THE FUNCTIONAL-ESTHETIC COMPLEX: CONSIDERATIONS BASED ON CLINICAL CASES

Stefan Schunke[1]

Is it at all possible to separate function from esthetics? These days the trend seems to be to present oral rehabilitations that are highly complex and supported by various implants or that exhibit esthetics that would turn even Mother Nature green with envy. In this article, I would like to remind the reader of what we originally set out to do—to provide replacements for missing or damaged teeth. Ultimately, we fabricate our dental restorations—tooth replacements—to allow dentists to properly treat their patients. This article will present a number of topics related to the functional-esthetic complex. The question of tooth shade will not be discussed here, as it is too prone to subjective perception.

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MATERIALS

The question of what materials to use can be a highly polarizing one. We may be shown ceramic crowns abrading natural tooth substance, citing the excessive hardness of ceramics—without ever mentioning the functional aspects of the case. Other authors show images of severely abraded teeth restored with gold inlays without exhibiting any adapted gold occlusal surfaces (Figs 1 and 2).

Whether a functional restoration should be executed in gold or whether using ceramics is preferable continues to be a subject of hot debate. Not infrequently, one hears that gold is the better of the two materials because it adapts more easily and exhibits superior abrasion behavior when compared to ceramics. But is that really the case? In my opinion, such a comparison is misleading. As far as I know, there has been no study on abrasion and gold occlusal surfaces. The abrasion behavior of ceramics, by contrast, has been sufficiently examined in the literature. (And of course we cannot compare the ceramics we have at our disposal

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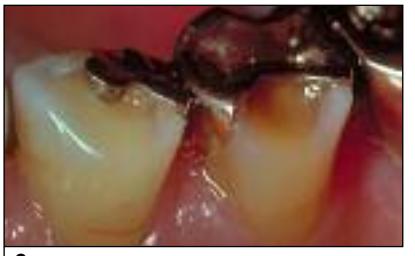

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Figs 1 and 2 When comparing ceramics and gold, it is not just the material and its technology that counts. Functional aspects, especially of the more recent materials, also play a role.

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Fig 3 Today's materials permit esthetic and functional ceramic onlays using the adhesive technique. Dentist: A. Enssle.

Figs 4 to 6 Any material can be used to create the correct morphology.

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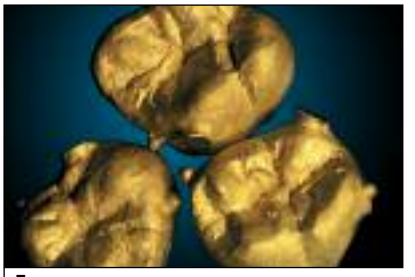

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today with the materials we worked with in the 1960s and 1970s.)

So if gold, as has been claimed, is abrasive, it should exhibit a rough surface, but, contrarily, functional anomalies manifest themselves intraorally as areas of high luster. Metals only exhibit high luster if they have been highly compressed, as in polishing, so high-luster areas simply consist of what would have to be considered cold-formed metal. That in turn means that a lot of tension will have built in the metal, tension that will be relieved in the form of natural enamel cracks or chipping, depending on the shape of the crown. This is one of the reasons why onlays were promoted in the first place.

Preparation shapes, on the other hand, became ever more daring as dentists increasingly strove to respond to patients' demands for better esthetics. The advent of adhesive techniques helped alleviate the ensuing problems (Fig 3).

Consider a natural mandibular first molar with a parafunction at the distolingual cusp. Now let us assume that this parafunction is very pronounced, causing the cusp to fracture. Let us further assume that we restore the tooth with a ceramic crown without changing the situation itself. What we get then is, of course, exactly the same situation as before, only in ceramics, and the ceramic cusp is ultimately bound to fracture as well. Assuming we had restored the same situation with a gold crown, while there will be no fracture of that gold crown, the parafunction will persist but manifest itself elsewhere—in the periodontal tissues, the bone, the orofacial muscles, the temporomandibular joint, or even more remote parts of the body. Not a good prospect, either.

Figs 7 and 8 Ceramic inlays and a metal-ceramic crown (material: Inspiration, Heimerle + Meule). Dentist: A. Kreisl.

