-adhesive or self-adhesive luting is recommended.
- In case a retentive preparation with minimum height of 4mm and convergence angle of 6-12 degrees, adhesive luting as well as conventional cementation can be used.

2) MECHANICAL AND OPTICAL PROPERTIES OF THE RESTORATIVE MATERIAL

Flexural strength and translucency of the restorative material are critical factors that influence the decision which luting agent to use.

a) Flexural strength

As a general guideline for all-ceramic restorations, ceramics with low and medium flexural strength under 350 MPa should be adhesively luted with composite resin cements, as these restorations rely on resin bonding for reinforcement and support [9, 14, 16]. This includes feldspathic-, glass-, hybrid-ceramics and composite.

Although discussions on conventional cementation versus adhesive luting for high-strength ceramics with flexure strength of more than 350 MPa have been going on for a long time [9], there are several studies showing an increased stability and strength of all types of ceramics, even lithium disilicate and zirconia, when they are adhesively luted [9, 17-20].

It is also important to consider that the documented success of most conventional cements is mainly combined with restorations made of metal or early generations of zirconia. Nonetheless, the clinical success of new generations of high-translucent zirconia can be significantly influenced by the luting agent as these new generations have notably lower flexural strength [9]. And therefore, attention has to be paid to minimal material thickness together with adhesive luting to ensure long-term clinical success and prevent fractures [9].

Conclusion / Clinical Significance:

- For glass-ceramic, hybrid-ceramics and composites, adhesive luting is a must.
- For lithium disilicate and zirconia restorations, adhesive luting is highly recommended.
- For metal restorations, adhesive luting as well as conventional cementation can be used.

TABLE 1: **ADVANTAGES OF DIFFERENT LUTING METHODS**

CONVENTIONAL CEMENT	FULL ADHESIVE RESIN CEMENT	SELF-ADHESIVE RESIN CEMENT
- Simple workflow	- Very strong and durable bond strength - Ability to work minimally-invasive - Stabilization of the tooth structure - Stabilization and strengthening of the restoration - Adhesive sealing of the gap between tooth and restoration and prevention of microleakage - Superior esthetics	- Moderately high bond strength (depending on the adhesive system) - Ability to work minimally-invasive - Stabilization of the tooth structure - Stabilization and strengthening of the restoration - Adhesive sealing of the gap between tooth and restoration and prevention of microleakage - Superior esthetics - Simple workflow

b) Translucency

To meet the increasing esthetic demands of the patients, new materials and techniques are continuously introduced, aiming to provide the perfect esthetic restorations. This includes not only new restorative materials but also new modifications to the luting agents as well.
Highly translucent ceramics can deliver superior esthetics and therefore their popularity and clinical applications expanded widely among clinicians. It is nevertheless very important for the clinician to apprehend that the final esthetic result is influenced by the complete restorative complex and not just by the restorative material, as the luting agent is a key factor in achieving the desired high esthetics [21-24].

For that reason, the choice of an opaque conventional cement for cementation of high-translucent restoration should not be recommended as it can negatively influence the final esthetic results. Therefore, composite resin cements are the material of choice, as they are available in different shades and translucencies for the clinician to be able to choose the suitable resin cement to achieve the desired esthetics based on the restorative material and thickness as well as the color of the underlying abutment. Some composite resin cements offer try-in paste so that the clinician and the patient can visualize the final results before luting and therefore better choose the appropriate shade of the resin cement.

Conclusion / Clinical Significance:

- For all translucent ceramic restorations, adhesive luting is highly recommended.
- For metal and opaque high-strength zirconia restorations, adhesive luting as well as conventional cementation can be used.

3) SIMPLICITY OF THE WORKFLOW AND SPECIAL REQUIREMENTS OF THE WORKING ENVIRONMENT

The process of adhesive luting with full-adhesive composite resin cements (e.g. PANAVIA™ V5, Kuraray Noritake Dental Inc.) requires separate etching and priming procedures usually using a self-etch adhesive system (e.g. PANAVIA™ V5 Tooth Primer, Kuraray Noritake Dental Inc.) as well as a primer for the restorative material such as a universal primer that can be used for different substrates including metal, ceramics and composites (e.g. CLEARFIL™ CERAMIC PRIMER PLUS, Kuraray Noritake Dental Inc.). These procedures are technique sensitive and intolerant to contaminations, therefore the luting process needs a dry oral environment avoiding any contamination, such as saliva or blood, preferably using rubber dam, as any contamination can compromise the bond strength. Therefore, inability to maintain dry field as in case of subgingival preparation margins is considered a contraindication for traditional full-adhesive luting. However, this method provides very durable bond strength, therefore it is the luting method of choice for minimal invasive non-retentive preparations, such as resin-bonded FDPs, labial and occlusal veneers and inlay-retained FDPs, in which the retention is mainly dependent on the adhesion [9-11].

