3D Scanning – and then what?

Currently the interested orthodontist faces a growing variety of model and intraoral scanners that are absolutely suitable for use in an orthodontic practice, both from economical and technical point of view.

The expectations of the implementation of such technology and the associated change in work processes are manifold and mainly focus on cost saving and workflow facilitation but also on safeguarding and even further improving on high-quality treatment results.

These objectives can mainly be achieved in the fields of model archiving, measurement/diagnostics, treatment planning, fabrication of treatment devices, but also patient counselling, case documentation, communication and many others.

Already the choice for a scanning technology is a key aspect because, although there is a large area of overlap of application possibilities of model and intraoral scanners, decision for one or the other or even both methods means a certain preliminary determination concerning specific options of the digital workflow.

Potential customers often want to employ all virtual work steps within one and the same software application which in turn can be incorporated into the infrastructure of practice management, imaging and image processing systems available in the practice without difficulty and which is also capable of dealing with other case-relevant image information, such as X-rays, facial photos or DVTs.

With the current version 3.2 of the orthodontic image processing software OnyxCeph³™ the manufacturer Image Instruments provides an application that aims at meeting this demand, also by constantly upgrading and refining the software since 1996. From the technical point of view OnyxCeph³™ is a client/server-network-application executable on Windows™ operating systems combined with a powerful SQL database that makes all currently requested functions for patient-related administration and processing of 2D and 3D image records available within a consistent user interface.

In the following, overview of the main features available for that purpose in OnyxCeph^{3TM} is presented for those who want detailed information on principle options of using digital models in orthodontic practices.

Patient-related Scanning, Importing and Archiving of Dental Models

In the module *Add Image* the two scan files for maxilla and mandible pre-aligned in occlusion are dragged to the appropriate session and classified with regard to date of recording, image type and other image attributes. Afterwards the record has to be patient-specifically aligned and, if necessary, topologically treated in the module *Adjust Image*.

The module *Cast Adjust* enables individual trimming of the maxillary and mandibular scans by means of polygon or planes and embedding them into virtual base trays of selectable size and geometry (Fig. 1). Alternatively, horseshoe-shaped bases can be used. All requirements with regard to digital model archiving are hereby fulfilled.

