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Issue 15 | 2016
The CAMLOG Partner Magazine

SETTING BENCHMARKS – DESIGNING THE FUTURE

ALLEGEDLY THE SAME, BUT DO NOT WORK THE SAME: INDIVIDUAL TWO-PART ABUTMENTS

PART 2: SURFACE TOPOGRAPHY IN THE SUBMUCOSAL REGION

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The authors have been involved with CAD/CAM abutments for more than ten years and their work and publications have contributed to the paradigm change in the manufacturing of implant abutments. In this series of articles they summarize their experience in surface topography. After describing fabrication precision and bonding of two-part abutments in the first part of the publication (logo 14), the second part focuses on the surface topography of abutments in the submucosal region. The third part is devoted to hygiene measures for abutments.

Presently there is great debate on the manufacturing of customized abutments – and that is a good thing! The topics fit, cleaning and surface topography of the individual structures are highly controversial. These aspects must be considered more and more in daily routine. We need reproducible rules, for example, for the fabrication and bonding of titanium bases (see Part 1, logo 14), for surface topography in the submucosal region (Part 2) and for a safe hygiene protocol (Part 3, logo 16). This article answers questions on: what are the decision parameters for a production concept – in-house or outsourced – which lead to fulfillment of the desired outcome quality? Does the industrially fabricated abutment need to be reworked? Are there concrete specifications on the roughness of the abutment in the submucosal region and how can these be complied with?

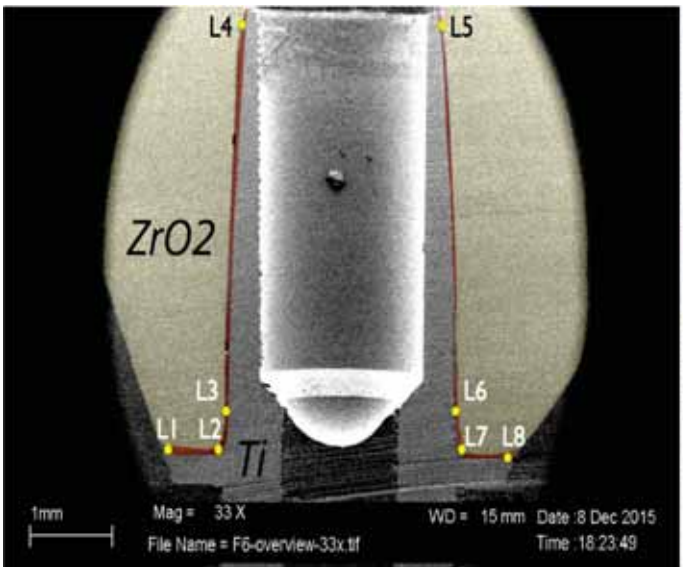
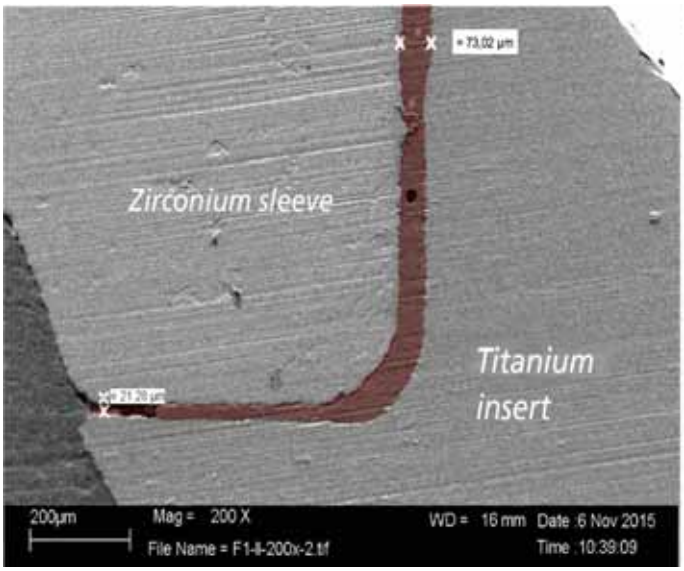
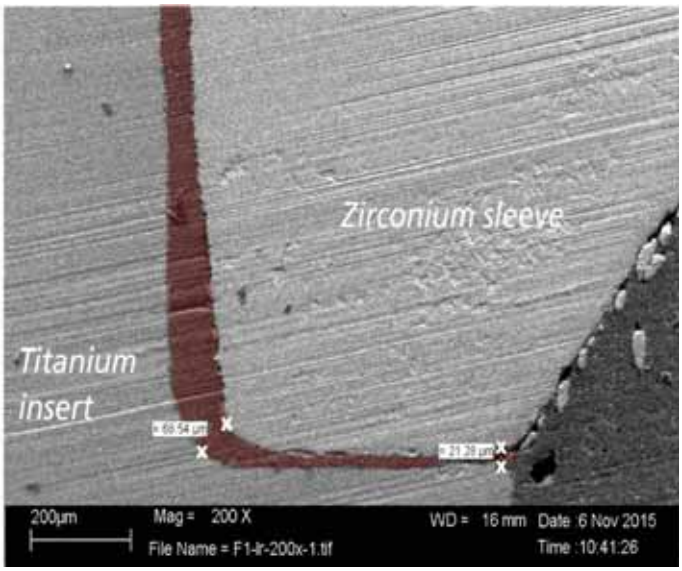