Still, in everyday practice, clinicians seek efficiency and effectivity by using a simple but durable luting agent for the insertion of full-coverage restorations such as tooth- or implant-supported crowns and FDPs. Although the conventional cements are simple and fast in their use, they provide little or no adhesion at all and therefore they are not recommended in several cases [6, 9, 14, 15, 19, 20]. A simple but reliable method can be well accomplished by the use of self-adhesive resin cements (e.g. PANAVIA™ SA Cement Universal, Kuraray Noritake Dental Inc.) as they can be considered the best alternative for full-adhesive adhesive luting in less critical situations that do not rely entirely on adhesion [9, 15]. Furthermore, self-adhesive resin cements are not as technique sensitive and intolerant to contaminations as traditional full-adhesive resin cements.

TABLE 2: **CONTRAINDICATION OF DIFFERENT TYPES OF LUTING AGENTS**

CONVENTIONAL CEMENT	FULL ADHESIVE RESIN CEMENT	SELF-ADHESIVE RESIN CEMENT
Contraindicated - Hypersensitivity to specific component (depend on the type of cement)	**Contraindicated** - Hypersensitivity to methacrylate monomers	**Contraindicated** - Hypersensitivity to methacrylate monomers
Not recommended - Low- and medium-strength materials - Highly-translucent ceramics - Non-retentive preparations	**Not recommended** - Inability to achieve dry working environment to avoid contamination	

Typically, a MDP phosphate monomer is integrated in the self-adhesive resin cement, which is required to chemically bond to different substrates, making it possible for the resin cement to chemically bond to non-precious metals and zirconia as well as tooth substance. However, regardless of the self-adhesive resin cement, the use of a separate silane coupling agent is still required when bonding to silica-based ceramics (e.g. leucite, lithium silicate and lithium disilicate), hybrid ceramics and composite restorations.

Recently, a unique self-adhesive resin cement (PANAVIA™ SA Cement Universal, Kuraray Noritake Dental Inc.) was introduced: through an innovative and distinctive production technology, a silane-coupling agent (long carbon chain silane (LCSi)) is integrated in the cement, and thus being the real universal adhesive system that completely eliminate the need for any other adhesive or primer when being used for all substrates including glass ceramics. So the luting process can be in this case truly shortened to one step.

Therefore, this unique cement combines several advantages of adhesive luting as well as the straightforward procedure of the conventional cementation without compromising the clinical success, regardless of the type of the restorative material.

As a conclusion, adhesive luting has more benefits over conventional cementation, regarding retention, esthetics, stabilization of the tooth and the restoration as well as preventing microleakage [6, 9, 14-17, 19, 20, 25, 26] (Table 1). Moreover, there are no absolute contraindications for adhesive luting other than hypersensitivity to methacrylate monomers, as self-adhesive resin cements can be used in cases where full-adhesive resin cements are contraindicated, such as inability to avoid contamination (Table 2). As a result, adhesive luting can be generally used in every clinical situation, whereas conventional cementation is limited (Table 3).

TABLE 3: **GUIDELINES FOR USING DIFFERENT TYPES OF LUTING AGENTS**

Clinical Situation	CONVENTIONAL CEMENT	SELF-ADHESIVE RESIN CEMENT	FULL-ADHESIVE RESIN CEMENT
Non-retentive minimal-invasive preparation			
Full-coverage preparation with compromised retention			
Full-coverage preparation with optimal retention form (min. 4 mm and 6-12 degrees)			
Translucent materials or highly-demanding esthetics			
Glass-ceramic, Leucite-ceramic, Hybrid-ceramic, Composite			
Lithium-disilicate and Zirconia			
Metal-based restorations			
Inability to achieve dry working environment (e.g. subgingival margins)			

INDICATED / RECOMMENDED NOT RECOMMENDED CONTRAINDICATED

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Cement everything* without primers. Even glass.