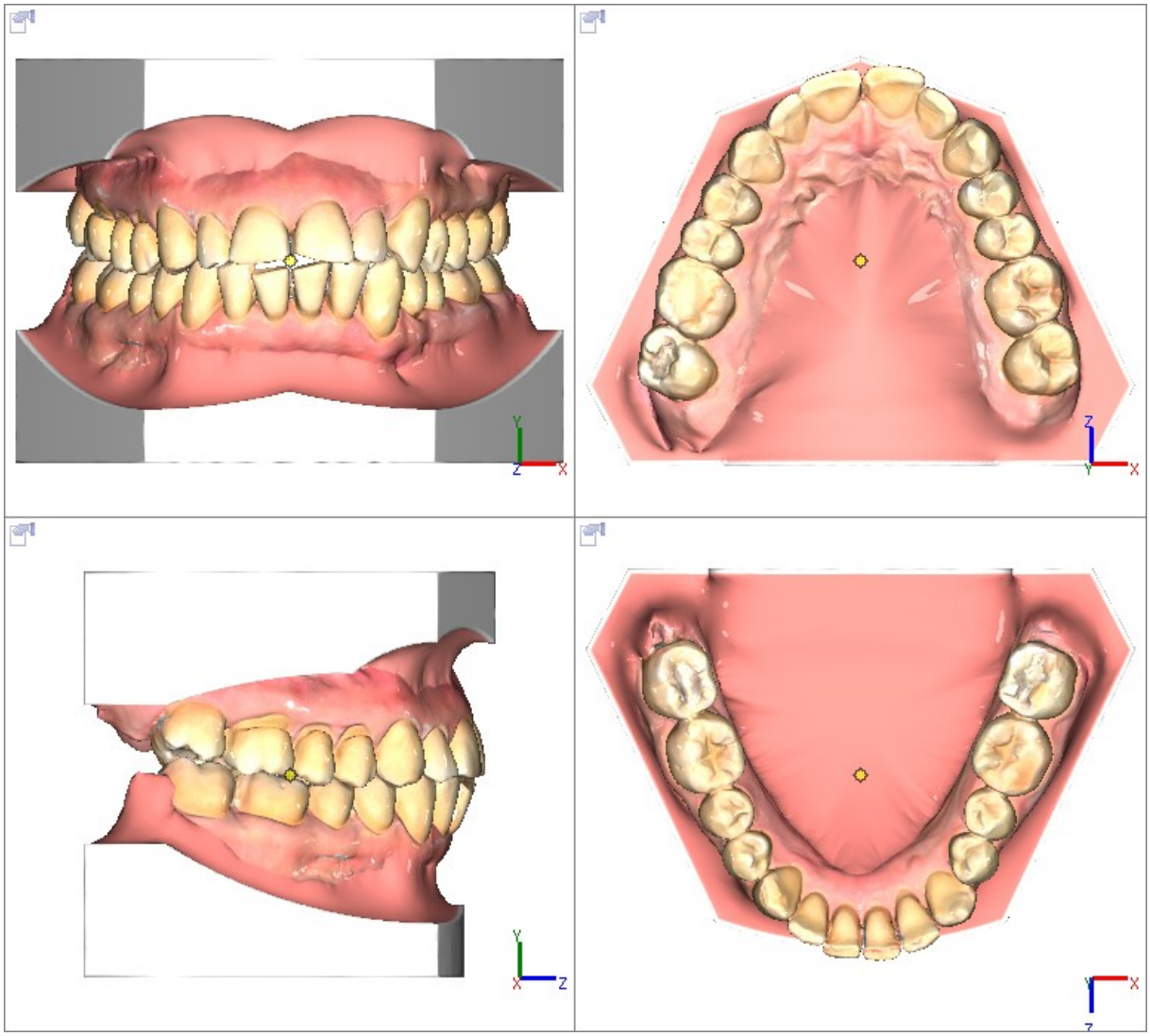


Fig. 1: Digital archive model created in module *Cast Adjust* (model consists of textured intraoral impression [CEREC Omnicam] and OnyxCeph³™ standard model base EU small)

Segmenting, Separating and Completing of Dental Models

Irrespective of whether the record is to be used for diagnostics, planning or patient counselling, segmentation of single crowns and completing them to so-called hybrid teeth is recommended. The module *Segmentation* not only allows completing the scanned crown surfaces by the interdental areas and virtual roots required for subsequent processing steps, but also adding a coordinate system and distinctive landmarks to each single tooth (Fig. 2).

