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Offprint

- Change, the constant of the future
  CAD/CAM fabrication of implant-supported bridges in the maxilla and mandible
  Part 1, Part 2 & Part 3

  An article by Master Dental Technician
  Ralf Bahle, Leutkirch/Germany

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CAD/CAM fabrication of implant-supported bridges in the maxilla and mandible – Part 1

Change, the constant of the future

An article by Master Dental Technician Ralf Bahle, Leutkirch/Germany

Only a few years ago many people smiled wearily as some visionaries stated that the computer would make inroads into dental technology. Today this initial scepticism is really no longer a topic of discussion, as CAD/CAM technology has become well-established – in laboratories, milling centres, dental practices and hospitals. It cannot be claimed, however, that the CAD/CAM technique has become standard practice. It has certainly made its mark and still remains an interesting technique that is subject to constant change. In this article Master Dental Technician Ralf Bahle provides an insight into computer-aided dental technology in 2010. Using an actual patient case he demonstrates in three parts the opportunities offered by selective use of this technique.

Introduction

As early as the 1990s, futurologists predicted that the most constant feature in our society in years to come would be change. This statement is now reality. We are now witnessing an increasingly fast pace in our society, which is supported by the fact that technical knowledge doubles about every two years.
This is most clearly illustrated by computer technology. The computer that we purchase today is already obsolete the next day, as there is another new model with an even larger storage capacity and a more extensive range of functions.

In the car industry and in engineering it can be seen that ever more complex and efficient machines are increasingly making humans dispensable in the digital age. What is required now is not purely manual strength and skill, but our computer know-how.
Only a few years ago many technicians smiled wearily as some visionaries stated that this trend would also make inroads into dental technology.
Today these sceptics have been proved wrong. The arrival of CAD/CAM technology many years ago and the constant further development of this technology have also become established in this branch.
The following first part of a three-part case report presents the digital design and laboratory realisation of implant-supported rehabilitation in all four quadrants. It was important to plan and realise the restoration and consequently all further analogue or digital working stages on the basis of a wax-up, which was fabricated right at the beginning of the procedure. This prevents the situation of duplicated or additional working stages. The maximum possible cost-effectiveness and optimal result with regard to quality are therefore guaranteed.

Case

As extensive full-mouth rehabilitations are part of the day-to-day business of *Master Dental Technician Ralf Bahle*, he is very happy that the concept installed in his laboratory that ensures reliable, efficient and reproducible planning and realisation of this type of restoration is more efficient and therefore more cost-effective due to the digital working stages. Precise planning at the beginning of the prosthetic restoration makes several design and fabrication stages possible with a single application of craftsmanship. The restoration can be digitally generated and then milled in the laboratory as in a type of

Indices

- CAD/CAM
- Implant prosthetics
- Silicone index
- Transfer die
- Wax-up

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Fig. 1 and 2 The 47-year-old male patient had been edentulous for 4 years in the posterior region. Implants were therefore placed in the region of tooth 4 and tooth 6 of each quadrant. The master models were mounted on an articulator based on a provisional centric and implant-supported bite blocks were made for the centric registration

Fig. 3 The dentist was able to create a reproducible centric and at the same appointment determine the position of the maxilla using an arbitrary facebow, which was transferred to the articulator in the laboratory

modular system. The use of machines makes it possible to concentrate more on function and aesthetics again and take more time for customer care and patient consultation.

The initial situation

In this case a 47-year-old male patient, who had an edentulous posterior region for 4 years, was to be provided with a restoration. The difficulty was in re-establishing the centric, as the patient had been without support in the posterior region for a long period of time. Following the relevant planning procedures, implants were placed in the tooth 4 and tooth 6 regions of each quadrant with the aid of surgical stents. After the healing period was complete and impressions had been taken of the implants, master models were fabricated and bite blocks fabricated for centric registration based on the provisional centric bite blocks. These are supported on the implant (Fig.1 and 2). The dentist can use them to establish a reproducible centric. At the same appointment the position of the maxilla was determined using an arbitrary facebow and this was later transferred to an articulator in the laboratory (Fig.3).

Due to the long-term edentulous situation in the posterior region the patient had adopted a masticatory pattern with an edge-to-edge bite in the anterior region. The aim was therefore to relax the muscular tension in the orofacial system and return the condyles to their correct position. The conditions, which were known to the dentist and laboratory, were therefore taken into consideration during all further treatment stages.

Thoughts regarding the treatment concept

It is often said that every natural tooth stands in the way of an implant. Occasionally we can be even more cynical and claim that the patient stands in the way of a reasonable restoration.
In order to find the centric relationship again with this initial situation (Fig.4 and 5), it would normally have been necessary to fabricate an implant-supported temporary restoration. The patient, however, wanted a permanent restoration as quickly as possible and to spend as little money as possible, as is often the case. For this reason we decided to fabricate the restoration in the maxilla on a porcelain-veneered zirconia framework. In contrast the mandible was to be treated with a composite-veneered metal framework made from a non-precious alloy.

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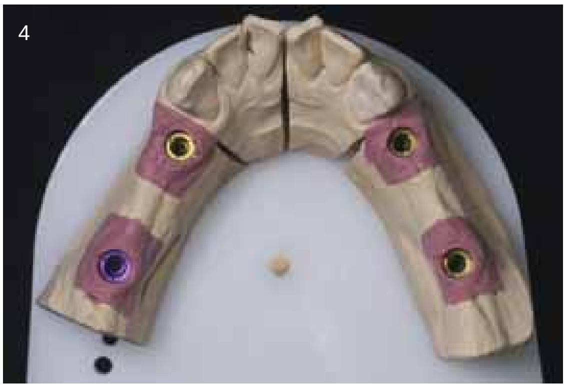

Fig. 4 and 5 In view of the initial situation it would normally have been necessary to fabricate an implant-supported temporary restoration in order to find the centric relation again. The patient, however, wanted a permanent restoration as quickly as possible and as reasonably priced as possible

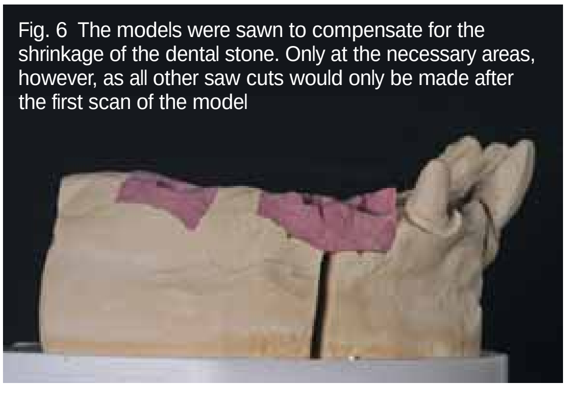

Fig. 6 The models were sawn to compensate for the shrinkage of the dental stone. Only at the necessary areas, however, as all other saw cuts would only be made after the first scan of the model

Fig. 7 An appropriate set of denture teeth was duplicated using 9:1 silicone to ensure a consistent, efficient procedure. The moulds could be filled with wax, …

Any changes in centric or overloading could therefore be compensated for by specific removal or addition of composite and adjustment at a later stage. At the same time we had fabricated a temporary bridge with a metal strengthener from tooth 21 to tooth 23, as tooth 21 was lost after placement of the posterior implants. An implant was placed in the region of tooth 21 four months later.

The wax prototype

To ensure the model could be securely placed in the Ceramill Motion unit we fabricated Giroform sectioned models, which we articulated using the relevant split-cast bases. The sectioned models were only sawn at the necessary areas to compensate for the shrinkage of the dental stone (Fig. 6).
All other saw cuts were only made after the first scan of the model. This avoids any potential inaccuracies.
An appropriate set of Creapearl denture teeth was duplicated using 9:1 silicone for efficiency during the subsequent procedure. The hollow moulds produced could be continually filled with wax. In this way we reproduced beautiful tooth shapes that were optimally coordinated with one another (Fig. 7).
The cooled wax teeth could be shaped to set them up on the master model according to functional facial aspects (Fig. 8 to 11).

After the optimal occlusion, articulation and excursion movements were established (Fig. 12 to 17), we were able to focus on the fine points of the planned implant prosthetic restoration. We were now in the position to determine the emergence profile as well an accurate pontic according to the established tooth shape. For this we drew the margin of the clinical tooth crown on the model using a felt-tip pen (Fig. 18).

It is important that the margin is drawn before the wax pattern is sprayed with scan spray. Otherwise the felt-tip pen will not be able to draw properly on the model (Fig. 19 and 20).

The scan spray is required to prevent reflections on the wax surface. Reflections are not recognised by the scanner or are misinterpreted. They produce virtual "holes" in the 3D image.

The upper master model was then mounted in the size 300 scanner. The model was securely retained in the scanner using the split-cast base plates of the Giroform models (Fig. 21). We have located the CAD/CAM technology in a separate room, as in our opinion this type of laboratory work does not fit into the routine working environment. In addition the precision technology requires as far as possible a certain degree of cleanliness and standardised conditions (Fig. 22a).