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A forerunner in self-adhesive resin cements that adheres to virtually every material including glass ceramics without the need for a separate primer. This is achieved by using a unique silane coupling agent, which is already integrated into the cement's paste, thanks to the innovative silane technology developed by Kuraray Noritake Dental. The cement delivers a strong, durable chemical bond to porcelain, zirconia, lithium disilicate and composite resin. It makes your daily cementations fast and predictable by offering single-step procedure, easy excess removal from the gums and storage at room temperature.

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*PANAVIA™ SA Cement Universal is suitable for the cementation of all regular used types of restorative materials such as ceramics (porcelain, lithium disilicate, Zirconia, etc.), composite resins and metal based restorations.

ONE SINGLE PROCEDURE, NO PRIMERS NEEDED.

PANAVIA™ SA CEMENT UNIVERSAL

Peter Schouten

Kuraray Noritake's self-adhesive cement series, PANAVIA™ SA Cement Universal, has evolved through several stages of development since it was first introduced as "CLEARFIL™ SA Cement". Over time, various improvements have been implemented and we are now proud to launch the latest version: PANAVIA™ SA Cement Universal. Improvements include strengthening of the bonding power to dental tissue, increasing the storage temperature to room temperature and extending the shelf life to three years. What hasn't changed is the easy removal of any excess cement, the moisture tolerance and the integration of the original MDP monomer.

The original MDP enables PANAVIA™ SA Cement Universal to be bonded to dental tissue as well as to metals and zirconia ceramics. Until recently, the chemical bonding of glass-based materials such as porcelain, glass ceramics, including lithium disilicate, and composite, was only possible with an additional silane-based primer.

The introduction of PANAVIA™ SA Cement Universal has rendered the silanisation step redundant. Instead, the silane has been incorporated into the PANAVIA™ SA Cement Universal paste. As a result, from now on, there is only one single universal procedure, without the need for separate primers.

LCSi

Adding silane to the paste sounds easy. However, there are some limiting factors. For example, keeping silane in the form of γ-MPS (γ-methacryloxypropyltrimethoxysilane) active for a long time is a challenge. This is partly due to γ-MPS' hydrophilic nature. Contact with water under acidic condition results in hydrolysis of alkoxy groups of silane. Therefore, it is best to use a more hydrophobic and thus stable silane and to avoid bringing it into contact with water and acid prematurely.

APPLY

REMOVE CEMENT

READY

MDP MONOMER
Innovating for your success

The Original MDP monomer creates a strong chemical bond to Enamel, Dentin, Metal Alloy and Zirconia.

Chemical Affinity
Long Carbon-chain Silane Coupling Agent
LCSi

The unique LCSi monomer creates a strong chemical bond to Porcelain, Lithium Disilicate and Composite Resin.

We have been using a long-chain silane (LCSi) for some time in a number of our superior composites, such as CLEARFIL™ MAJESTY™ Posterior and CLEARFIL™ MAJESTY™ ES Flow. However it's the first time we have used it in a cement.

This unique silane has long hydrocarbon spacer (the hydrocarbon chain between the silanol group and the methacrylate group) which makes it more hydrophobic and stable than the small γ-MPS molecule. The reaction with the silica particles in the glass-based materials is expected to be also more orderly and faster. The result is a more optimally bonded surface with a greater resistance to hydrolysis.
A great deal of thought has gone into combatting the degradation of silanes in PANAVIA™ SA Cement Universal. It was decided to separate the more hydrophilic components from the hydrophobic ones so they only come together when the paste is mixed. This is why we are able to achieve a three-year shelf life, even when stored at room temperature.

Research

It's not only in-house data that show comparable or even better bonding of PANAVIA™ SA Cement Universal to glass-based materials, than with its previous version, PANAVIA™ SA Cement Plus, in combination with CLEARFIL™ CERAMIC PRIMER PLUS. The first results from independent research are also strongly supporting this. With PANAVIA™ SA Cement Universal, there is now a self-adhesive resin cement on the market that allows virtually all indirect materials to be bonded directly without the intervention of primers or bonding.

MONOLITHIC CHAIRSIDE RESTORATIONS IN THE POSTERIOR AREA – EFFECTIVE AND EFFICIENT.

