Digital support for simulating bite alterations in the periodontally compromised dentition

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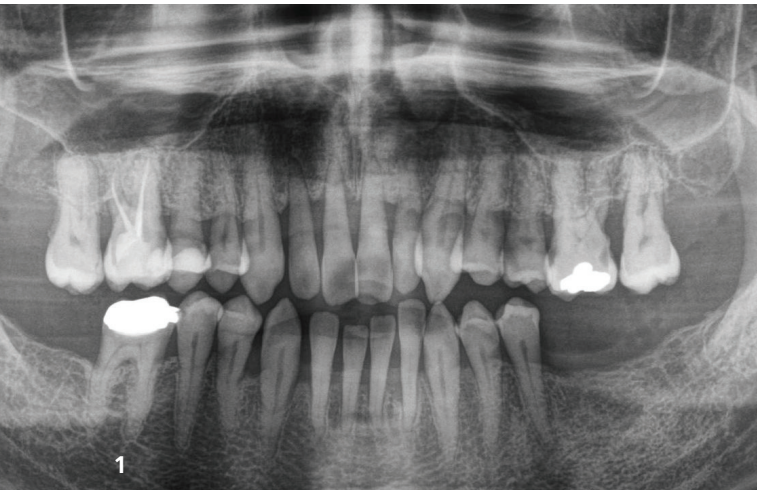
Achieving stable long-term results with implant-supported restorations in patients with periodontally compromised teeth can be challenging in many respects. Patient acceptance is of vital importance for keeping the patient compliant and motivated. Issues to resolve include the best way to preserve existing tooth structures, the right timing for implant placement, the most suitable healing mode and the choice of restoration type. Meeting the patient's desire for optimum function and aesthetics after tooth removal is never an easy task for the dental and laboratory teams—especially in patients with periodontal disease or misaligned teeth. The anticipated prosthetic result is usually simulated with the help of a mock-up. An initial step can be a visual simulation using digital technology. If this visualisation is not enough to arrive at a treatment decision, CAD/CAM technology can translate a digital design into a mock-up that additionally facilitates functional testing.

Patients with generalised periodontal disease will require a prosthetic restoration if progressive bone loss persists, even if stringent periodontal maintenance is performed.[1] Implant-prosthetic solutions avoid fixed partial dentures supported by compromised natural abutment teeth.[3] The so-called complete oral rehabilitation, involving a reduced number of implants restored with a full-arch fixed denture, has been widely propagated in recent years.[17]

However, this procedure requires the patient's entire residual dentition in the affected jaw to be removed. Patients may find this difficult to accept if some or all of the remaining abutments are otherwise sound. Also, extracting all the teeth may be medically contraindicated where the periodontal situation is stable. Complete oral rehabilitation usually calls for involved treatment procedures and implies considerable cost.

By replacing only a few teeth with a short-span implant-supported fixed partial denture or dentures, other teeth can be preserved and even receive extra protection afforded by a stable vertical bite.[4]



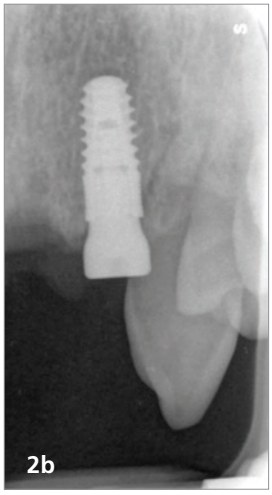


Fig. 1: Panoramic radiograph. Chronic periodontitis with hopeless maxillary incisors. **Figs. 2a & b:** Control radiograph after immediate implantation with healing abutments in place (narrowSky, diameter 3.5 mm, length 10 mm; bredent medical).

Depending on the further prognosis of the residual dentition, additional implants may be required later.

This successive approach requires more implants to be placed than would have been necessary for a complete oral rehabilitation. Alternatively, after successful periodontal treatment, the lost teeth can be restored with adhesive bridges or stabilised with an archwire splint,[8] depending on the available treatment options and on patient cooperation.

Implant placement in the periodontally compromised jaw

In a typical periodontally compromised jaw, the remaining teeth are only minimally anchored in the alveolar process. The available bone can therefore be used to best advantage by opting for immediate implants in the context of an implant-prosthetic treatment—now a common approach. Immediate placement also avoids extensive flaps, keeping postoperative morbidity low.[18]

This procedure, however, requires detailed diagnostics. Depending on the anatomical findings ahead of implant placement, this may involve the use of a navigation or orientation template, or a freehand approach can be chosen. Especially in patients with advanced atrophy of the jaw, a good prosthetic result can be achieved with freehand implant insertion, since the pilot hole will be located near the root apex of the extracted tooth anyway; this saves the cost for the navigation template.[16]

If the alveolar process is relatively well preserved, the pilot hole should be positioned on the lingual or palatal wall of the socket, taking into account the inclination of the socket relative to the apical base.[17] The use of a navigation template is recommended, since a freehand preparation can easily cause a vestibular deviation of the implant axis.[11] If some teeth are already missing, the prospective restoration should be simulated by means of a mock-up to obtain the most preferable implant position from a prosthetic point of view.[12]

Fig. 3: Checking the implants before taking the impression. The soft tissue is stable.