The situation scan

Before the model could be scanned, a file card of the overall situation first had to be created in the software. Data such as the patient name, tooth shade, design as well as the individual materials that

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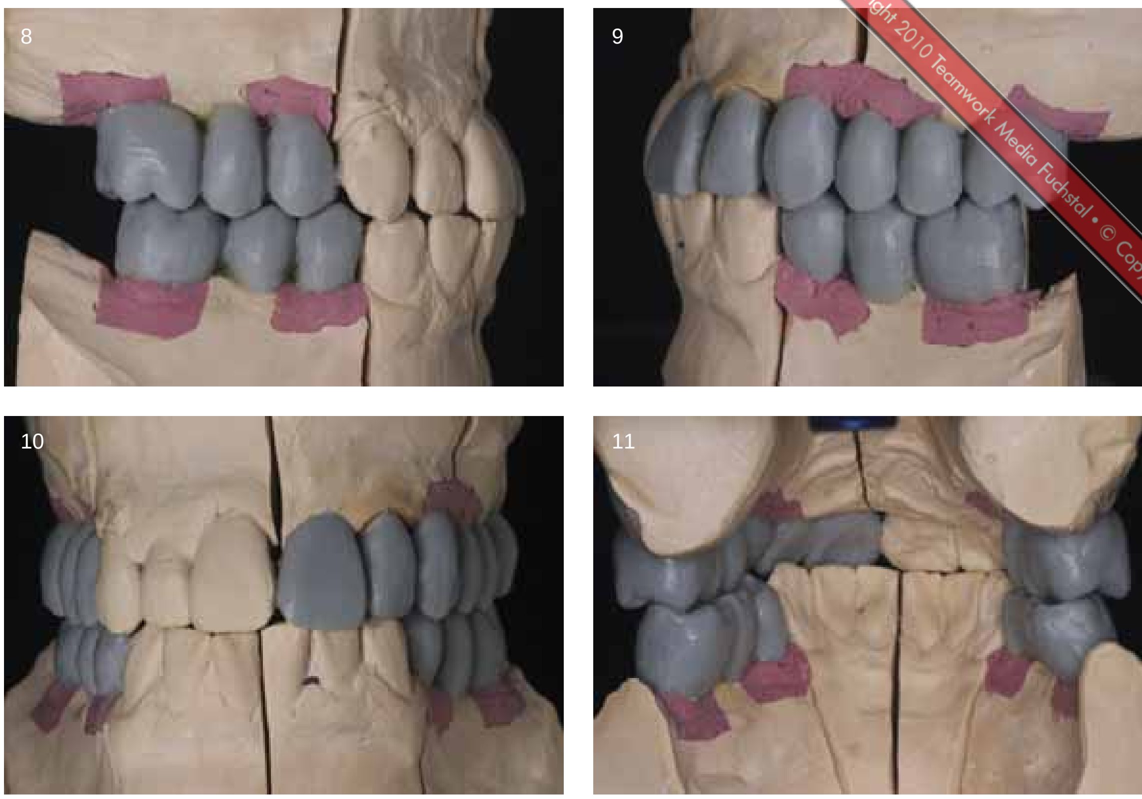

Fig. 8 to 11
… which produced optimally coordinated wax duplicate teeth. These were set up on the master models according to functional and phonetic aspects

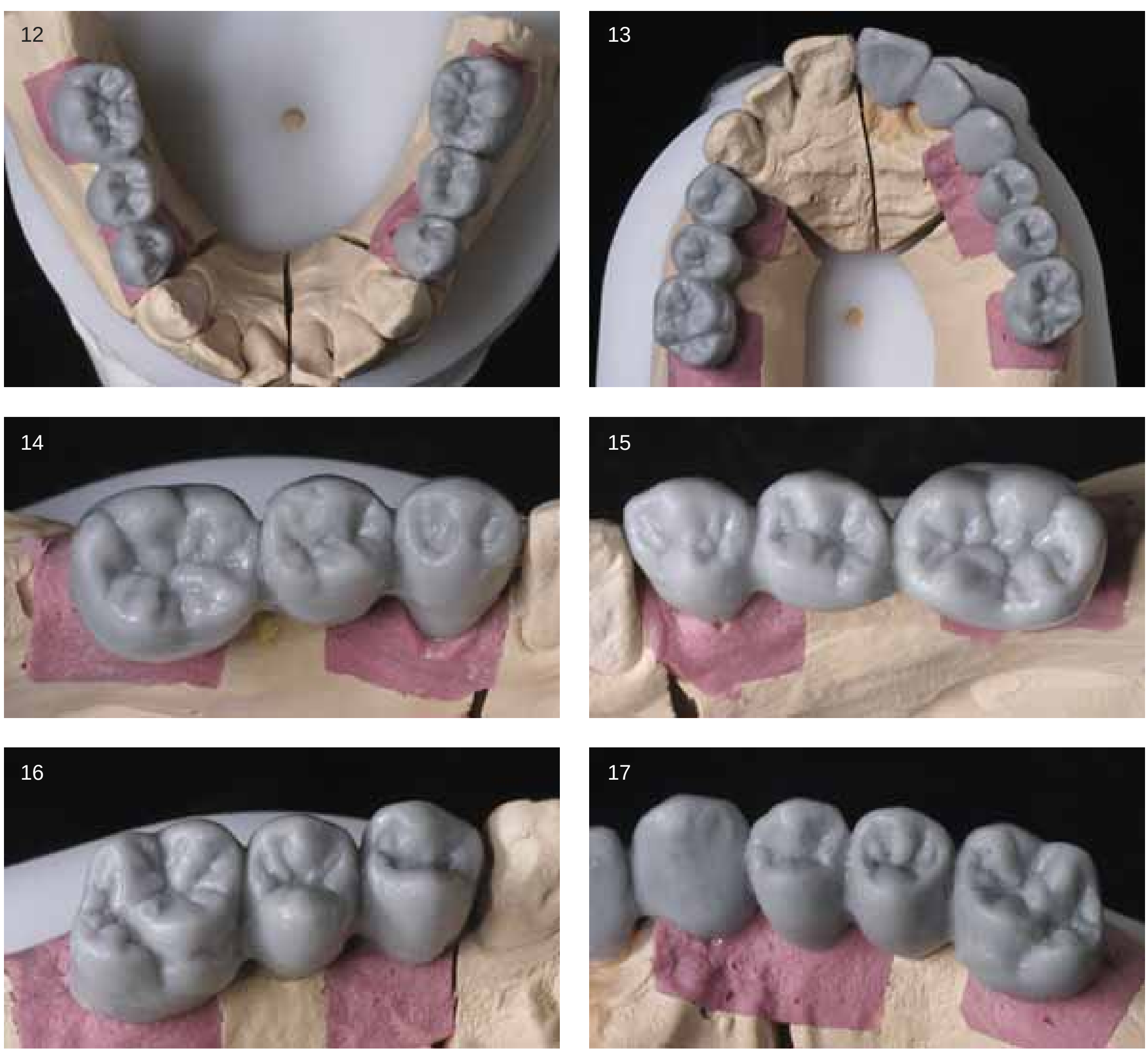

Fig. 12 to 17
After the occlusion, articulation and excursion movements had been established, adjustment of the fine points of the planned restoration could begin

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Fig. 18 The emergence profile of the planned implant crowns as well as the exact pontic were drawn on the model

Fig. 19 and 20 The drawing should be made before the wax pattern is sprayed with scan spray The scan spray makes the surface matt and prevents reflections impairing the scan result

Fig. 21 The master models can be securely mounted in the scanner using the split cast base plates of the Giroform model system

Fig. 22 a We have located our CAD/CAM technology in a separate room. In our opinion this type of laboratory work does not fit into the routine working environment. A positive side effect: the digital workplace remains clean

have been used are stored in the file card. It has to be filled out accurately, so that the milling order can be correctly processed at a later stage (Fig. 22b).

First a 2D scan was taken of the occlusal view, so that the predefined dental arch in the programme could be adapted to the actual dental arch on the model. The programme then finds the exact position of tooth 26 again for example (Fig. 23).

Scanning then starts automatically and is repeated at individual areas until the 3D image is displayed completely without holes (Fig. 24 and 25). After scanning, all excess sections are cropped, so that only the scanned wax-up remains (Fig. 26 and 27). This working stage forms an important basis for all further working stages and is essential for the spatial visualisation of the planned restorations.

Back in the analogue world

After scanning all wax prototypes – which must be completed at this time and no later – first we fixed in clear silicone the anatomical shapes that were fabricated in wax for the lower bridges as well as the upper anterior restoration, which was to be initially fitted with a temporary restoration. The articulator was used as a reference to ensure absolutely accurate reproduction of the occlusion. Using special silicone sleeves plaster tables were fabricated at this stage (Fig. 28). The wax-ups were then fixed in the correct position in the lower jaw (Fig. 29).

Product list

Product	Name	Manufacturer/ Distribution
Articulator system	Artex	AmannGirrbach
CAD/CAM system, Inhouse	Ceramill Motion	AmannGirrbach
Facebow	Artex facebow	AmannGirrbach
Implant system	Screw-Line	Camlog
Model stone	Alpenrock	AmannGirrbach
Model system	Giroform System	AmannGirrbach
Sculpting wax	GEO	Renfert
Denture teeth	Creapearl, Dynamicline, designed by D. Schulz	Creation Willi Geller/ AmannGirrbach
Scan spray	Ceramill Scanmarker	AmannGirrbach
Silicone, clear	–	Dreve
Silicone sleeve	Silicone sleeve, large (Creation CP accessories)	Creation Willi Geller/ AmannGirrbach
Gingival mask	GumQuick	Dreve
Centric material	Zetatray LC	Zhermack

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Fig. 22 b
Before the model is scanned, a file card of the patient case has to be created in the software.
All patient and order specific data are entered into the file card

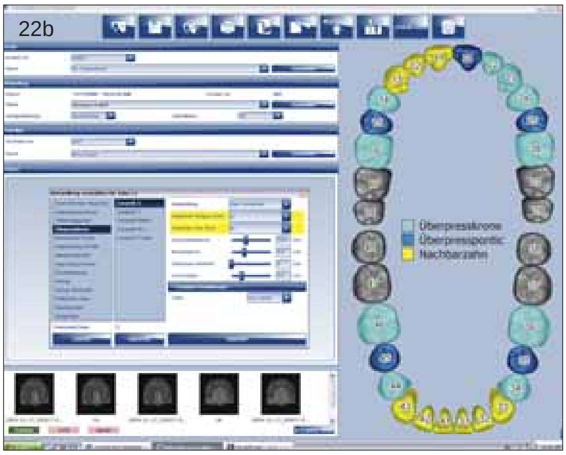

Fig. 23
First a 2D scan was taken of the occlusal view for reference.
The programme then finds the exact position of tooth 26 again for example

Fig. 24 and 25
The actual 3D scan procedure then starts automatically.
This is automatically repeated at individual areas until the 3D image is completely without holes

Fig. 26 and 27
All excess sections on the digital model were automatically cropped, so that only the scanned wax-up remained

Fig. 28
In our concept the articulator is used as a reference for absolute reproduction of the occlusion.
We fabricated a plaster transfer table using a silicone sleeve

Fig. 29
The models with the wax-up were mounted in the articulator to the correct position

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Fig. 30 The plaster table was fitted with a sleeve made from wax sheets in order to be able to duplicate the model situation and wax-up using clear silicone to the correct position in the articulator

Fig. 31 This wax sleeve was filled with transparent silicone and the articulator was closed until the incisal pin was in contact. The situation described is shown here still without silicone to allow easier visualisation

Fig. 32 After the silicone had cured and the wax sheets had been removed, a repositionable silicone index is available. With this index the metal framework can be veneered with light-curing composite to conform to the wax-up

We constructed a mould using wax sheets for the transparent silicone (Fig. 30). After the wax mould had been filled with silicone the articulator was closed until the incisal pin was in contact. In Figure 31 the situation is shown still without silicone for easier visualisation. The wax sheet mould was removed after the silicone had cured. This produced a repositionable silicone index for subsequent veneering of the metal framework using light-curing composite (Fig. 32). The composite can be easily injected and polymerised through the clear silicone.