KATANA™ Zirconia Block
TRANSLUCENT MULTI-LAYER BLOCK WITH HIGH STRENGTH FOR CEREC USERS

Dr. Hendrik Zellerhoff

Not all zirconia is created equal. This finding presented by Prof. Martin Rosentritt[7] back in 2014 has lost none of its actuality and even appears to be increasingly relevant these days. This is because dental practitioners are spoilt for choice between various zirconia blanks, which differ widely in terms of quality, flexural strength, shade appearance, translucency and production complexity. Hence, each material has its own specific processing requirements and range of indications[6]. Profound knowledge of the available zirconia options is therefore an absolute prerequisite for long-term success of every full-contour restoration produced in a time-efficient and economic procedure.

While in the early years of zirconia manufacturing in dentistry, the dental practitioner's choice was limited to industrially milled zirconia frameworks hand-veneered by the dental technician, a wide range of material variants for chairside CAD/CAM production is nowadays available. Material-specific improvements are one of the reasons for the fact that every single zirconia has its specific indications and its own material parameters[6].
Zirconia milling blocks for monolithic restorations are in principle very well suited for the chairside production of single crowns for the anterior and specifically the load-bearing posterior area. This is due to their stability and the reduced processing effort compared to hand-veneered crowns. However, the material in use needs to fulfil high demands with regard to strength, translucency, and shading - parameters that also need to be balanced against each other[2]. (Fig. 1 to 4)

NOT ALL ZIRCONIA IS CREATED EQUAL

Due to their high flexural strength of more than 1,000 MPa, tetragonal zirconia variants (3Y-TZP) of the first and second generation are perfectly suited as framework materials. However, they lack the translucency required

Fig. 1 Initial situation with multiple insufficient fillings.

Fig. 2 Crown milled from a KATANA™ Zirconia Block (Kuraray Noritake Dental Inc., Tokyo, Japan).

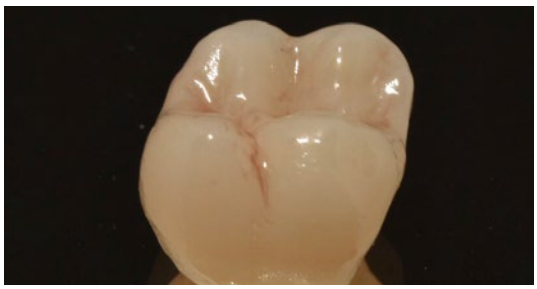

Fig. 3 Crown glazed after sintering, with fissures characterized using stains.

Fig. 4 Adhesively cemented crown with the appearance of a natural molar.

for monolithic use. It is theoretically possible to improve the translucency of 3Y-TZP materials by increasing the sintering temperature, however, this would result in restorations with insufficient strength. This is different for the third and fourth generations of cubic-tetragonal zirconia (5-TZP and 4-TZP). Due to the increased yttria content in the formulation, cubic crystals grow in the crystal microstructure. These cubic crystals have a larger volume, which leads to reduced scattering at the grain boundaries and improved light transmission. In addition, cubic crystal structures are more isotropic than tetragonal structures, so that incoming light is spread more evenly into all directions[8]. The combination of a high flexural strength and a high translucency in the fourth generation zirconia sets the stage for monolithic use of the material. This, in turn, eliminates the risk of chipping of the veneering porcelain.

PREMISES OF MONOLITHIC CHAIRSIDE RESTORATIONS

In order to ensure the desired long-term stability, intraoral functionality and aesthetics of a monolithic restoration on one hand and a time- and cost-efficient chairside workflow on the other, two factors are crucial. One is a proper functional occlusal adjustment of the restorations, the other is knowledge about the material parameters of the zirconia blocks in use.

Hardness and abrasion

Clinically, monolithic zirconia shows virtually no abrasion and an antagonist-friendly behaviour – provided that the occlusal surface is polished properly, is free of sharp edges and is covered with glaze. In order to leverage this effect and to avoid improper occlusal contacts as factors triggering parafunctions, the dental practitioner should carefully carry out an occlusal and functional analysis. This analysis should include an examination of the vertical dimension and of different jaw movement like protrusion, retrusion, laterotrusion and mediotrusion. Based on the results, a precise dynamic occlusal adjustment is possible. Any retrospective adjustment – even in case of minimal irregularities – is impossible or, more specifically, restricted to the glazing layer. If the surfaces, especially the cusps, are not polished to a high gloss, any wear of the glaze would lead to the exposure of a rough abrasive zirconia surface. Material-specific high-gloss polishing and glazing, however, effectively avoids abrasive wear of the antagonist[3,4,5].