Depending on the preparation technique used and the implant design available, immediate implant placement can achieve sufficient primary stability for transgingival healing or even immediate restoration, even in bone of reduced quality. For immediate restoration to be possible in the partially edentulous jaw, it must be ensured that laterotrusive contacts cannot occur. Particularly after periodontally caused tooth movements or in patients with congenital anomalies of the teeth or jaw, occlusion-related risks cannot always be avoided, and implant loss is imminent.[9] However, to limit the cost of the treatment, early loading might be performed after six weeks, so that immediate restoration is not initially a necessity.

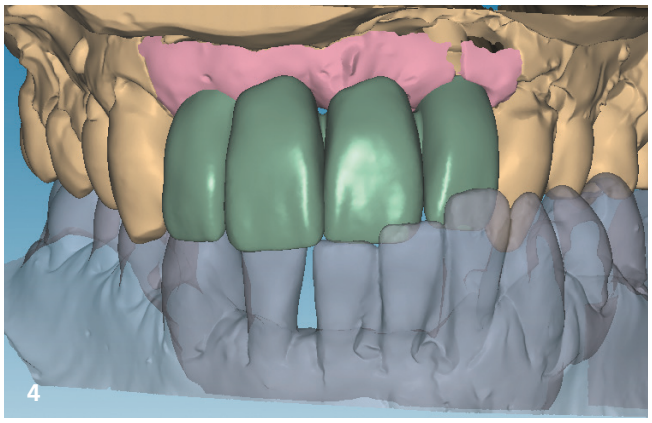
Prosthetic treatment with bite alterations

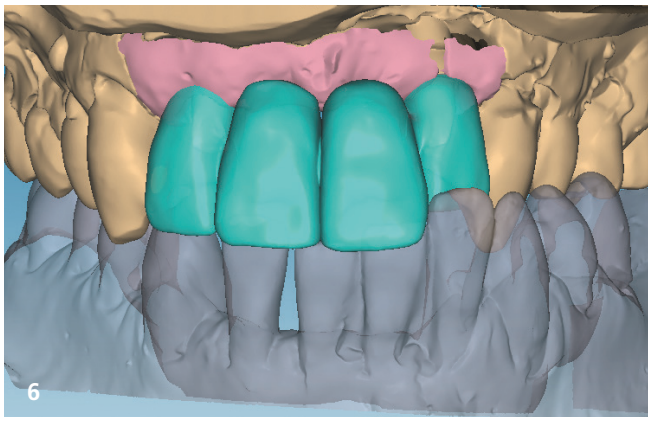
A provisional or initial prosthetic restoration will usually be based on the existing occlusal and positional findings in terms of restoring the original situation.

But in the case of a complete rehabilitation, patients often express their desire for an "ideal" restoration—normally easily achieved by standard methods. However, if there are abnormal findings in the partially edentulous jaw, such as a unilateral anterior crossbite or palatal positioning of individual teeth, the patient's request to compensate for this and to provide a more ideal physiological situation is understandable. This may well imply a protracted period of adaptation, since older patients in particular will have adapted to their malocclusion for decades. A mock-up would appear necessary here to simulate the desired result, so that the patient's aesthetic and functional acceptance can be ensured.[5] Also, the mock-up allows the dental technician to investigate the feasibility of the desired outcome and the required abutment design.[15]

Digital technology and its advantages

Compared to conventional wax-ups, CAD/CAM technology offers significant advantages in that the positions of the crowns can be easily modified onscreen.[13] This makes it possible to design multiple variants, which are first shown to the patient in the form of images. In this first step,