In the second part *Master Dental Technician Ralf Bahle* reports on CAD/CAM fabrication of the bridge frameworks and the preparation for the framework try-in.

To be continued …

About the author

Ralf Bahle was born in 1963 as the son of a master precision engineer. He already discovered his artistic streak in his youth with creative handicraft work and painting. He completed his training as a dental technician in Stuttgart, Germany, from 1980 to 1984. After his training he began his technician years with rich experiences, which he enjoyed in numerous dental laboratories in and around Stuttgart. This included a year in the Braunwarth laboratory, where he – according to the circumstances at the time – gained new insights into aesthetics. In 1989, attracted by the beauty of the natural surroundings, he moved to the Allgäu region, Bavaria, Germany, where he purchased a farmhouse that was over 100 years old and restored it to its original condition. From 1989 to 1992 he worked in different laboratories in the Allgäu region – including over one year in the Thiele laboratory. There he learned, according to the circumstances at the time, new insights into precision and function.
In 1993 after two years as the head of a laboratory, he became self-employed in his farmhouse. The former stables were converted into a 100 m^2, modern and exceptionally well-situated laboratory. He was now able to use the experience and knowledge he had acquired in numerous courses, including by Heinz Polz (†), Klaus Mütterthies, Jochen Peters and many more, to realise his own concept. He fabricated his first implant restoration as far back as 1989. Fascinated by this technique and the demands associated with it he quickly decided: our laboratory will specialise in this field! Through collaboration with renowned implantologists like Dr Wolfram Bücking, Dr Gerhard Iglhaut and Dr Ralf Masur and Partner he developed a reliable, efficient and reproducible team concept that he has been teaching in courses and evening events since 2000. In a specially equipped training room, which was established in 2005, course participants can learn his success concept in small groups and enjoy the charming surroundings. Since 2008 he has been an instructor with the Curriculum Implant Prosthetics and Dental Technology of the DGI (German Society for Implantology).

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CAD/CAM fabrication of implant-supported bridges in the maxilla and mandible – Part 2

Change, the constant of the future

An article by Master Dental Technician Ralf Bahle, Leutkirch/Germany

When people talk about computer-aided dental technology nowadays, the term future is used all too often in connection with the subject. But this is incorrect, as CAD/CAM has fully arrived and has become an established part of dental technology and prosthetic reconstructive dentistry. Master Dental Technician Ralf Bahle – well-known for numerous, more technical manual publications – demonstrates in this three-part article (an actual patient case) how he integrated CAD/CAM technology logically into his established and successful work routine. After the wax-up had been manually waxed up and digitised in the first part, the author describes in this part how the designs via CAD/CAM are converted into the relevant framework material. The framework try-in at the end of this article demonstrates, however, that ultimately the standard, manual processes are continually required.

Indices

- CAD/CAM
- Implant prosthetics
- Framework design
- Function
- Matching
- Multiple scan
- Silicone index
- Transfer die
- Wax-up
- Zirconia

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What has happened so far

As extensive full-mouth rehabilitations, as described in this article, are part of the day-to-day business of the author, he is very pleased that CAD/CAM technology could be seamlessly and efficiently integrated into his existing laboratory concept. *Master Dental Technician Ralf Bahle* is of the opinion that precise planning is required at the beginning of prosthetic treatment to ensure efficient, reproducible realisation of a restoration. This makes several subsequent design and fabrication stages possible due to a single application of craftsmanship at the beginning of a laboratory restoration.

After the wax prototypes had been scanned (cf. dental dialogue 5/10), an impression of the wax anatomical forms for the lower and upper restorations was taken using clear silicone. The articulator is used as a reference to ensure absolutely accurate reproduction of the wax occlusion. Due to the fact that the clear silicone duplicate mould is synchronised with the individually adjusted articulator, all of the duplicated structures have the same occlusal relationship as the fully anatomical wax-ups. Light-curing composite can now simply be injected into the silicone index, which is fixed in position in the articulator, and polymerised through the index for veneering the metal framework.

In the following the author explains CAD/CAM fabrication of the bridge frameworks for the permanent restoration as well as the preparation for the framework try-in.

Design and fabrication of the framework structures

After removal of the wax prototypes, the exact emergence profile that had been drawn with a felt-tip pen is shown on the model. We use these outlines for accurately shaping the soft gingival mask (Fig. 33 to 36). The gingival mask is now opened in a funnel shape using a sharp scalpel – from the implant shoulder to the margin of the marked anatomical tooth shape (Fig. 37 to 39). Occasionally the required details cannot be maintained, so that compromises have to be made with the aesthetics. The pontic can also be contoured to the shape of an ovate pontic [1-6]. After smoothing of the soft tissue with relevant cutters, manipulation of the emergence profile is complete.

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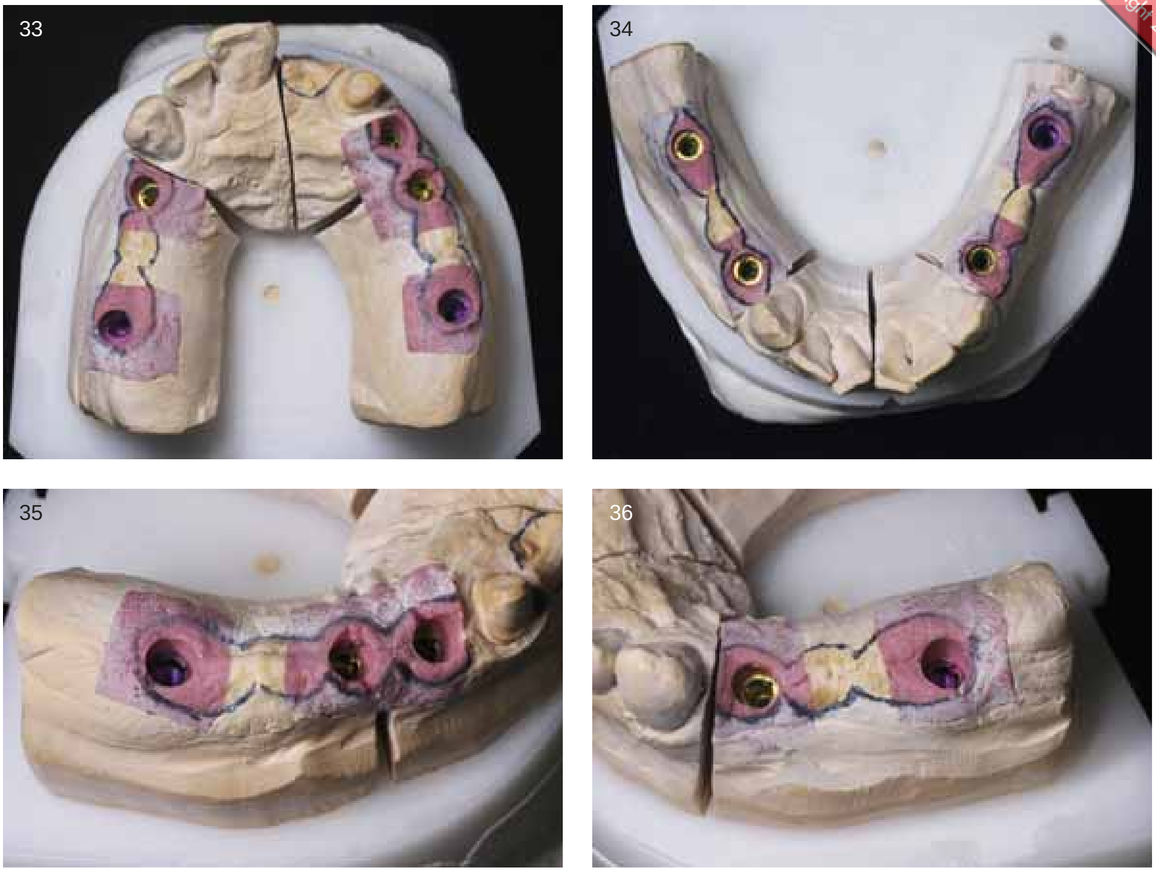

Fig. 33 to 36 After the wax prototypes had been removed, the exact emergence profile that had been drawn with a felt-tip pen was shown on the model

The model can now be scanned without the wax-up (Fig. 39 and 40).
After the model with the manipulated gingival mask had been replaced in the scanner, the gingiva scan was clicked in the design programme and the scan of the gingival situation was started around the planned construction. Once all relevant areas of the gingiva have been depicted, the gingival sections required for the design were cut out (Fig. 41 to 43).

Abutment selection and preparation

Buccal and palatal indexes, which we fabricated from the model with wax-up, allowed us to visualise the three-dimensional space in which we could position and prepare the abutments accordingly. The implant shoulder could now be accurately defined based on the emergence profile created earlier (Fig. 44 and 45).

With the aid of the silicone index the titanium abutments must be prepared, so that bridge frameworks – particularly in the areas where no solid frameworks can be created – maintain the minimum thickness for zirconia restorations. The sectioned model was then replaced in the scanner and the implant abutments and dies scanned. As we had already scanned the gingiva masks in the previous scan stage, we could remove the gingiva masks for this scan cycle. This allowed better access to the implant shoulders and preparation margins. If shadows are still created during scanning due to gingival sections, existing dies or implant shoulders, we can saw the sectioned model into even smaller segments. This allows the stripe light scanner to reach all relevant details unhindered (Fig. 46 to 48).