Strength, translucency and shade

Under these premises, 5Y-TZP materials like KATANA™ Zirconia UTML (Ultra Translucent Multi Layered) with a flexural strength of 557 MP and a translucency of 43 percent are particularly well suited for the production of highly aesthetic anterior crown or veneer restorations. In the load-bearing posterior area, however, higher flexural strength values are necessary. Using 4Y-TZP materials like KATANA™ Zirconia Block (Super Translucent Multi Layered) with a flexural strength of 763 MPa provides

more stability of the restoration, which is required for the posterior region. The product offers a translucency of 38 percent and is suitable for the chairside production of aesthetically and functionally demanding restorations with high stability even in case of a reduced wall thickness. Thanks to the colour gradient, light shines through in the incisal area in an enamel-like way, while in the cervical area, the level of translucency is similar to dentin. The imitation of a colour gradient found in natural teeth, which ensures that the restoration will blend in perfectly with the adjacent teeth, is obtained with a multi-layered, polychromatic structure with a smooth shade transition from the incisal to the cervical part. This feature eliminates the need for a time-consuming manual application of shades prior to sintering. A patient-specific post-sintering characterisation with stains is optional. As shade, form and effects are already visible during application, the dental practitioner gains full control over aesthetics at all times (Fig. 5 to 8).

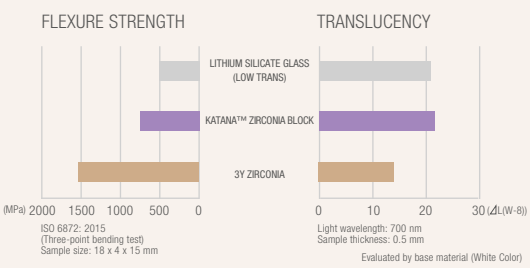

Fig. 5 Comparison of flexural strength and translucency.

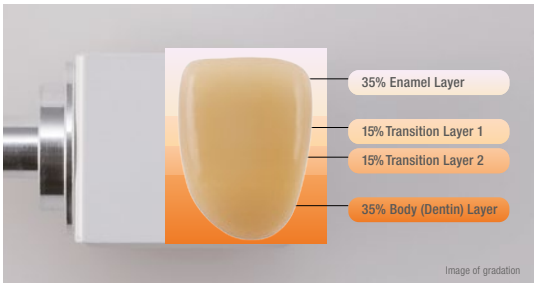

Fig. 6 Smooth shade transition from the enamel to the dentin and cervical area.

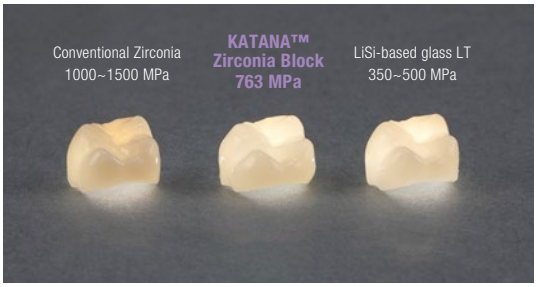

Fig. 7 Comparison of the translucency exhibited by different ceramics.

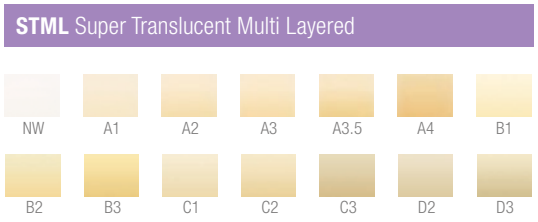

Fig. 8 Range of shades of KATANA™ Zirconia Single Unit Blocks.