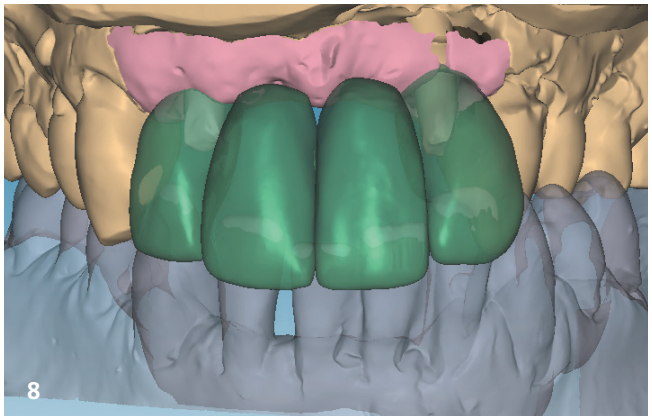
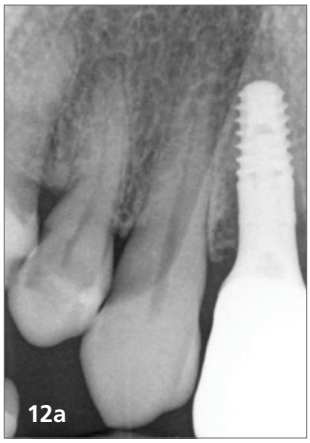


Fig. 4: Designing the mock-up of the anterior incisors that had been extracted. **Fig. 5:** Mock-up with overlay of tooth 22 only (exocad, exocad). **Fig. 6:** Mock-up with overlay of all anterior crowns. **Fig. 7:** Try-in of the mock-up (breCAM.multiCOM, bredent) of the anterior incisors. **Fig. 8:** Try-in of the mock-up with tooth 22 in crossbite. **Fig. 9:** Try-in of the mock-up with overjet of 21 and 22.

the desired result can be simulated with little effort. If this form of visualisation is not enough for the patient to form an opinion, the design can be implemented next as a resin temporary or mock-up, still at low cost. These can then be used for a try-in. In this manner, the patient can envision the potential prosthetic outcome, which is particularly important in the aesthetic zone. Mock-ups can also be used to assess speech function and the influence of changes in tooth position on extraoral physiognomy and, especially, on lip closure.

Particularly when restoring anterior edentulous spaces, the mock-up can be anchored to neighbouring teeth with so-called "onlay shells" to check the speech function; depending on the positions of the adjacent teeth, they can also be designed as veneers or tabletops in the definitive restoration. Since these CAD/CAM mock-ups do not cover the palate the way a wax-up typically does, phonetic limitations can be recognised early and corrected accordingly.[15] This makes it easy to functionally verify the intended prosthetic outcome.

Once the optimal design has been agreed on, its data can be used for sub-



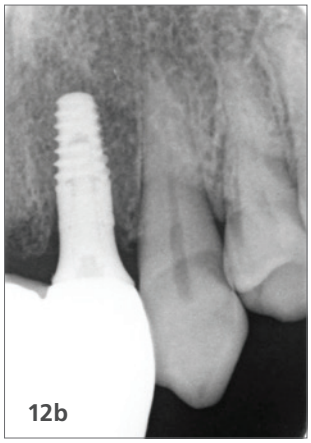


Fig. 10: Try-in of the custom CAD/CAM abutments. **Fig. 11:** Inserted fixed partial denture with customised gingival profile. **Figs. 12a & b:** Control radiograph after insertion of the fixed partial denture made of ZrO_2 ceramics. **Fig. 13:** Harmonious profile of the upper lip following the rehabilitation of the dental arch with an implant-supported fixed partial denture.

sequent design steps. Not until this point will the cost-intensive individual abutments be fabricated. For the final reconstruction, a CAD/CAM temporary made of acrylic resin is again recommended, since it is easy to adjust, and the patient can start adapting to the new bite position. Any occlusal adjustments are easily performed, and any palatal obstacles to proper phonetic articulation can be resolved by adding or removing acrylic resin.

If the patient is satisfied with the restoration after a break-in phase of several weeks, the clinically optimised temporary restoration is again scanned intraorally to obtain the data set that is superimposed on the design data by the dental technician for the final superstructure. There is a wide choice of materials for the framework or monolithic superstructure.

Since clinical crowns sometimes end up being quite long in patients with vertical attachment loss, the crown length can be visually adjusted by applying gingiva-coloured veneering material. The various shades require individual adjustment in close coordination with the dental technician and the patient.

Discussion

Patient-specific treatment planning in the surgical and prosthetic phases makes it possible to meet patients' expectations as closely as possible. In addition to considering the ideal timing of tooth extraction and implant placement, it must be decided whether to opt, in the osseointegration phase, for a complex (immediate) prosthetic restoration or whether the desired result can be achieved with a simple temporary thermoforming sheet in which the missing teeth are filled with acrylic.[6]

Three-dimensional diagnostics now allow an accurate assessment of the available bone supply, so that the extent of any bone augmentation can be determined in advance, escaping the need for major soft-tissue mobilisation.[19]