The preparation margins were then defined in the software. This is automatically completed by the programme with a click and can be checked and, if required, adjusted manually (Fig. 49 and 50).

In the next working stage the situation/wax-up scan was matched (merged) with the model and gingiva scan using the software. This produced a digital situation that was exactly the same as shown with the model situation in the articulator (Fig. 51).

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Fig. 37 and 38
The gingival mask was manipulated with a scalpel in a funnel shape from the implant shoulder to the margin of the marked tooth shape. Occasionally, however, aesthetic compromises have to be made


37


38

Fig. 39 and 40
Here the finished models with the manipulated gingiva are shown. The material used for the gingival masks was easily smoothed using cutters


39


40

Fig. 41 to 43
A gingiva scan was now completed with the model (cf. Fig. 40). As all relevant gingival areas are displayed, the gingiva sections required for the design were cut out using the software

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43

Fig. 44 and 45
Indexes of the model with wax-up visualising the three dimensional space in which the implant abutments have to be placed and prepared accordingly

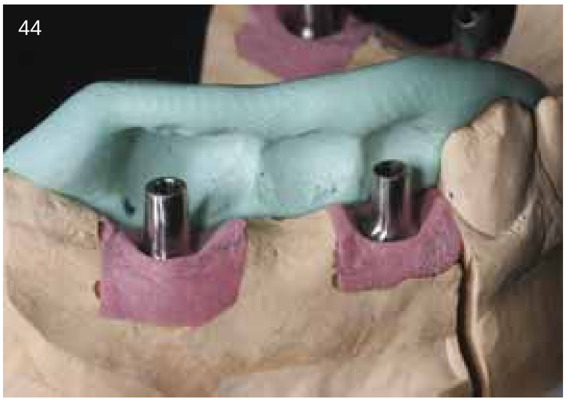
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Fig. 46 to 48
The sectioned model can now be sawn into smaller segments to prevent creating shadows during the next scan cycle (stripe light)

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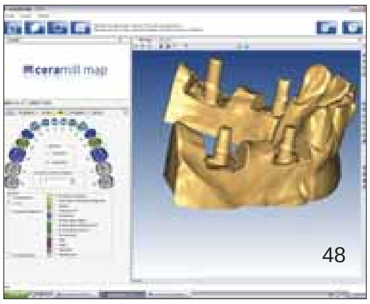

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Fig. 49 and 50 The stripe-light scanner has captured all relevant areas. The software defines the preparation margins automatically with the click of the mouse. The recommendation can be checked and, if necessary, adjusted manually

Fig. 51 The individual scans are brought together (matched) in the next working stage

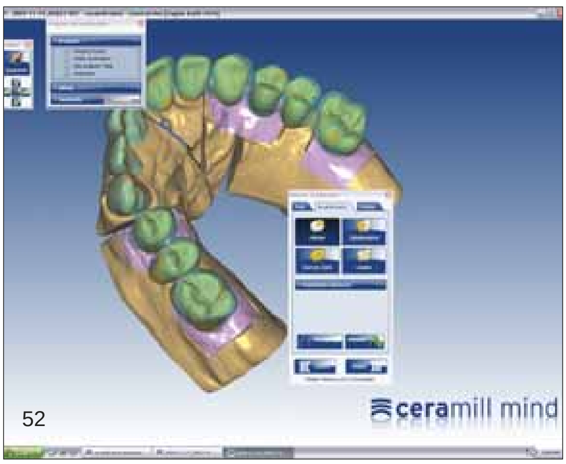

Fig. 52 and 53
The situation scan (green) is critically important for the subsequent procedure. There is a virtual void between the situation scan and the model as well as gingiva scan in which virtual teeth (yellow) are placed and "inflated" out of the situation scan with a click of the mouse

Fig. 54 to 56
The virtual design corresponds exactly to the wax-up in shape, function and aesthetics. With a click of the mouse the digital design can now be "shrunk" to the framework that supports the porcelain veneer

The situation scan is critically important and a great help for the subsequent procedure. The virtual image of the wax-up should be imagined as a thin skin, which depicts the margin for the bridge design. It is only a visual support display and does not represent any design element that can be produced with the press of a button.

Seen figuratively a void is created between the outer skin of the situation scan and the model and gingiva scan. Virtual teeth are now placed in this void, which are "inflated" out of the situation scan with a click of the mouse until they have the exact shape of the outer shell (Fig. 52 and 53). This procedure can be compared to filling a silicone index – only virtually [7].

In this way a virtual construction is produced that corresponds exactly to the wax-up in form, function and aesthetics. With another click of the mouse we now shrink the digital construction to anatomically supporting frameworks and to a thickness that should incorporate the veneer at a later stage. This ensures the same thickness of veneering porcelain on each tooth (Fig. 54 to 56).

Now we must place the bridge connectors, which can be selected in different cross sectional shapes and according to the respective situation. This prevents a detrimental aesthetic effect being produced in the interdental region at a later stage, though the minimum cross section is maintained (Fig. 57 and 58).

Once the bridge connectors are placed and the contact points have been appropriately rounded, the design of the bridge framework is complete. To ensure, however, that we do not have to start from the beginning again later with regard to

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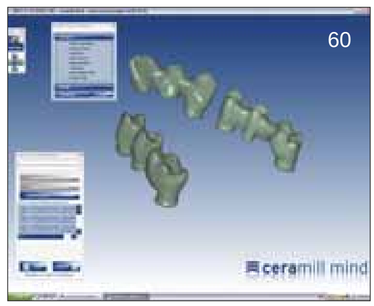
Fig. 57 and 58
The respective bridge connectors are also selected and placed with the help of the software. This prevents a detrimental aesthetic effect being produced in the interdental region and nevertheless maintains the minimum cross section



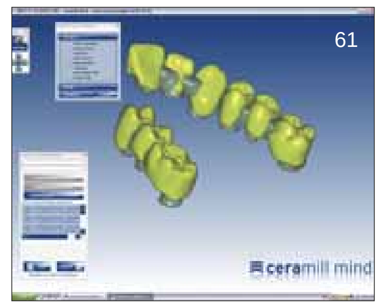
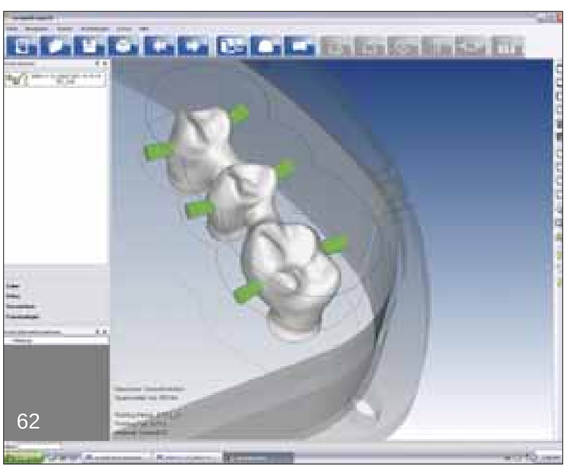


Fig. 59 to 61
The system calculates the difference between the situation scan and the permanent bridge design. This corresponds to the veneer and can, for example, be milled from wax for the press-on technique



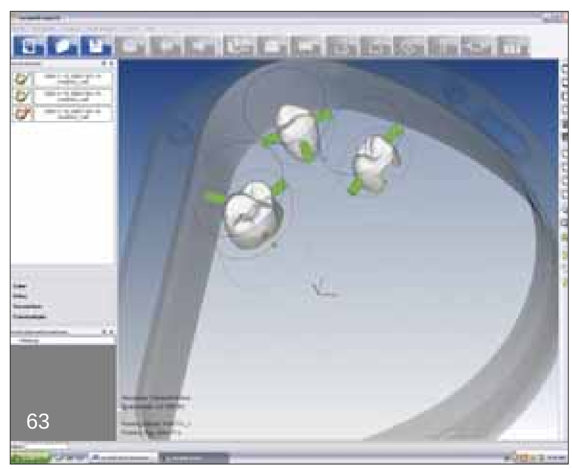


Fig. 62 and 63
When placing the bridge and wax designs virtually in the respective zirconia and wax blanks, it should be ensured that the connectors are stable enough during milling

veneering of the bridges, we will utilise what we have. After all, we have produced the shape, aesthetics and function in wax. All this information is available due to the double scan. The system we use has a function that calculates the difference between the situation scan and the final bridge design and can construct this difference as tooth veneers and, for example, mill them from wax based on the calculation (file splitting). These fit exactly on the bridge frameworks and are used as anatomical patterns for the subsequent press technique (Fig. 59 to 61).

The bridges and the wax crown designs were then virtually placed in the relevant zirconia and wax blanks (nested) and provided with relevant connectors. These must be placed to ensure that there is adequate stability during milling and that the patterns do not break out of the blank (Fig. 62 and 63).