KATANA™ ZIRCONIA BLOCK IN THE CEREC WORKFLOW

Reliable material properties are imperative for a smooth production workflow leading to a consistent high quality of the restorations. They are only obtained with industrially produced zirconia blanks, which offer a defect-free, homogeneous grain structure1,10. At Kuraray Noritake Dental, the whole manufacturing process of zirconia products is carried out in-house, including the production of the raw materials. Therefore, it is possible to optimize the material parameters of KATANA™ Zirconia Blocks for chairside production and with high-speed sintering process. Using these components, the dental practitioner can reduce the time needed for the production of a monolithic zirconia restoration including scanning, milling and sintering to less than an hour.

Design

For this purpose, the teeth to be restored are prepared and captured together with the adjacent and antagonist teeth using an intraoral scanner (Omnicam or Primescan, Dentsply Sirona). The digital data set is then imported into the CEREC software. The software extracts the required information from the data and generates a design proposal for the restoration. Usually, this proposal may be accepted without major modifications. Due to the high mechanical properties of KATANA™ Zirconia, a wall thickness of 1.0 mm is sufficient for a posterior crown. This design has two positive effects: it optimizes the translucency of the restoration and supports a minimal preparation, which also facilitates clinical procedures in situations with limited space conditions. The shade and translucency of the restoration is also customizable via virtual positioning of the designed crown in the multi-layer block. This enables the dental practitioner to harmonize the brightness and translucency with the parameters of the adjacent teeth (Fig. 9 to 13).

Sintering

The designed crown is milled from the KATANA™ Zirconia Block with the CEREC milling machine. Subsequently, finishing steps are carried out and the sintering process is started using the induction furnace CEREC SpeedFire. This furnace reaches a maximum heating rate of 300° C per minute. Neither pre-heating is required nor holding

Fig. 9 Initial situation with insufficient porcelain layer.

Fig. 10 Abutment teeth after preparation prior to digital impression taking.

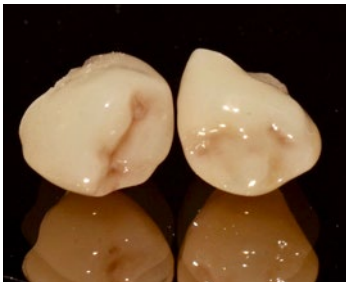

Fig. 11 Restorations after polishing, occlusal and cervical characterization and glaze firing.

Fig. 12 – 13 Final restorations in place – occlusal and frontal view.

temperatures needed. As the material properties of KATANA™ Zirconia Block are optimally aligned with the CEREC SpeedFire programme, the user can be sure that the device adheres to all sintering parameters. This, in turn, is important for the growth of the crystals as well as phase transformation and stabilization[9], which affect the natural shade results after sintering. (Fig. 14 to 18)

Individualisation and characterisation

After sintering, dental practitioners may individualize or characterize KATANA™ Zirconia Block restorations if desired. This requires only a few simple work steps. The marginal ridges, mamelons, fissures or enamel cracks are imitated controllably using paste stains (CERABIEN™ ZR FC Paste Stain, Kuraray Noritake Dental), as the shade, shape and effects created are already visible during application. For the final glaze firing process with Glaze or Clear Glaze (Kuraray Noritake Dental), the SpeedFire induction furnace is used again. (Fig. 19 to 25)

Fig. 14 – 15 Labial and palatal view of the initial situation with restorations on the lateral incisor and canine.

Fig. 16 Varying shade and translucency gradient depending on the position of the restoration in the multi-layer block.

Fig. 17 Crowns with a natural colour gradient from the incisal to the cervical area merely glazed after sintering (without any additional adjustment).

Fig. 18 Natural aesthetic appearance of the KATANA™ Zirconia crowns even in the esthetic zone.

Fig. 19 Initial situation with secondary caries below the amalgam restoration on the maxillary left second premolar (tooth #25).

Fig. 20 Tooth prepared for a core build-up after caries excavation and proximal modification of the adjacent premolar (tooth #24).

Fig. 21 Crown milled from the block before …

Fig. 22 … and after sintering (at try-in).

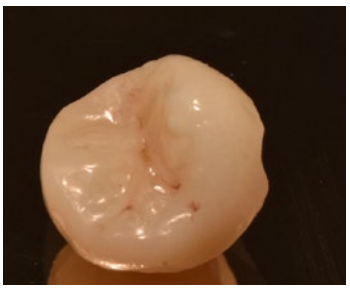

Fig. 23 Fissures with age-specific characterization.