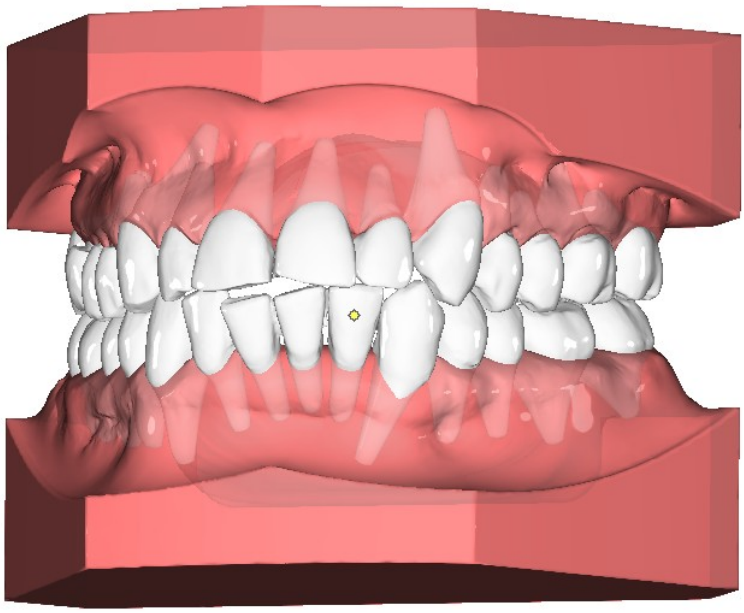
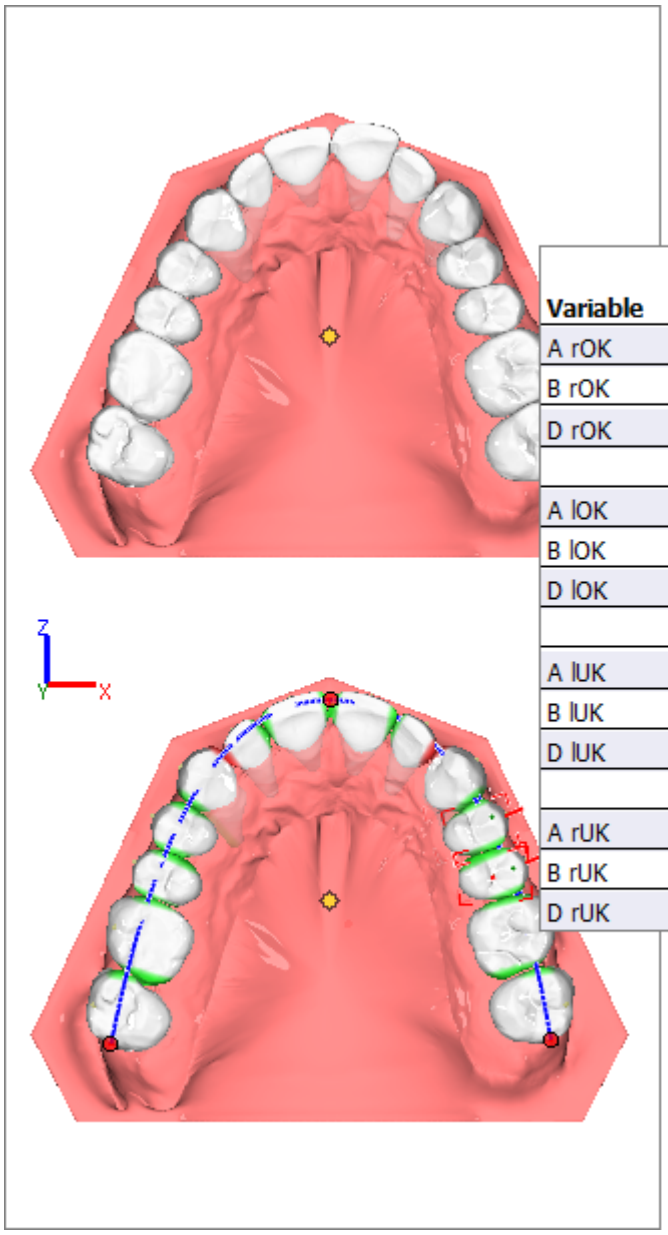


Fig. 2: Model record treated in the *Segmentation* module

Measuring, Analyzing and Assessing of Dental Models

These distinctive landmarks and possibly some more points that have to be positioned manually enable applying any of the traditional model analysis available in the library of analyzes for deciduous, mixed or permanent dentition in the *Digitize* module.

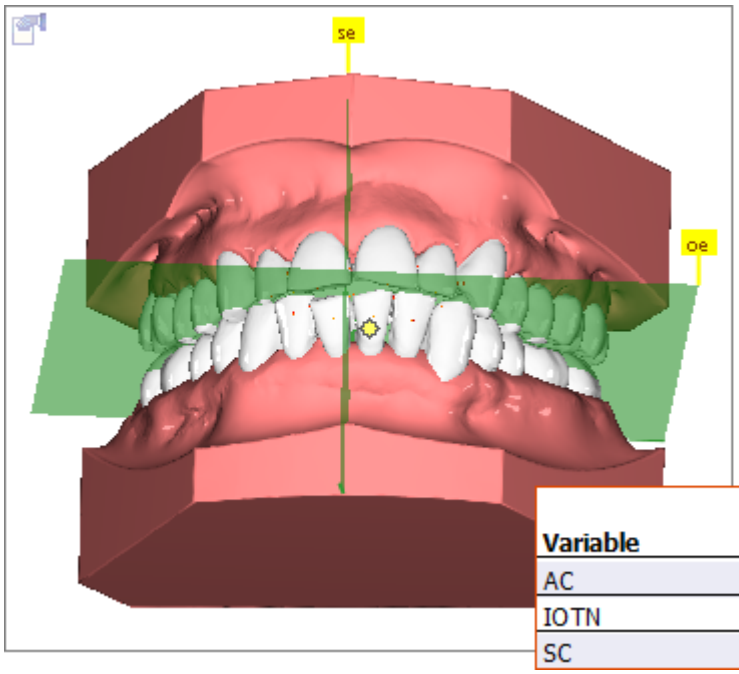
Beyond that the Onyx-Model Analysis is available for mixed and permanent dentition. It calculates space discrepancies by comparing the space available and the space required in the regular target situation based on the known geometric parameters of the dental arch and the single teeth in consideration of the real (effective) crown contacts. This method merely requires setting specifications concerning symmetry and inclination desired for the target (plus selection of an approximation method in case of mixed dentitions) and provides quick information about the treatment required (Fig. 3).