Finally, the correct size of blank was selected for the construction and inserted in the milling unit (Ceramill Motion) (Fig. 64). At this point a little should be said regarding the nomenclature. Presintered material (usually zirconia) is milled, densely sintered – such as with the DCS system – and trimmed. After clamping the blank, the design and milling data are sent to the milling unit, which mills the frameworks and wax copings in a short time using sophisticated milling strategies (Fig. 65 and 66). Once milling is complete, the zirconia bridges and wax units are removed carefully from the blanks. In our experience large sharp fissure burs have proven useful for this. After the zirconia frameworks had been stained and sintered, they fitted very well on the model following minimal preparation. In the maxillary anterior region,

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Fig. 64
The correct size of blank (here zirconia) was inserted in the milling unit

Fig. 65 and 66
After clamping the blank, the design and milling data was sent to the milling unit. A sophisticated milling strategy ensured that the frameworks and wax copings were milled in a short time



Fig. 67 to 69
As it involves one data set, the frameworks could be fabricated using different materials. The fit is remarkable. The non-precious metal framework in the upper jaw is used for the temporary restoration of the anterior teeth

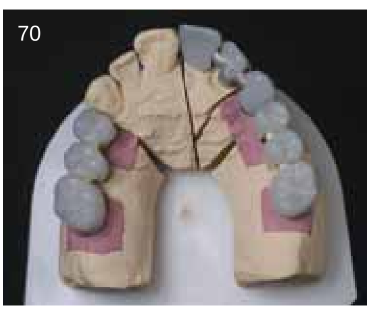

Fig. 70 to 72
The milled wax crowns could also be fitted on the zirconia bridge framework without adjustment or seating


Fig. 73 and 74
As the temporary anterior restoration was to be permanently replaced later by a zirconia-based restoration, we fabricated a single-tooth zirconia framework over the implant abutment in the region of tooth 23 using the same data set

where a temporary bridge had to be fabricated as a result of late implant placement in the region of tooth 21, we opted for a laser-sintered, non-precious alloy framework due to the free-end situation of tooth 21. The data set for this was sent to the milling centre. After 3 days we received the laser-sintered bridge back by post in the laboratory (Fig. 67 to 69). The milled wax crowns could now be fitted on the zirconia bridge framework – in a similar way to a modular system or jig-saw puzzle. Adjustment or seating was virtually unnecessary (Fig. 70 to 72). As the temporary anterior restoration will also be converted into a zirconia-based restoration later, we had also already fabricated a zirconia single-tooth framework over the implant abutment in the tooth 23 region from the data set of the laser-sintered, non-precious metal framework (Fig. 73 and 74). This allowed us to kill two birds with one stone, because on the one hand we no longer had to redesign this crown, and on the other hand if the crown has to be fabricated at a later stage, the implant abutment can remain in the

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Fig. 75 to 79
A situation scan, gingiva scan and model scan are also completed in the lower jaw based on the wax prototype and the bridges were designed as already described

Fig. 80
Two laser-sintered CrCo bridge frame-works were manufac-tured in a milling centre. At the same time we utilised the shell of the situation scan to generate a fully anatomical PMMA temporary restoration

Fig. 81 to 83
The temporary restoration was so precise that it did not require any prepara-tion but only had to be polished to a high lustre

patient's mouth until treatment is complete and consequently also the temporary restoration. To ensure that this crown can be integrated in the sectioned model later, the dentist must also integrate the zirconia framework coping in the impression for the permanent anterior restoration. A resin die is fabricated in the zirconia framework, which is fixed in the impression material, and then a standard section model can be fabricated.

The lower jaw design

A situation scan, gingiva scan and model scan had to be completed in the lower jaw – also on the basis of the wax prototype. The bridges were designed in the same way as the upper jaw and the data set generated was sent to the milling centre for the fabrication of two laser-sintered bridge frameworks. At the same time we utilised the shell of the situation scan to generate a data set for a fully anatomical PMMA temporary restoration. This data set could be milled in the Motion in-house milling machine using our own milling strategy (Fig. 75 to 79). It is therefore clear that we have also taken time to fabricate just one ideal wax-up for this working stage. Based on this wax-up – which fulfilled all requirements for the dynamic and static occlusion – we were able to have a laser-sintered, non-precious metal framework as well as a fully anatomical, tooth-coloured PMMA temporary restoration manufactured (Fig. 80).

The temporary restoration fitted so well due to an optimally coordinated milling strategy that it did not require any preparation but only had to be polished to a high lustre (Fig. 81 to 83).

We decided on a non-precious metal framework veneered with composite in the lower jaw. As already described in the first part of the article (cf. Page 3), that although the patient exhibited a reproducible centric at this stage of treatment despite being edentulous in the posterior region for years, we could not claim with certainty that this would remain stable with restoration of the support zones in the posterior region and any accompanying change in muscle tension of the orofacial system. This may ultimately result in a change to the centric relationship. In addition, the patient often stands in the way of a reasonable restoration. We therefore have to follow the wishes of the patient and – against our established concept – fabricate a permanent restoration right away due to his professional occupation.

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Fig. 84
We added a plateau of approximately one square centimetre on the frameworks for each quadrant using pattern resin, so that the dentist could check the centric already established at the framework try-in

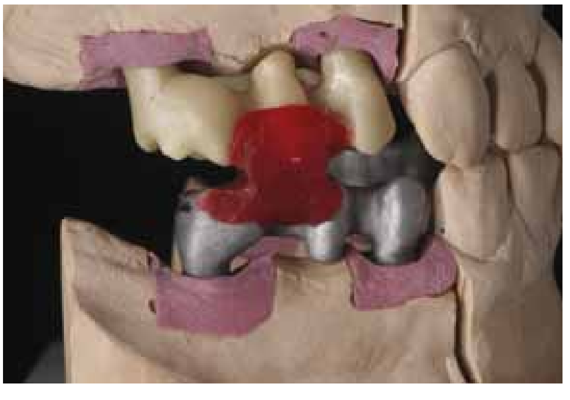

Fig. 85 and 86
A tongue was placed on the plateau in the lower jaw and a groove was placed in the plateau in the upper jaw, which the patient locked during a check of the centric. Any inaccuracy was indicated by a gap between the plateaus – here in the picture simulated in the articulator

As we would rather have developed the patient's centric in a gradual, successive manner using a temporary restoration, we decided on a composite veneered restoration in the lower jaw. This allowed us to counteract any functional interference or changes in centric, for example balance contact etc., using the "softer" composite restoration in the lower jaw as the upper jaw was treated with a porcelain veneered zirconia restoration. This counteracts associated chipping of the veneer material and still fulfils the patient's wishes for a permanent restoration. The composite veneer also offers the possibility of adjusting the occlusal surfaces afterwards in the laboratory, i.e. when the orofacial system has relaxed. We fabricated a PMMA temporary restoration for this purpose. The temporary restoration ensures that the patient does not have wait at home edentulous while the permanent composite restoration is in the laboratory for adjustment. This is only feasible in such an efficient, cost-effective manner using the digital processing chain.

Centric check

To allow the dentist to check the established centric, we created a plateau of approximately one square centimetre on the frameworks for each quadrant. This plateau is level and has a tongue in the lower jaw and a groove in the upper jaw (Fig. 84). This tongue and groove is locked to the centric established by the dentist. With this the dentist can check the centric reproducibly at the framework try-in [8]. Any inaccuracy – simulated here on the model – is indicated by a gap between the plateaus (Fig. 85 and 86).

The dentist can now make fine adjustments to the bite. If there is inaccurate keying in the lower jaw the dentist grinds the tongue away, separates the groove in the upper jaw with Vaseline and applies a small amount of pattern resin or temporary acrylic in the plastic state. The pa-

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Fig. 87 to 89 The dentist grinds the tongue away in the lower jaw for fine adjustment of the bite, separates the groove in the upper jaw using Vaseline and applies a small amount of pattern resin or temporary restoration acrylic in the plastic state. The patient bites together. The tongue made from white acrylic indicated that fine adjustment of the centric was necessary in this case – check stages like this facilitate the subsequent working procedure and ensure the final result

Product list

Product	Name	Manufacturer/ Distribution
Articulator system	Artex	AmannGirrbach
CAD/CAM system, Inhouse	Ceramill Motion	AmannGirrbach
Milling wax	Ceramill WAX	AmannGirrbach
Facebow	Artex facebow	AmannGirrbach
Implant system	Screw-Line	Camlog
Acrylic, temporary restorations	Ceramill TEMP	AmannGirrbach
Alloy, non-precious laser sintered	Ceramill NP L units (CoCr)	AmannGirrbach
Model stone	Alpenrock	Amann Girrbach
Model system	Giroform System	Amann Girrbach
Pattern resin	Pattern Resin	GC Europe
Sculpting wax	GEO	Renfert
Denture teeth	Creapearl, Dynamicline, designed by D. Schulz	Creation Willi Geller/ AmannGirrbach
Scanner	Ceramill Map300	AmannGirrbach
Scan spray	Ceramill Scanmarker	AmannGirrbach
Silicone, clear 1:1	Adisil clear	Siladent
Gingival mask	GumQuick	Dreve
Centric material	Pattern Resin	GC Europe
Centric check	Structur 2 QM	Voco
Zirconia	Ceramill Zi	AmannGirrbach

tient now bites together again. As the groove in the upper jaw has been separated, the patient can open the mouth easily after the material has cured and close several times to a reproducible centric. In our case it was evident that fine adjustment of the centric was necessary – the white temporary acrylic indicates the adjustment (Fig. 87 to 89).

In the third and final part the author describes the fabrication of the upper and lower restorations and discusses the results.

To be continued …

About the author

Ralf Bahle was born in 1963 as the son of a master precision engineer. He already discovered his artistic streak in his youth with creative handicraft work and painting. He completed his training as a dental technician in Stuttgart, Germany, from 1980 to 1984. After his training he began his technician years with rich experiences, which he enjoyed in numerous dental laboratories in and around Stuttgart. This included a year in the Braunwarth laboratory, where he – according to the circumstances at the time – gained new insights into aesthetics. In 1989, attracted by the beauty of the natural surroundings, he moved to the Allgäu region, Bavaria, Germany, where he purchased a farmhouse that was over 100 years old and restored it to its original condition. From 1989 to 1992 he worked in different laboratories in the Allgäu region – including over one year in the Thiele laboratory. There he learned, according to the circumstances at the time, new insights into precision and function. In 1993 after two years as the head of a laboratory, he became self-employed in his farmhouse. The former stables were converted into a 100 m^2, modern and exceptionally well-situated laboratory. He was now able to use the experience and knowledge he had acquired in numerous courses, including by Heinz Polz (†), Klaus Mütterthies, Jochen Peters and many more, to realise his own concept. He fabricated his first implant restoration as far back as 1989. Fascinated by this technique and the demands associated with it he quickly decided: our laboratory will specialise in this field! Through collaboration with renowned implantologists like Dr Wolfram Bücking, Dr Gerhard Iglhaut and Dr Ralf Masur and Partner he developed a reliable, efficient and reproducible team concept that he has been teaching in courses and evening events since 2000. In a specially equipped training room, which was established in 2005, course participants can learn his success concept in small groups and enjoy the charming surroundings. Since 2008 he has been an instructor with the Curriculum Implant Prosthetics and Dental Technology of the DGI (German Society for Implantology).