Figs 9 and 10 Ceramic inlay, ceramic onlay, and two all-ceramic molars (material: Inspiration, Heimerle + Meule, and Procera Alumina, Nobel Biocare). Dentist: A. Enssle.

Figs 11 to 13 Ceramic onlay and two all-ceramic molars (material: Inspiration, Heimerle + Meule, and Zircon, Nobel Biocare). Dentist: A. Kreisl.


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It is therefore imperative for us to have intimate knowledge of the esthetic as well as functional aspects of the anatomic and morphologic structures and to be able to imitate them. This is not only true of metal occlusal surfaces, but also, and especially, of ceramic occlusal surfaces (Figs 4 to 6).

The question of what kind of ceramics is also answered in the literature, which likes to favor glass ceramics in this situation.[1–3] Glass ceramics exhibits the most favorable abrasion behavior. But due to the (in my opinion) esthetic disadvantages of pure glass ceramics, I currently prefer Inspiration (Heimerle + Meule, Pforzheim, Germany), a state-of-the-art two-phase leucite glass-ceramic material, for metal-ceramic restorations. The leucite is important for obtaining a beautiful esthetic result that is convincing not only on the master cast but also intraorally. Personal observation over a period of approximately 4 years has shown me that this ceramic material is in fact abraded by natural antagonists (Figs 7 to 13).

There is no longer any reason to say no to ceramic occlusal surfaces, whether from the point of view of material technology and science or of adhesion technology. Technicians who are less comfortable with ceramics may utilize the more recent pressable ceramics to achieve their goals, although with some esthetic compromises. Given the enormous variety of materials on the market today, the number of challenges is rising exponentially. Alumina and zirconia ceramics are trendy materials that none of us can afford to ignore entirely.

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Figs 14 and 15 In Angle Class I situations, the temporomandibular joint is moved away from the sensitive dorsal bilaminar zone during lateral excursions due to the anatomic position of the teeth and jaws. The teeth automatically afford protection for the joint.

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Figs 16 and 17 In Angle Class II, the temporomandibular joint is moved into the bilaminar zone during lateral excursions.

ANTERIOR/CANINE GUIDANCE

Many dental technicians, when discussing esthetics, will talk about beautiful anterior teeth, more beautiful than almost anything we ever see in nature. But while a beautiful appearance is one thing, function is another. Length-to-width ratios, gingival scalloping, and emergence profiles are the focus of attention, while the functional aspects of the anterior teeth are sometimes neglected. Let us therefore take a look at the definition and the effects of anterior/canine guidance.

In an Angle Class I situation, lateral movements are characterized as follows: The distal slope of the mandibular canine moves along the mesial slope of the maxillary canine. During the lateral movement, the temporomandibular joint is moved laterally and forward, away from the sensitive dorsal bilaminar zone. The teeth thus protect the temporomandibular joint during lateral excursions (Figs 14 and 15).

In an Angle Class II situation, by comparison, lateral movements are characterized as follows: It is the *mesial* slope of the mandibular canine that moves past the *distal* slope of the maxillary canine, based on the canine guidance that starts further distally. Consequently, the lateral movement guides the temporomandibular joint further into the dorsal cranial region, ie, *into* the sensitive bilaminar zone[4] (Figs 16 and 17).


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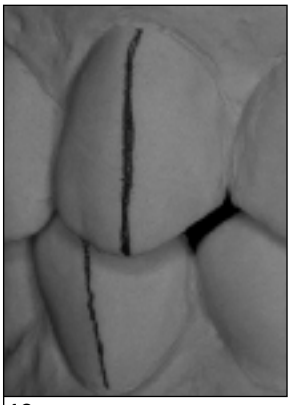
Fig 18 In a distally oriented bite, the canine tip is positioned for functional reasons.