Onyx Modellanalyse 3D		
Variable	**Beschreibung**	**Wert [ ]**
A rOK	Platzangebot OK rechts	60,1mm
B rOK	Platzbedarf OK rechts	60,8mm
D rOK	Diskrepanz OK rechts	-0,7mm
A lOK	Platzangebot OK links	60,0mm
B lOK	Platzbedarf OK links	60,7mm
D lOK	Diskrepanz OK links	-0,6mm
A lUK	Platzangebot UK links	56,7mm
B lUK	Platzbedarf UK links	58,1mm
D lUK	Diskrepanz UK links	-1,4mm
A rUK	Platzangebot UK rechts	57,0mm
B rUK	Platzbedarf UK rechts	58,4mm
D rUK	Diskrepanz UK rechts	-1,4mm

Fig. 3: OnyxCeph³™ space discrepancy rating based on the Monson curve and effective crown contacts

Quantitative evaluation of misalignment and treatment need by means of calculation of factors such as IOTN or PAR-Index is based on the same calculation concept. (Fig. 4).



IOTN

Variable	Wert
AC	4
IOTN	2
SC	d

Fig. 4: IOTN-determination using a digital model in the *Digitize* module

Planning of Treatment Goals

Visualizing the treatment goal by rearranging the virtual teeth and simulating the resulting gingival changes may be useful for diagnostics and treatment planning. For this purpose, OnyxCeph³™ provides several tools in module V.T.O.3D that allow automatic and manual correction of dental arch and tooth alignment on the basis of the Monson-Andrews concept, which was developed specifically for this, while individual critical values for tooth movement are observed (Fig. 5).