Fig. 1: Overview of scanning electron microscope (SEM) cross-section for a DEDICAM hybrid abutment. Colored white: ZrO2-CAD/CAM abutment on titanium base. Colored red: internal bonding joint with the measuring points L2 - L7 and the external bonding joint (contact with mucosa) with measuring points L1 and L8.

Fig. 2: Magnification of the external bonding gap (L1) with a size of 0.21µm. The gap of the bonding joint is therefore more than half as small as for adhesive mounting of crowns on teeth, where a bonding joint of 50µm is regarded as being ideal.





Figs. 3a and 3b: DEDICAM-fabricated (left image) and lab-fabricated (right image) zirconium oxide sleeve. Both approaches can achieve high-precision results.

Precision and bonding gap

State-of-the-art dental technology is able to fabricate precision-customized abutments with modern milling machines and advanced know-how. However, one should take into account: the procedure or the quality of the result respectively, depend on numerous influencing factors, for example, calibration of the milling machine, milling cutter or sintering process. Predictability and reproducibility are of utmost importance, both for fabrication in the own lab or in centralized fabrication (e.g. DEDICAM). For us, the competent "extended workbench" of an external partner delivers equally perfect results – day by day. The guarantee for maximum safety of a hybrid abutment lies in the fit of the abutment sleeve on the titanium base. Next to bonding itself, the bonding gap plays an elementary role. To achieve a secure bond according to our studies, the bonding gap must be small.

In a clinical investigation we compared the bonding gap between the titanium base and the zirconium oxide sleeve of in-house fabricated abutments with DEDICAM structures. Images taken under a scanning electron microscope (SEM) showed the discrepancies which can occur if perfect lab conditions deviate **(Figs. 1 to 3)** [3].

Case study: Dr. Rafaela Jenatschke, Frankfurt a. Main / DT Carsten Fischer, Frankfurt a. Main

Figs 4a to 4d: Sequences of prosthetic implant restorations for posterior teeth with customized implant components for forming the emergence profile. For us, the forming of the emergence profile with customized gingiva formers is a necessary step in the protocol on the route to an optimal esthetic result.

Case study: Dr. Rafaela Jenatschke, Frankfurt a. Main / DT Carsten Fischer, Frankfurt a. Main

Figs. 4e to 4g: After forming, the definitive zirconium oxide CAD/CAM abutments and the ceramic crowns are inserted. The protocol described in the article for ideal surface topography and surface cleanliness was applied when fabricating the customized hybrid abutments.

The effect of micro-design on the health status of soft tissue

Two aspects need to be discussed when looking at the surface topography of the basal region **(Fig. 4)**.

1. Surface topography: Whether milled in the lab or coming from centralized manufacturing, there is always a risk that the abutments are too rough in the basal region. On the other hand, surfaces which are too smooth are contraindicated.

2. Surface cleanliness: Contamination of the surface can occur in centralized manufacturing (coolants, milling chips etc.) as well as during further processing in the lab (excess adhesive, wear from rubber polishers etc.). Pre-assembled abutments can also be contaminated.

