Customised abutments for long-term aesthetics—software tools to meet clinical and laboratory requirements

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Replacing missing single teeth with dental implants has become routine, yet restoring anterior teeth with implant-supported restorations is a technique-sensitive task for which aesthetic and functional success remains a challenge for the surgical-restorative team.

Indispensable factors for success are the amount of available alveolar bone, morphological soft-tissue type, correct positioning of the implant in all three dimensions, and a successful provisional phase. In addition to establishing an adequate implant recipient site and a harmonious and natural blending of the restoration with the surrounding tissues and dentition, the long-term stability of the peri-implant tissue architecture is a significant challenge. The selection of suitable materials and an optimal design are paramount for the success of the definitive restoration. This is where the advantages of CAD/CAM technology and all-ceramic materials become evident.

These technological advancements have had a considerable impact in various areas of dentistry and will continue to do so into the future. Advantages related to material and manufacturing...
processes will promote the ongoing adoption of CAD/CAM systems in preference to conventional casting and manufacturing techniques. This is because CAD/CAM technology offers numerous benefits compared to conventional framework fabrication, including reproducible precision, material homogeneity, individual customised design, and ease of fabrication. At the same time, industrialised fabrication methods guarantee standardised quality and reduce cost-intensive manual labour. In addition, the availability of homogeneous, bio-compatible materials will minimise material incompatibilities and corrosive phenomena arising from dissimilar metal alloys and interfaces between cast and machined components.

Ongoing research in ceramic materials development has led to the use of high-strength, non-silica-based ceramics in dentistry with beneficial properties in terms of bio-compatibility, aesthetics and long-term clinical function that have been investigated in numerous scientific investigations. Aluminium oxide ($\text{Al}_2\text{O}_3$) and zirconium dioxide ($\text{ZrO}_2$) ceramics are the most common oxide ceramic materials used today. Owing to its material properties and strength, $\text{ZrO}_2$ is applied whenever high loads are expected (e.g. posterior fixed dental prosthesis frameworks, implant abutments and multi-unit implant restorations). In addition to its strength, the greatest advantage of $\text{ZrO}_2$ is its excellent tissue integration. Various studies have demonstrated the successful application of zirconia abutments in terms of stability of soft tissue and marginal bone. Results indicate that the type of material used affects both the amount and quality of the surrounding tissues (when comparing zirconia to cast alloys). Also, ceramic abutments minimise bacterial and plaque adhesion and prevent soft-tissue inflammation.

Customised abutments: manufacturing options

The clinician may choose between prefabricated or customised abutments for implant-retained single or multi-unit restorations. The primary objective must always be proper support of the surrounding tissues, optimal morphology to support the restoration without impairing hygiene maintenance, and anatomic design to allow for proper support of the veneering ceramics in case of screw-retained restorations. These goals can easily be achieved if an abutment is custom-made. Using prefabricated abutments, on the contrary, has several disadvantages. Customising is a time-consuming and highly unpredictable process in the laboratory, requiring additional finishing procedures in the dental office. Postsintering manipulation of oxide ceramic components significantly increases the risk of micro-cracks that could result in subsequent failure...
industry report

Under clinical function. Scientific investigations have revealed that the reaction of cells towards materials with a corrosive potential such as cast-alloy components or veneering porcelain is inferior to homogenous materials such as titanium or zirconia.

**Fast and intuitive design of implant abutments**

Work processes to fabricate an individual abutment that in the past required significant amounts of time can be realised within minutes today. The newest generation of CAD software eliminates the need for a wax-up to achieve the desired definitive abutment shape. While an automated software function suggests a superstructure or abutment following a model or impression scan, the dental technician can easily adapt the contour and form virtually to any desired shape (Figs. 1a & b). In addition, one software programme offering an intuitive software interface and the ability to restore using different implant systems is a very interesting alternative to conventional fabrication, for which cast-on components have to be ordered for the respective implant system and then customised.

**Virtual design of transgingival contour and positioning of the crown-abutment margin**

When designing an abutment, the following two major criteria supporting long-term success should be considered: the contour and shape of the abutment in the sub-gingival area and the height, angulation and taper to provide adequate retention for a cement-retained crown. There is no scientific evidence that supports a more concave or a convex peri-implant abutment contour. Communication and close collaboration between the dental technician and the dentist are needed, taking the individual clinical situation into consideration. This includes the position of the implant in relation to the definitive crown contour, the thickness and biotype of the surrounding tissue, and location within the arch.

It is generally agreed that the abutment-crown margin should always be located at or slightly below the gingival crest in order to allow for complete removal of cement (Figs. 2a–d). If remnants of the cementation media remain, peri-implant inflammation and adverse tissue reactions are very likely. Here another advantage emerges. While metal abutments or porcelain-fused-to-metal crowns had to be positioned deep underneath the gingival margin in order to minimise the risk of discolouration, utilising oxide ceramic materials eliminates this concern and improves the aesthetic outcome.

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<tr>
<th>Table 1: Biological advantages of customised CAD/CAM abutments:</th>
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<tbody>
<tr>
<td>• formation of an intimate soft-tissue contact</td>
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<tr>
<td>• long-term clinical stability through bio-compatible and homogenous materials</td>
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<tr>
<td>• eliminates the risk of corrosion in contact areas of dissimilar metals and alloys</td>
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<td>• maximises aesthetic results through application of shaded Zirconia</td>
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<th>Table 2: Customised CAD/CAM abutments: design advantages</th>
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<td>• free-virtual design options</td>
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<td>• screw- or cement-retained restorations</td>
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<td>• optimal support of peri-implant soft tissue through individual abutment profile</td>
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<td>• round contours, no sharp edges</td>
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<td>• ideal positioning of cement line</td>
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Mechanism of retention

A significant disadvantage of screw-retained restorations in the past compared to cemented restorations was the aesthetic closure of the screw access channel. Using metal-based frameworks and composite resin for closure resulted in impaired aesthetic outcomes on the occlusal surface. Zirconium-dioxide-based frameworks eliminate this disadvantage. If white or shaded substructures are used, easy and fast closure of the screw access channel can be achieved with conventional composite resin materials. The retrievability and the absence of cement between the abutment and the crown are amongst the greatest advantages compared to cemented solutions or cast abutments.

Porcelain is fired directly onto the abutment and the abutment-crown complex can be screwed onto the implant. Here again CAD technology supports the dental technician in the design of the final abutment shape. Numerous publications emphasise the need for an homogenous veneering material thickness in order to minimise the potential problem of chipping (Figs. 3a & b). Utilising a software system that makes use of an anatomic tooth library supports the user in designing the later contour of the final restoration (taking occlusal and functional aspects into consideration). Whether an implant-retained crown is cemented or the abutment-crown complex is screw retained depends on the dentist’s preference and the positioning of the implant (Figs. 4 & 5a–c). A cement-retained restoration on an individual ceramic abutment allows for simple compensation of misaligned implants and can be treated like a natural tooth. The main disadvantage of cemented prostheses is irretrievability._

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Editorial note: A complete list of references is available from the authors.

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