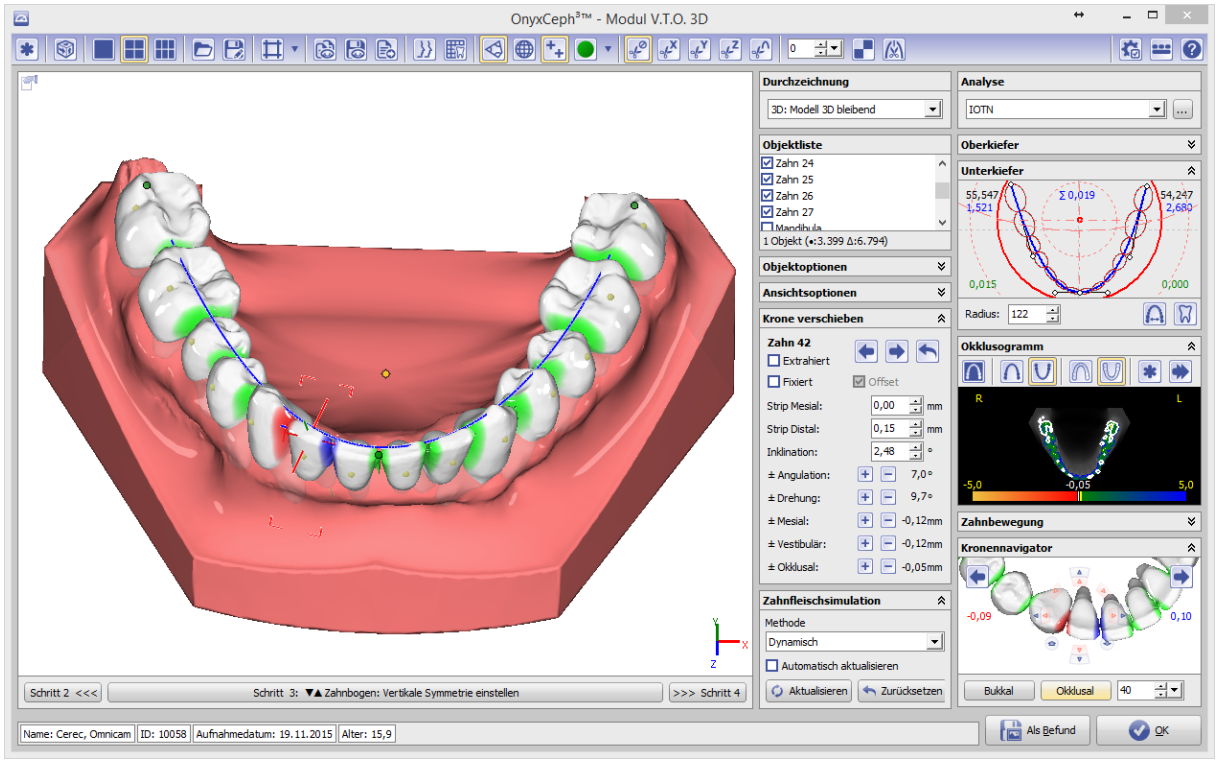


Fig. 5: Planning of the treatment goal in module *V.T.O.3D*

Planning of Aligners

If the planned treatment result is to be achieved by means of aligner therapy, incremental treatment steps can be specified in the *Aligner 3D* module. Each step can be individually modified, furnished with attachments and, if desired, adjusted to the currently achieved treatment situation by means of intermediate scans (progress-refinement) while upholding the treatment goal (Fig. 6).

By using the export functions, the individually planned increments can be trimmed, inscribed, numbered, blocked out separately or in series and printed in different 3D formats with or without remeshing and afterwards they can be manufactured.

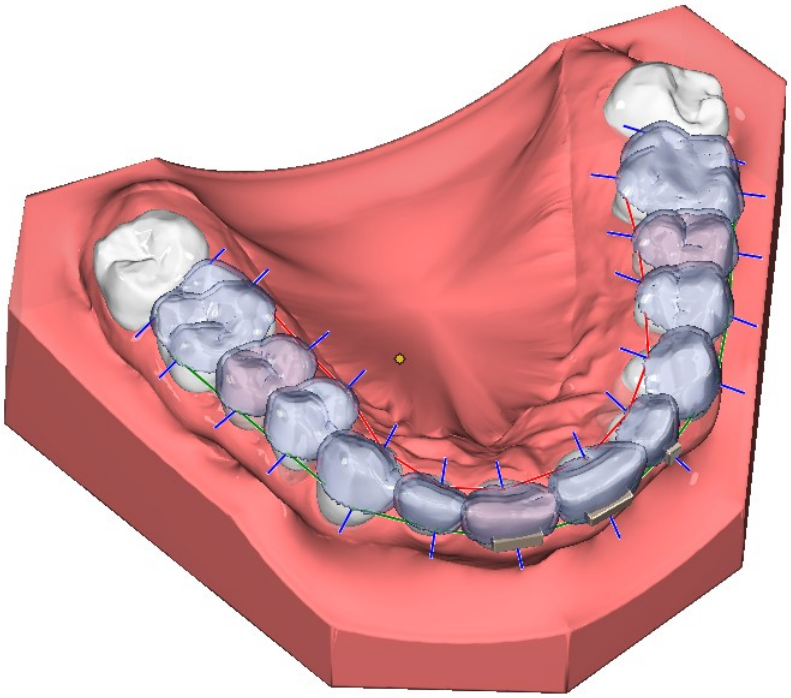


Fig. 6: Incremental planning of aligner steps in module *Aligner 3D*

Planning and Transferring of Bracket Positions

If fixed appliances are designated for realizing the virtually planned treatment goal, optimal bracket positions can be calculating either in the *FA_Bonding* or the *Wire_Bonding* module. In *FA_Bonding* the virtual brackets are positioned on the malocclusion using different empirical rules and visual alignment aids while *Wire_Bonding* requires specifying the geometry of the virtual archwire and customizing the target wire and bracket base in relation to the target situation with a subsequent reset to malocclusion. This method can be applied for buccal or lingual treatment and apart from typical straight-wire geometry also spherical curved target wires are possible.