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CAD/CAM fabrication of implant-supported bridges in the maxilla and mandible – Part 3

Change, the constant of the future

An article by Master Dental Technician Ralf Bahle, Leutkirch/Germany

In the final part of his series of articles Master Dental Technician Ralf Bahle demonstrates how conventional, manually based dental technology is ideally and seamlessly linked to CAD/CAM technical procedures. After the model situation and wax-up had been digitised, the frameworks and superstructures were designed with the aid of a computer. The data sets created in this way were then fabricated using CAM. In this article the author describes how these frameworks are refined technically. As all frameworks – regardless of the material from which they were fabricated – are based on the same data set, it is a very efficient working procedure. Dental technicians can therefore concentrate on what they do best: the functional and aesthetic restoration of missing

Review

As extensive full-mouth rehabilitations, as described in this series of articles, are part of the day-to-day business of the author, he is very happy that with CAD/CAM technology he has access to a practical, efficient tool that can be easily integrated into his existing laboratory concept. The restoration was initially prepared in wax and fixed to the correct position in the articulator. The wax prototypes were then digitised in the system scanner and further processed digitally from this point onwards (cf. Part 2). In practical terms this meant that all the structures could now be prepared virtually with the aid of the software. The result: anatomically supporting ZrO_2 and non-precious metal frameworks for the permanent restoration, fully anatomical PMMA bridges for the temporary restoration stage and anatomical wax facings for the overpress technique. All restorations, the temporary and permanent restorations, were based on the wax-up prepared specifically for the patient. The CAD/CAM technique is therefore both a highly efficient and reliable process. Unnecessary and error-prone manual copying is no longer required. Thanks to CAD/CAM technology the motto is now: waxed up only once and then always copied one to one – and in the material combination of choice.

The traditional procedure, however, is also used in this case. This means that it must now be possible to transfer the structures, in particular their outer, functional section, to the framework according to the bite registration; at least during the customised composite build-up. The articulator is virtually the coordination centre that must meet the requirements for all types of restoration – whether temporary or permanent. How this is successfully achieved has already been described in detail in the other series of articles [1, 2]. The silicone index is again used to transfer of the outer wall of the framework.

From wax prototype to composite

As already described for the mandible, we also fabricated a transparent silicone index of the temporary bridge wax-up for the maxilla in the articulator, (Fig. 90). First a temporary anterior bridge from tooth 21 to 23 was to be fabricated in the maxilla, as described in Part 1. We inserted several openings at convenient positions in the index using twist drills (Fig. 91) into which we were to syringe flowable composite material at a later stage. We then applied opaque dentine to the bridge in the pontic and cervical regions and tapered it thinly towards the incisal (Fig. 92).

In accordance with the information acquired when taking the shade, a thin layer of B4 was then applied to the cervical

Indices

- CAD/CAM
- Implant prosthetics
- Framework design
- Function
- Matching
- Multiple scan
- Silicone index
- Transfer die
- Wax-up
- Zirconia

Category

System-related
Series of articles

Übersicht

5/10 Part 1
6/10 Part 2
7/10 Part 3

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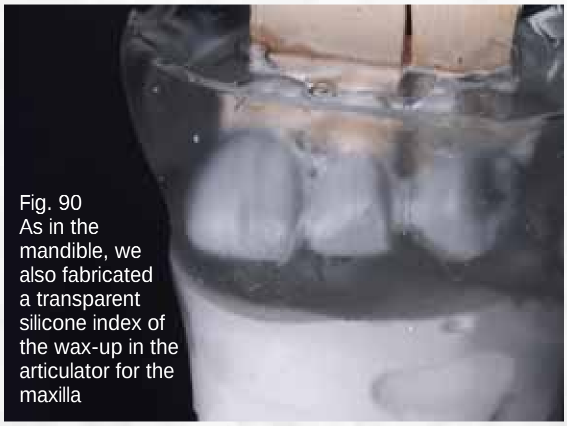
Fig. 90 As in the mandible, we also fabricated a transparent silicone index of the wax-up in the articulator for the maxilla


Fig. 91 First a temporary anterior bridge from tooth 21 to 23 was to be fabricated in the maxilla. We therefore inserted several openings in the index using twist drills for the flowable veneering composite

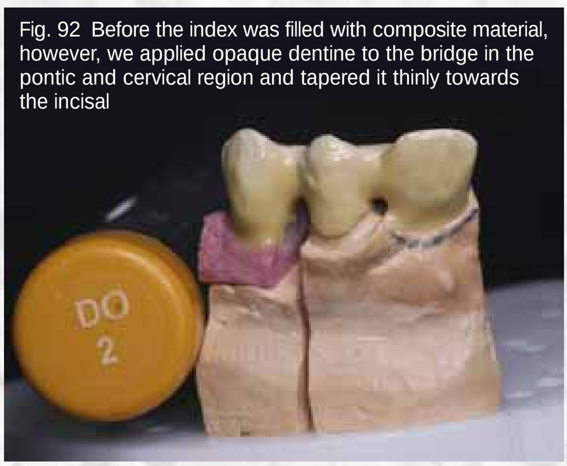

Fig. 92 Before the index was filled with composite material, however, we applied opaque dentine to the bridge in the pontic and cervical region and tapered it thinly towards the incisal

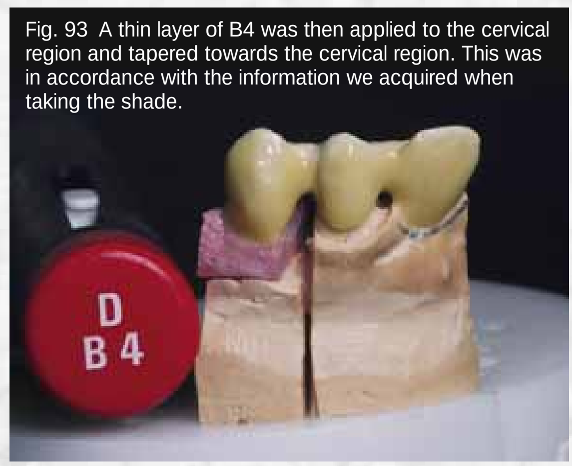

Fig. 93 A thin layer of B4 was then applied to the cervical region and tapered towards the cervical region. This was in accordance with the information we acquired when taking the shade.

region (Fig. 93). This layer was also tapered thinly towards the cervical and cured. The model and prepared framework were then placed in the articulator and lowered into the transparent silicone index (Fig. 94). Dentine material (composite) was then injected into the cavity between the silicone index and the prepared framework via the syringe channels. The flowable, light-curing composite was cured through the transparent silicone index using a UV lamp, as described by *Galip Gürel* [3]. The only difference was that we did not cure the composite intraorally but in the articulator. After curing, we removed the model from the silicone index and reduced the section of dentine required for the custom incisal build-up (Fig. 95 and 96). The reduced dentine body was then characterised using mamelon shades and transparent composites (Fig. 97).

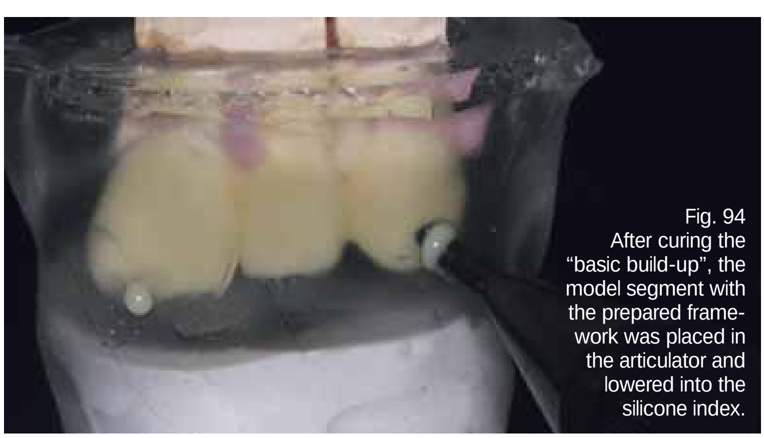
Fig. 94 After curing the "basic build-up", the model segment with the prepared framework was placed in the articulator and lowered into the silicone index.

The prepared framework and model were then replaced in the articulator and lowered into the silicone index. Incisal composite was injected, again via the syringe channels, and cured externally using UV light (Fig. 98 and 99).

The same procedure was used with the permanent posterior restorations in the mandible (Fig. 100 to 105). These were planned as composite bridges – in order to remedy any functional problems more easily or control the situation. The frameworks were also fabricated using CAD/CAM technology; though they were fabricated from laser-sintered, non-precious alloy in the same way as the temporary restorations. This procedure enabled us to transfer the initially prepared parameters of the wax prototypes exactly to the composite veneered bridges. This provided us with a highly efficient, reliable procedure. As these working stages were completed in an articulator, the incisal pin provided a reference for

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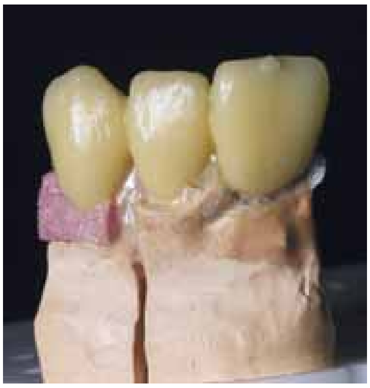
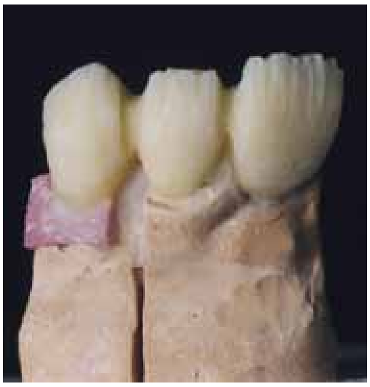


Fig. 95 and 96 Composite (dentine) was then syringed into the silicone index via the syringe channels. The composite was then cured through the transparent silicone using a UV lamp. After curing the dentine was reduced by the incisal section

Fig. 97 The reduced dentine was characterised using mamelon shades and transparent composites


Fig. 98 and 99 The prepared framework and model were then replaced in the articulator and lowered into the silicon index. Incisal composite was then applied, again via the syringe channels, and cured in the same way as the dentine composite

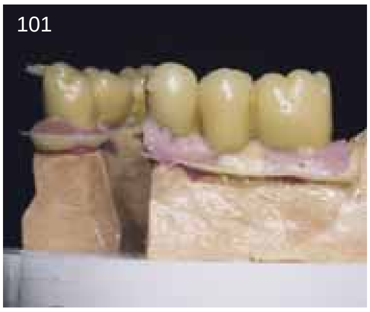

Fig. 100 to 105 The same procedure was used in the mandible, however, in this case it involved permanent posterior restorations

Note: In a few months the permanent restoration of the anterior teeth 21 to 23 will also be completed. This will of course be documented in detail and published as a separate Part in the dental dialogue. Unfortunately, a more definite publication date cannot be given at this point in time. You can be assured, however, that we will follow up with this report …

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Fig. 106 After removal of the silicone index, we only had to remove the flash

Fig. 107 The trimmed wax facings were now set up on the zirconia frameworks. The occlusion was checked in the articulator

Fig. 108 and 109 As the centric had to be adjusted slightly, minimal preparation of the occlusion was necessary

the vertical dimension. This avoided raised bites. After removal from the silicone index (Fig. 106) the syringe flash was trimmed and the model replaced in the articulator.