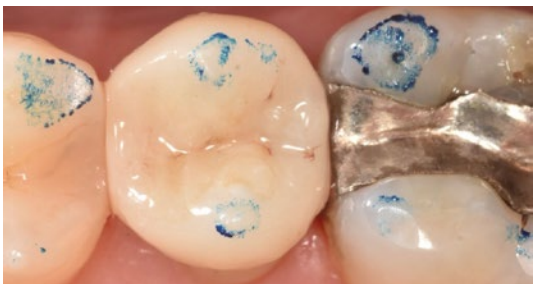

Fig. 24 Functional contact point created in consideration of the adjacent teeth.

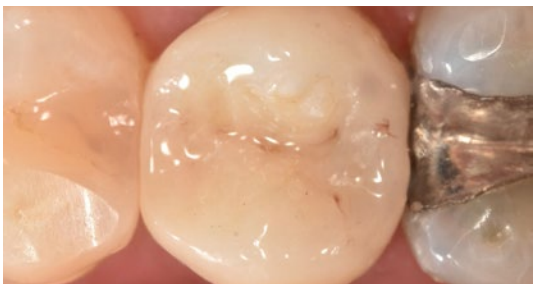

Fig. 25 Final crown after glazing and adhesive cementation with PANAVIA™ V5 (Kuraray Noritake Dental).

Conditioning and placement of the restoration

Prior to restoration placement, the inner surface of the crown is sandblasted with Al_2O_3 (grain size: 50 µm, pressure: 1 bar) and treated with CLEARFIL™ Ceramic Primer Plus (Kuraray Noritake Dental), whereas PANAVIA™ V5 Tooth Primer (Kuraray Noritake Dental) is applied to the prepared tooth structure. Finally, PANAVIA™ V5 (Kuraray Noritake Dental) is applied for adhesive luting of the crown. The MDP monomer contained in the primer establishes a stable chemical bond and eliminates the need for additional conditioning. The fact that PANAVIA™ V5 is free of amines ensures long-term colour stability of the restoration.

CONCLUSION

With its combination of a high translucency and a high flexural strength, chairside dentists may use KATANA™ Zirconia Block for monolithic restorations with confidence. Restorations made of KATANA™ Zirconia offer the required long-term stability and fulfil the high aesthetic standards demanded from it to be able to serve as an alternative not only to cast metal and PFM crowns, but also to glass ceramic restorations. Due to the lack of a porcelain layer, the risk of chipping does not exist. Optimally aligned components enable dental practitioners to make use of a simplified and constantly monitored digital workflow that offers a high process reliability. Aesthetic functional restorations for the load-bearing posterior and the anterior area can be produced and placed within a single appointment. This is an important factor, which greatly affects patient satisfaction.

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SATISFIES THE PERFECTIONIST IN YOU

KATANA™ ZIRCONIA BLOCK:

KATANA™ Zirconia Block is the innovative multi-layered block that makes it possible to fabricate full zirconia restorations at chairside in just 45 minutes. With it Superb Mechanical Properties and aesthetic qualities that mimics natural teeth, it brings the best of both worlds. Highly Translucent and great Flexural Strength.

MULTI LAYERED

For optimal adhesion
ADHESIVE RESIN CEMENT SYSTEM
PANAVIA V5

BORN IN JAPAN

Kuraray Europe GmbH, Bu Medical Products, Philipp-Reis-Str. 4, 65795 Hattersheim am Main, Deutschland, +49 (0)69-30585980 dental@kuraray.com **www.kuraraynoritake.eu**

kuraray

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DO YOU SEE ANY CONTAMINATION?

Of course not!

KATANA™ CLEANER IS THE FIRST INTRA- AND EXTRA-ORAL UNIVERSAL CLEANER

During trial fitting your restoration might become contaminated with proteins reducing the bond strength. KATANA™ Cleaner removes contamination to optimise your adhesive procedures.
Rub, rinse and dry - that's all you need to do.

CLEANERS COMPARISON	KATANA™ CLEANER	OTHER BRANDS*
Extra-oral use	✓	✓
Intra-oral use on Tooth Structure	✓	✗
Intra-oral use on Implant Abutments	✓	✗
Application Time	10 sec.	20+ sec.
Handling	No shaking Single handed	Shake before use

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*Ivoclean (Ivoclar Vivadent) and ZirClean (Bisco)