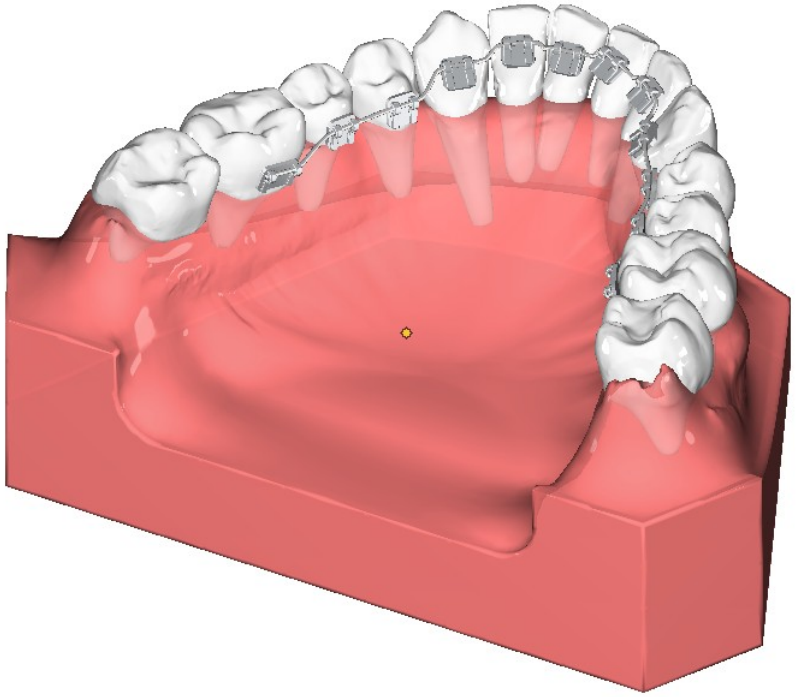


Fig. 7: Planning of optimal bracket position in module *Wire_Bonding* using lingual therapy with spherically curved 3D target wire as an example

OnyxCeph^{3TM} supports direct and indirect transfer of virtually planned bracket positions to the patient in the form of several procedures that are implemented in separate modules. In this article we merely refer to the method of direct bonding offered in the *Kylix* module that allows encoding of bracket position and alignment in relation to the respective crown by means of a base frame of selectable design. The real bracket is furnished with the selected individual base on the printed or milled model and transferred by means of the well-established vacuum-forming technology.

The second image in Fig. 8 illustrates the virtual construction of direct transfer trays in module *Bonding Trays*. At present, however, widespread use of this process technology fails due to detailed problems concerning mechanical properties of the splint material available for the additive manufacturing process (Fig. 8).