This tandem of facts makes it necessary to subject all customized CAD/CAM abutments to subsequent reprocessing. This needs to follow controlled and validated processes, as described in the following. We are of the opinion that this should not only apply to customized abutments, but to all prosthetic implant components – including pre-assembled catalog items.

It is the responsibility of the treatment team to assess the biocompatibility of the materials used, both from a dental and a material point of view. We have examined different abutment surfaces and observed considerable differences in manufacturing quality. The surface quality of individual abutments is to be assessed in terms of the following aspects: plaque deposit, bacterial adhesion, potential for accumulation of peri-implant mucosa.

Surface topography

Optimal adhesion of the peri-implant mucosa is desirable for a successful long-term result. A decisive role is played here by the surface of the implant abutment in the transmucosal region. The goal is solid adaptation of the peri-implant mucosa. However, we also know that this region is fragile and can react sensitively to toxic or mechanical influences. Using

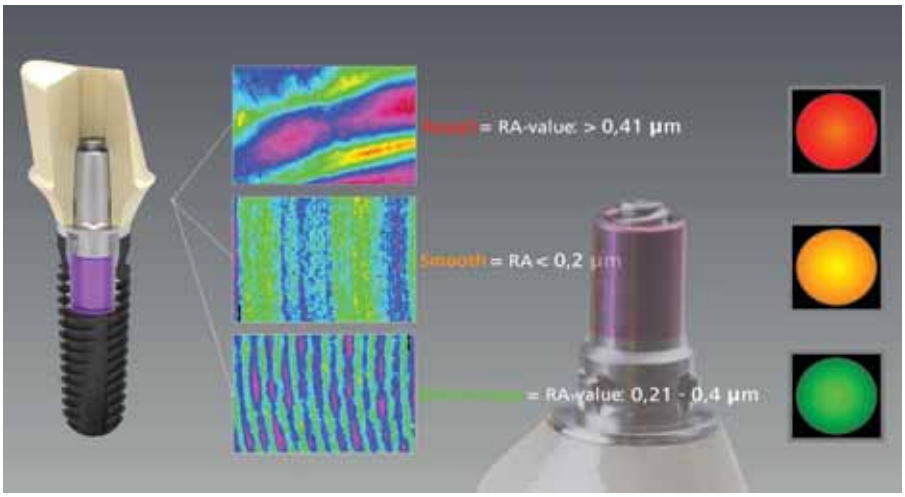


Fig. 5: The traffic light system for the classification of roughness in the basal region could be established as follows [1]:
Rough = > 0.41 µm (red: increased risk of plaque accumulation)
Smooth = < 0.2 µm (amber: reduced accumulation of fibroblasts)
Medium rough = 0.21 – 0.4 µm (green: perfect)

Fig. 6: Reworking of the surface in the basal, submucosal region with special rubber polishers. The desired residual roughness of 0.2-0.4 µm was achieved.

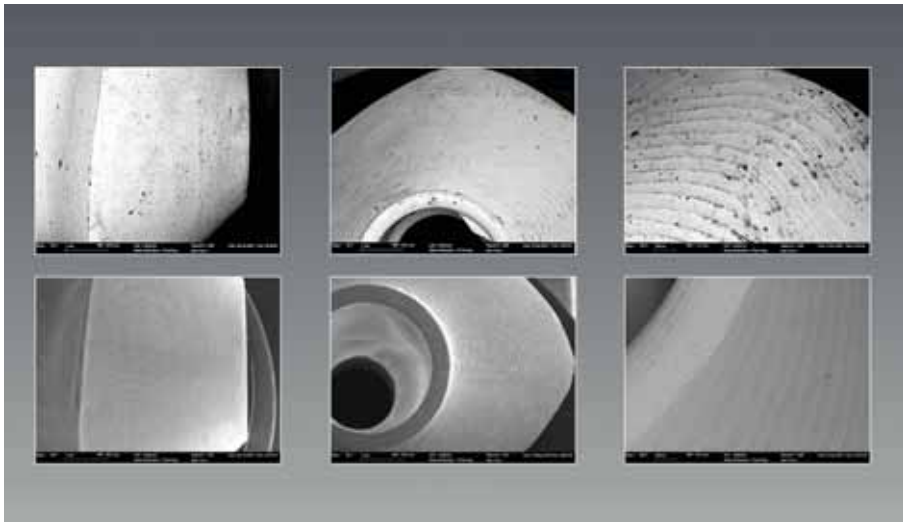


Fig. 7: The three images in the top row show contaminated components. The bottom three images show the same surface after applying the validated cleaning process presented here.