The prosthetic treatment in particular has been significantly simplified by CAD/CAM. Mock-ups are fabricated as monolithic items and can be used for a near natural simulation of the final result *in situ*.[12] Unlike a wax-up with its irritating palatal plate, the mock-up also permits a reliable

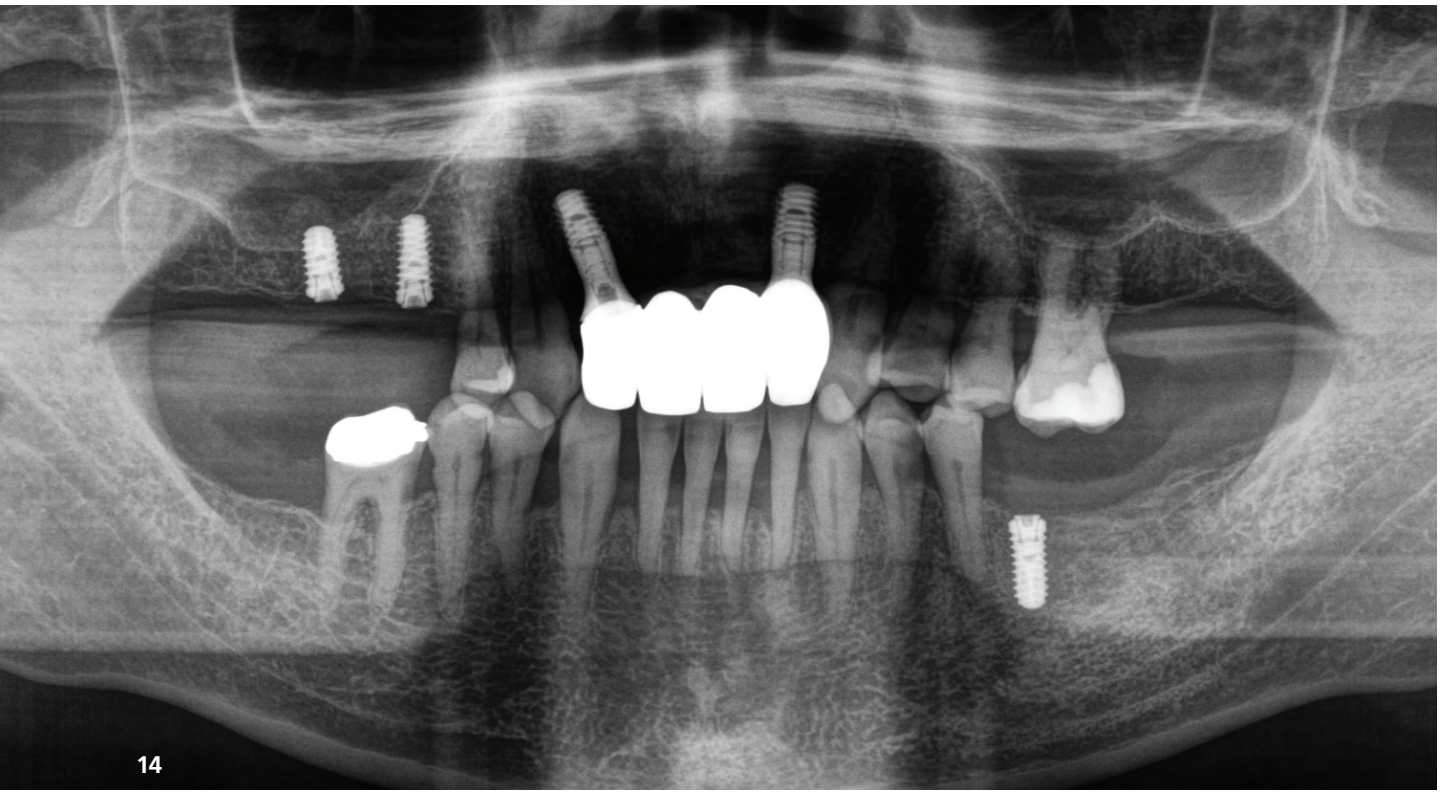


Fig. 14: Panoramic radiograph. Control 3 years after prosthetic restoration, Stable periodontal findings. Further implants have been placed in the posterior region.

assessment of the expected effect on speech function. Once the final design has been defined, it can be used on the basis of the data used for mock-up fabrication.

CAD/ CAM technology also allows the cost-effective fabrication of additional temporary restorations, permitting additional patient adaptation phases, which is particularly valuable after extensive occlusal changes. The more intensely the patient participates in selecting options as part of the treatment process, the greater will be his or her subjective acceptance of the overall outcome.[2] Especially when it comes to more elaborate prosthetic restorations, CAD/CAM simplifies the workflow, for more effective treatment routines and maximum patient satisfaction.[10]

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Literature

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