From wax prototype via CAD/CAM to press-over zirconia

The milled wax facings were used at this stage and set up on the zirconia framework for the procedure. For reasons of efficiency and to avoid a raised bite, the plan was to set up the CAD/CAM-fabricated wax facings on the zirconia frameworks and then overpress the frameworks with ceramic. The occlusion was checked in the articulator (Fig. 107). As there had been fine adjustment when registering the centric relationship (cf. Page 17), only minimal preparation of the occlusion was required (Fig. 108 and 109).

As these wax components were made from milling wax, they could be easily prepared using rotary cutters (Fig. 110). Details could also be efficiently sculpted using sharp sculpting instruments (Fig. 111).

After “fine trimming” had been completed, all the missing sections of wax were extended to the crown margin and the pontics waxed up (Fig. 112 to 114). When waxing up it was important to ensure that the emergence profile was accurately reproduced using the gingival mask as a reference. The waxed up zirconia frameworks were then fixed onto the press mould formers using wax (Fig. 115 and 116). Because the dies of implant-supported restorations are relatively small and the contact surfaces of the bridges are relatively large, the investment dies may bend during pressing of the ceramic. For this reason we stabilised the investment dies using tungsten wires (Fig. 117). We then filled the mould with investment (Fig. 118).

After devesting the overpressed zirconia bridges, the anatomical shape should look exactly like the pattern we had invested (Fig. 119). In this case, however, it could be seen that despite using tungsten wire stabilisers the pressure on the investment dies was so great that they were bent. Consequently it can be seen in Figure 120 that there was flash in the region of the crown margin. The position of the zirconia framework therefore no longer corresponded with the occlusal surface, as the framework had twisted on contact with the molten ceramic.

When this happens the question of course is, “Why all the effort?” Above all – and this is much more important in the long term – the question is, “What can be changed, so that this does not happen again?” We therefore remade the bridges, which did not present a problem thanks to CAD/CAM technology. The data sets were still available and so we only had to press a button and allow our machine to complete the work.

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Fig. 110 As milling wax was used, the facings could be easily prepared using rotary cutters

Fig. 111 Sharp sculpting instruments are also very suitable. The hard wax could be easily sculpted

Fig. 112 to 114 After "fine trimming" the missing wax sections were extended to the crown margins and the pontics waxed up

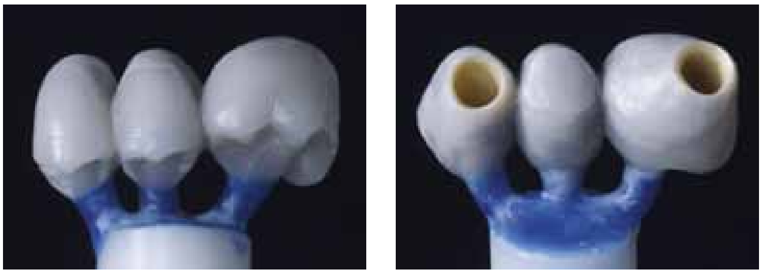

Fig. 115 and 116 It was important to ensure that the emergence profile was accurately reproduced using the gingival mask as a reference. The waxed up zirconia frameworks were then fixed onto the press mould formers using wax

Fig. 117 We used tungsten wires to stabilise the bridge frameworks

This time we left two connectors on the palatal aspect of the milled zirconia frameworks (Fig. 121) that were used for retaining the frameworks in the investment – this is practical troubleshooting.

These connectors had to be long enough so that they extended beyond the wax facings after sintering. This provided retention in the investment (Fig. 122 and 123). This approach proved to be an effective option to prevent the investment dies from bending and consequently displacing the framework (Fig. 124).
After devesting and fitting of the overpressed zirconia frameworks, the occlusion and contact points were just as accurate as we had invested them. This was provided, however, that the investment had been mixed so that there was virtually no expansion (Fig. 125 and 126).

All the details that we had originally waxed up were to be found in the veneered zirconia bridges. Even the dimensions of the pontics and emergence profile had bee accurately transferred (Fig. 127 and 128).

As a result the bridges only had to be stained and glazed. After three stain/glaze firing cycles, the maxillary bridges were finished (Fig. 129 and 130). Finally, the completed restorations were again checked in the articulator. It could also be seen in the articulator that there was an excellent shade match between the overpressed zirconia bridge framework and the composite-veneered, non-precious metal frameworks (Fig. 131 to 135).

In situ

The clinical photographs, taken four weeks after fitting (Fig. 136 to 139), showed a very smoothly contoured emergence profile. The design of the pontics made them indistinguishable.

Fig. 118
The prepared bridges were then invested. There should be as little expansion as possible

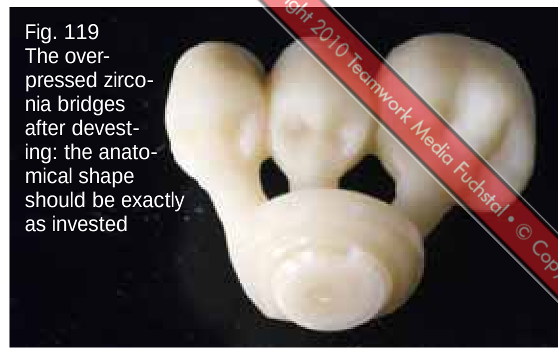

Fig. 119
The over-pressed zirconia bridges after devesting: the anatomical shape should be exactly as invested

Fig. 120
In our case the stabilising tungsten wires were inadequate. The pressure on the investment dies was too great, with the result that the dies bent. The flash indicated the deformation

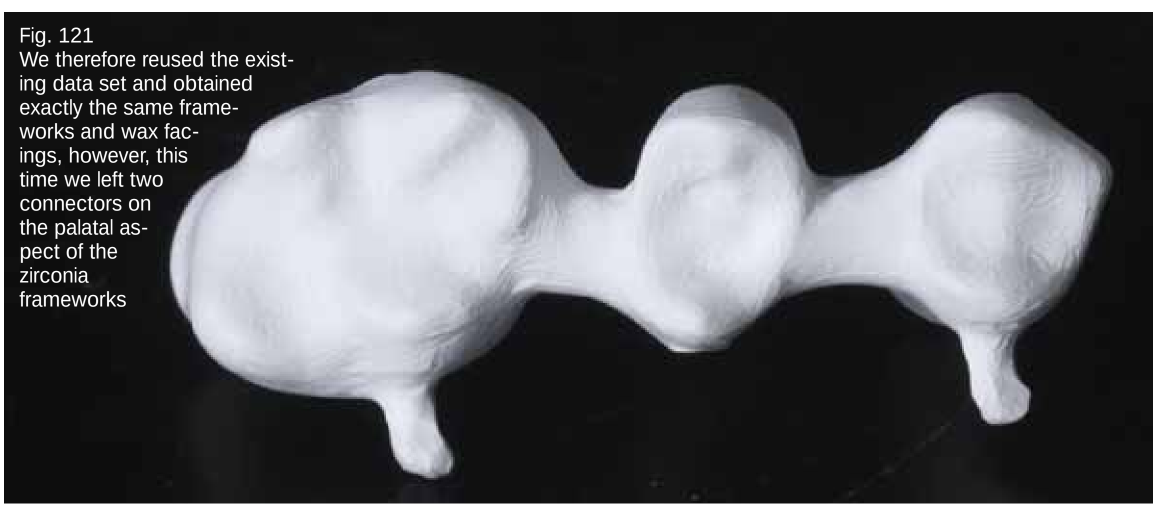

Fig. 121
We therefore reused the existing data set and obtained exactly the same frameworks and wax facings, however, this time we left two connectors on the palatal aspect of the zirconia frameworks

123

Fig. 122 and 123 The connectors had to be long enough, so that they still extended beyond the wax facings after sintering. This provided retention in the investment

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Fig. 124 The connectors left in position proved to be an effective option to prevent the investment dies bending and esulting in displacement of the framework to be overpressed

Fig. 125 and 126 The devested and fitted Press-over zirconia frameworks had exactly the same occlusion and contact points as the wax-up. This was provided that the investment had been correctly mixed

Fig. 127 and 128 All the details that we had originally waxed up had also been reproduced in the permanent restorations

Fig. 129 and 130 As the overpressed bridges were an exact copy of the wax-up, they only had to be stained and glazed. After three stain and glaze firing cycles, the maxilla bridges were finished