optical profilometry (focus variation microscopy), we examined the micro-design below the shoulder of CAD/CAM abutments of various manufacturers in a study. The objective was to define the ideal topography and surface roughness respectively.

Today, we can presume that there is a threshold value at which bacterial and plaque accumulation on the surface is low while at the same time promoting the accumulation of fibroblasts **(Fig. 5)**. If the surface is too rough, this bears the risk of increased plaque accumulation. However, if the surface is too smooth, the fibroblasts of the peri-implant mucosa cannot "attach" optimally. Therefore a medium roughness value (in µm: Ra = 0.21-0.40) is regarded as the ideal surface. During the investigation on CAD/CAM fabricated abutments, a ten-fold higher surface roughness was detected in parts. In other words, this requires reworking to achieve the mean roughness value. According to our validated processing protocol (see surface cleanliness), the CAD/CAM hybrid abutments offer optimal roughness and demonstrate good conditions for the desired accumulation of peri-implant tissue.

Consequence for lab and practice routines

In order to generate perfect surface finishing for all prosthetic implant abutments, we have defined a documented, validated work protocol. According to this protocol we machine the basal region of the abutment with special diamonded rubber polishers (Serius Ceramics, Frankfurt/Main) and so obtain a surface of between 2 to 4 microns of residual roughness, the proven standard for optimal tissue accumulation **(Fig. 6)**.

Surface cleanliness

It has been proven that contamination can occur on implant abutments – regardless of being customized or pre-assembled – which leads to questions regarding a long-term stable outcome **(Fig. 7)**. The following applies as a matter of principle: customized abutments are medical devices which are classified as being semi-critical (Robert-Koch-Institute, RKI). In other words, professional cleaning must be

performed. Evaporating is not sufficient, and could, in fact, be counterproductive **(Fig. 8)**. This requires rethinking and readjusting the dental work processes. The third part of the article (logo 40) will present a validated 3-step cleaning protocol which leads to a clean and perfectly hygienic abutment surface [2].

Abutments are medical devices

We should be aware that implant abutments are medical devices which have to meet certain criteria. Dental technicians in particular, are faced with a new range of tasks which they should take on responsibly. It should be determined in advance between the team partners dentist and dental technician, who is responsible for which step, and how documentation is to be performed.

Conclusion

After the first article covered manufacturing and the second article the surface quality of implant abutments, the third part will discuss the following questions: which tasks are assigned to the dental technician in the finishing of pre-assembled or customized implant abutments? Which formula ("cooking recipe") leads to the desired goal? Which steps does a clean abutment surface according to RKI guidelines bring with it? These are all new work steps for dental technicians which need to be incorporated into a state-of-the-art laboratory concept.

This information is summarized by the authors on a video which can be viewed on the Sirius Ceramics YouTube channel. The intention, status quo and the validated procedure are presented in an interesting and understandable manner.

Fig. 8: Simple evaporating of the CAD/CAM abutment is common practice, however, this does not comply with the hygiene requirements for a semi-critical medical device. A clean result according to the RKI guidelines is not obtained.

Scan QR code and view video

LITERATURE

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Self-employed as dental technician with his own business since 1996, and active as international speaker since 1994. Publications in numerous countries (Brazil, Argentina, Japan, Australia, Europe). 2012-2015 part-time assistant at the Goethe University Frankfurt. Carsten Fischer is a member of advisory boards and has acted as advisor in the dental industry for many years. He focuses on CAD/ CAM technologies, the ceramic double crown, customized abutments and full ceramic materials. In 2013, his contribution was honored as best lecture by the Working Group Dental Technologies, ADT. Carsten Fischer is lecturer at the Steinbeis University, Berlin, and speaker for various organizations (DGI) and Vice President of the EADT.