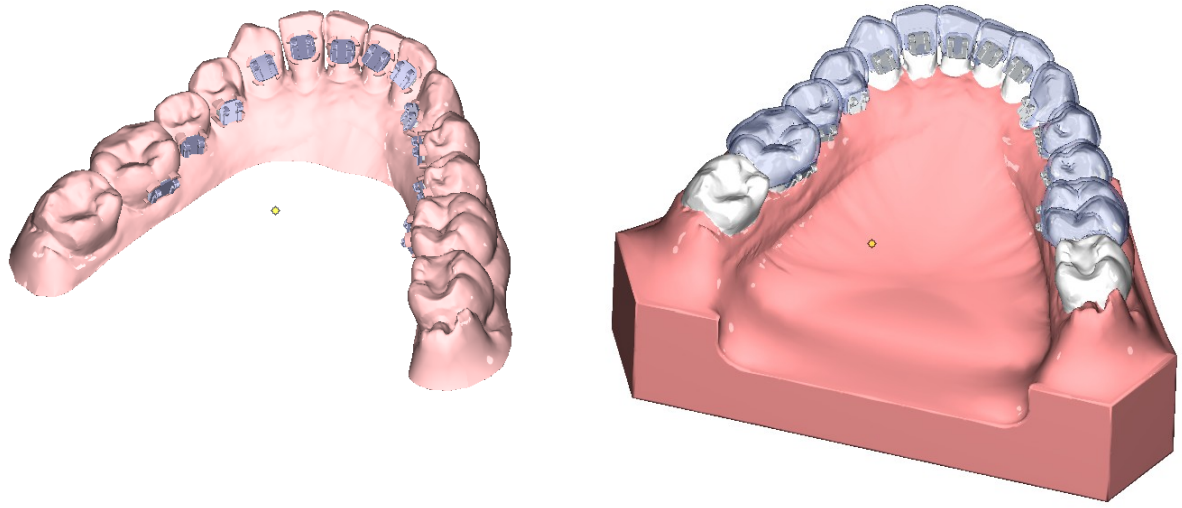
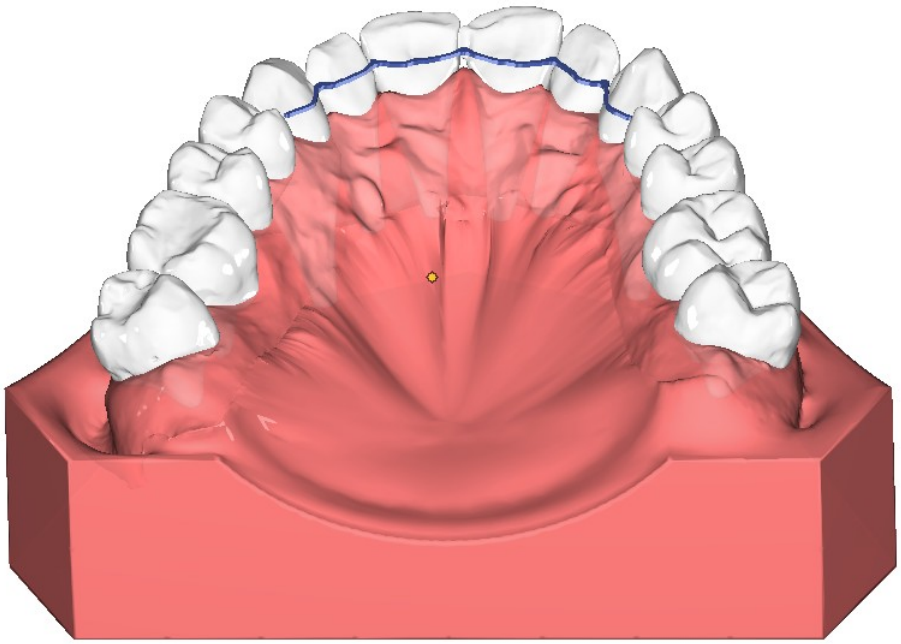


Fig. 8: Bracket transfer methods left side: Module *Kylix* | right side: Module *Bonding Trays*

Planning of Retainers

The comparatively simple task of constructing and manufacturing CAD/CAM retainers provides clear evidence for the potential of improvement and savings associated with the digital approach. Just a few mouse clicks in the module *Retainer 3D* are required for positioning and designing virtual retainers with pre-selectable parameters. Following they can be sent to specialist service providers[1] for fabrication.



[1] Placing the order for fabrication of the retainers constructed by the option Memotain® as well as data dispatch to CA-Digital GmbH Mettman can be effected online directly out of OnyxCeph³™.

Fig. 9: Retainer-Design in module *Retainer 3D*

Planning of Waefers

The module *Waefer Creation* enables construction of positioning splints for interim or target situations of oral and maxillofacial surgical treatment procedures and their export or dispatch for manufacturing as 3D record. (Fig. 10).

Based on digital models the jaw relation to be fixed can be adjusted for example in the module *V.T.O.3D*. In case of matching face or volume scan data being available, jaw reconstruction and tooth rearrangement can be planned by means of the combined records in *Morph 3D.* In addition, treatment-related changes to the facial appearance can be simulated.