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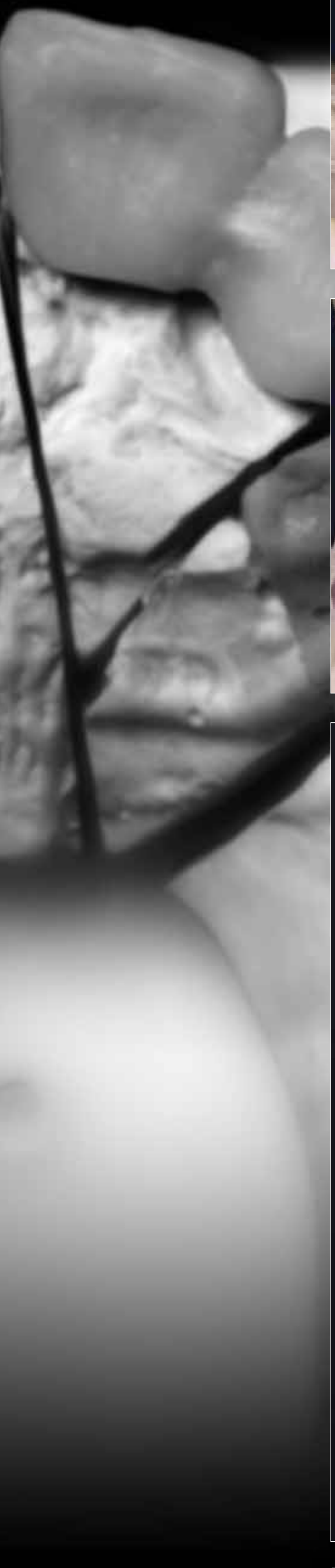

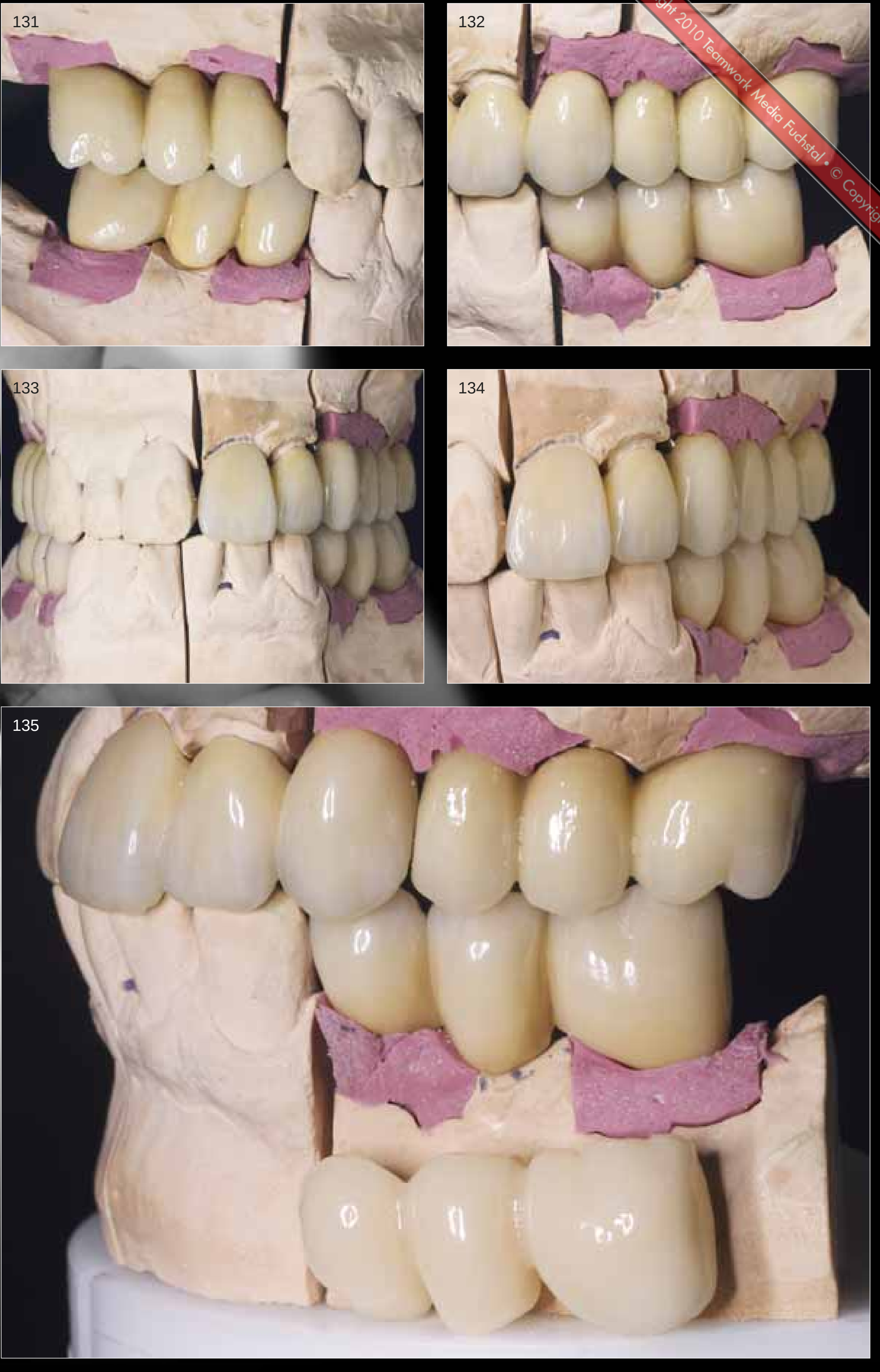

Fig. 131 to 135 Finally, the completed restorations were checked again in the articulator. It could also be seen in the articulator that there was an excellent shade match between the overpressed zirconia bridge frameworks and the composite-veneered, non-precious metal frameworks. The all-dentine shade PMMA bridge (Fig. 135) was used as a temporary restoration for all cases and maintained exactly the same anatomical shape

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Fig. 136 and 137 The clinical photographs, taken four weeks after fitting the restorations. The occlusion was stable. The patient was very satisfied with his restoration. The design of the bridge pontics made them indistinguishable …

The occlusion was stable and the patient said he was very satisfied with his restoration. Only the oral hygiene of the patient was not as effective as it should be – this still required attention in the practice. In addition, we had to monitor the composite bridge in the mandible. If it should turn out that composite was not the appropriate material, we could fabricate overpressed zirconia bridges – as in the maxilla – at any time using the available data set. As we could use the composite bridges for transferring the centric bite, the additionally fabricated PMMA bridges could serve as temporary restorations for the time being.

Conclusion

Modern CAD/CAM systems used in combination with a procedure like the one presented in this article, now provide dental technicians with the option of utilising wax prototypes, fabricated at the very beginning of reconstruction, throughout the process. This is because once the data set has been generated from the wax prototypes, a digital component is then available that provides a practical option for combining the most varied material concepts. In our case this included a zirconia framework with the respective wax crowns for the overpress technique, laser-sintered non-precious metal frameworks that could be veneered accordingly with the aid of a matching silicone index and also temporary PMMA restorations. If the amount of manual work the types of restorations mentioned above required in our previous daily routine and how much working time is saved with this new proce-

Product list

Product	Name	Manufacturer/ Distribution
Articulator system	Artex	AmannGirrbach
CAD/CAM system, Inhouse	Ceramill Motion	AmannGirrbach
Milling wax	Ceramill WAX	AmannGirrbach
Facebow	Artex facebow	AmannGirrbach
Implant system	Screw-Line	Camlog
Composite	Sinfonie	3M ESPE
Acrylic, temporary restorations	Ceramill TEMP	AmannGirrbach
Alloy, non-precious, laser sintered	Ceramill NP L units (CoCr)	AmannGirrbach
Model stone	Alpenrock	AmannGirrbach
Model system	Giroform System	AmannGirrbach
Pattern resin	Pattern Resin	GC Europe
Sculpting wax	GEO	Renfert
Press ceramic system	Creation Press & Paint On Zirconium Dioxide	Creation Willi Geller/ AmannGirrbach
Denture teeth	Creapearl, Dynamicline, designed by D. Schulz	Creation Willi Geller/ AmannGirrbach
Scanner	Ceramill Map300	AmannGirrbach
Scan spray	Ceramill Scanmarker	AmannGirrbach
Silicone, clear 1:1	Adisil clear	Siladent
Zahnfleischmaske	GumQuick	Dreve
Zirconia	Ceramill Zi	AmannGirrbach

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Fig. 138 and 139 … Only the oral hygiene was not as effective as it should be. If it should turn out that composite was not the correct material, we could fabricate overpressed zirconia bridges, as in the maxilla, at any time using the existing data set

dure is taken into account, then the efficiency of this technology will become clear to everyone. Efficiency is not the only decision criterion, however, but also the ability to fabricate restorations to a consistently high quality in accordance with planning details. Form, function and aesthetics are therefore no longer left to chance. Taking all this into consideration, CAD/CAM technology will be indispensible in my laboratory in the future.

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About the author

Ralf Bahle was born in 1963 as the son of a master precision engineer. He already discovered his artistic streak in his youth with creative handicraft work and painting. He completed his training as a dental technician in Stuttgart, Germany, from 1980 to 1984. After his training he began his technician years with rich experiences, which he enjoyed in numerous dental laboratories in and around Stuttgart. This included a year in the Braunwarth laboratory, where he – according to the circumstances at the time – gained new insights into aesthetics. In 1989, attracted by the beauty of the natural surroundings, he moved to the Allgäu region, Bavaria, Germany, where he purchased a farmhouse that was over 100 years old and restored it to its original condition. From 1989 to 1992 he worked in different laboratories in the Allgäu region – including over one year in the Thiele laboratory. There he learned, according to the circumstances at the time, new insights into precision and function. In 1993 after two years as the head of a laboratory, he became self-employed in his farmhouse. The former stables were converted into a 100 m^2, modern and exceptionally well-situated laboratory. He was now able to use the experience and knowledge he had acquired in numerous courses, including by Heinz Polz (†), Klaus Mütterthies, Jochen Peters and many more, to realise his own concept. He fabricated his first implant restoration as far back as 1989. Fascinated by this technique and the demands associated with it he quickly decided: our laboratory will specialise in this field! Through collaboration with renowned implantologists like Dr Wolfram Bücking, Dr Gerhard Iglhaut and Dr Ralf Masur and Partner he developed a reliable, efficient and reproducible team concept that he has been teaching in courses and evening events since 2000. In a specially equipped training room, which was established in 2005, course participants can learn his success concept in small groups and enjoy the charming surroundings. Since 2008 he has been an instructor with the Curriculum Implant Prosthetics and Dental Technology of the DGI (German Society for Implantology).

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