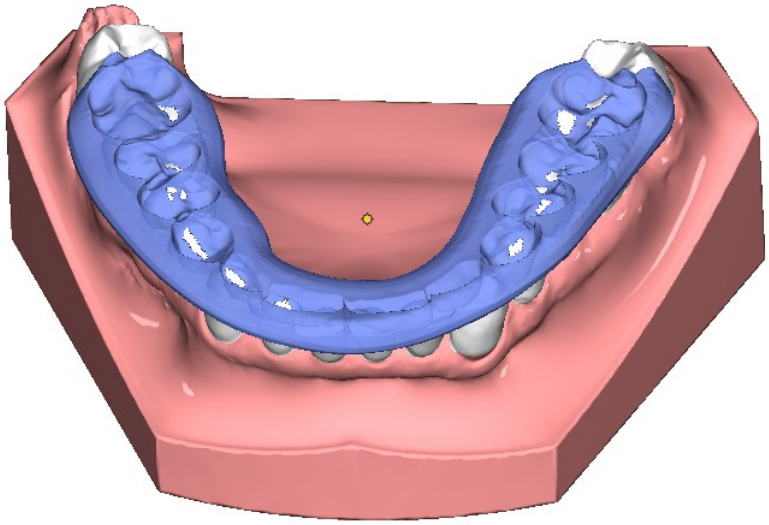
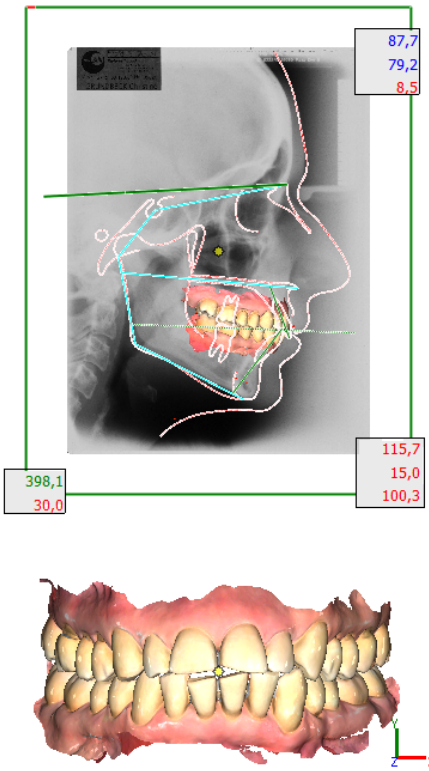


Fig. 10: Construction of positioning splints in module *Waefer Creation 3D*

Counselling / Documentation

Additionally OnyxCeph³™ provides a variety of functions for presenting the digital models or the evaluations and plannings based on them together with the results of other analyses within the framework of case documentation or patient counselling.



Sampermans - IOS

Variable	Norm [ ]	Wert [ ]	Diff	Abweichung	Verbal
Skelettale Auswertung					
Anteroposterior-Skelettale Beurteilung					
1. NA - TH	91,0±3°	87,7°	-3,3		
2. NB - TH	88,0±3°	79,2°	-8,8		
3. ANB	3,0±3°	8,5°	+5,5		
4. NP - TH	90,0°	79,2°	-10,8		
5. A:Nperp TH	2,0mm	-2,2mm	-4,2		
6. B:Nperp TH	-2,0mm	-17,2mm	-15,2		
7. P:Nperp TH	0,0mm	-19,8mm	-19,8		
8. True Wits	4,0±2mm	15,0mm	+11,0		
9. SN - GoSN	100%	103%	+3		
10. Spa-Spp ArGr	50%	57%	+7		
Vertikal-Skelettale Beurteilung					
11. Symphysenbr	16,5±3mm	11,4mm	-5,1		dolichofacial
#V_12. BP-MeTH					
12. GoMe-TH	27,0°	30,0°	+3,0		
13. NS-SAr-ArGo-	396,0±4°	398,1°	+2,1		mesofacial
14. ArGo-GoMe	130,0±7°	128,2°	-1,8		mesofacial
15. ArGoN:NGoM	75%	74%	-1		dolichofacial
16. SAr:ArGo	75%	67%	-8		dolichofacial
17. SGo:NMe	65%	62%	-3		dolichofacial
18. SpaMe:NMe	60%	56%	-4		brachiofacial
Dentale Auswertung					
19. OP - TH	8,0°	5,0°	-3,0		
20. OK1:Spa-Spp	110,0°	115,7°	+5,7		
21. UK1:GoMe	95,0±2°	100,3°	+5,3		

Fig. 11: Presentation as an example of documentation facilities

Communicating with Partners

An essential advantage of the digital work process is the quick online exchange of treatment-relevant data. The so-called Container function provided by OnyxCeph³™ for this purpose enables effective and secure communication with referring doctors or colleagues, experts, dental laboratories and, if desired, with the patient himself.

Outlook

Digital models generated from model scans or intraoral impressions offer manifold options for optimizing the traditional work routine in orthodontic practices. Such conversion not only means to invest in new or upgraded hardware and software at the beginning but also is it associated with a thorough familiarization phase. However.

The challenge for software developers besides the provision of a practical and wide range of functions as described in the article before is the increasing need for mediation of underlying methodical approaches and operational concepts as well as for assistance in installation and operation of their products.