Figs 19 to 23 If the canine guidance is distalized, this will invariably result in a mandibular ledge between the canine and the first premolar.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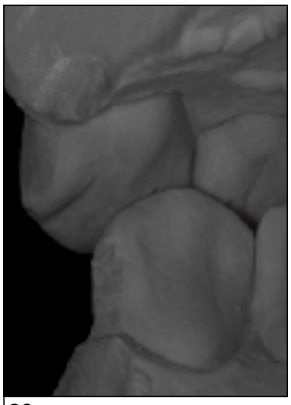
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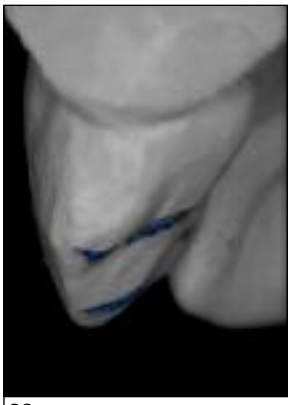
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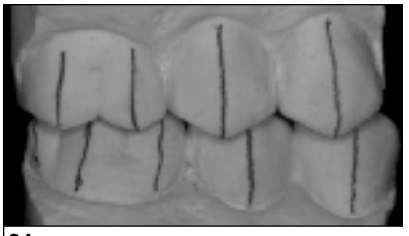
Various problems and options ensue. Esthetically speaking, the Class II situation mandates a different position of the canine tip, which, compared to Angle Class I, should be located further mesially. This mesialization of the maxillary canine tip in turn lengthens the distal slope. Therefore, if anterior teeth are designed following esthetic and functional principles, the overall result will be harmonious only if these details are taken into account (Fig 18).

Normally, then, canine guidance serves to protect the joint. If the canines cannot provide this protection, the posterior teeth will have to perform this task, as will be shown below.

Other functional considerations also ensue. In an Angle Class I situation, the mandibular canine is positioned to the mesial of the maxillary canine. Due to the conical shape of the maxillary canine, the canine guidance will be relatively steep and long. In an Angle Class II situation, the starting point (actually the ending point, since the movement is intrusive in nature) is located further distally and cranially. The starting point is located behind a cone, making the canine guidance shallower and shorter than in Angle Class I. This is why these dentitions typically feature a ledge between the mandibular canine and the mandibular first premolar (Figs 19 to 23).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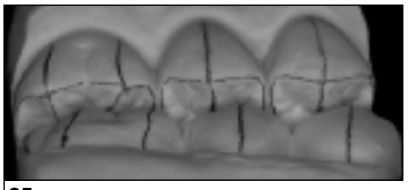
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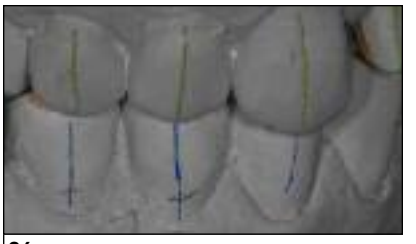
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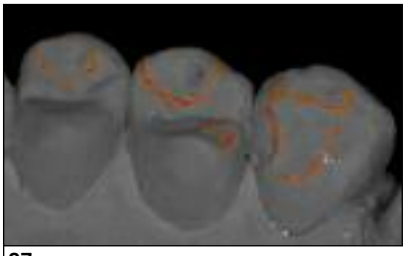
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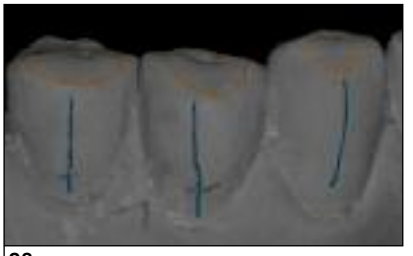
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Figs 24 to 28 Different occlusal relationships result from different Angle classes.


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Figs 29 to 34 Differences in canine guidance steepness and intercuspation based on the anatomy of the teeth and their positions in the jaw. Dentist: A. Kreisl.

The problem discussed also affects the posterior teeth. A healthy occlusion will typically show a cusp-fossa relationship or a cusp-ridge relationship, as is normally found in Angle Class I or in a distalized neutral occlusion. But in a distalized occlusion, depending on how pronounced the distalization, we may find a tooth-tooth relationship, permitting only "abrasion teeth" instead of a cusp-fossa relationship (Figs 24 to 28).

These characteristics vary between patients and should be examined on a case-by-case basis (Figs 29 to 34).

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Figs 35 to 37 The immediate side shift requires sufficient space by providing "backpacks" in the correctly designed occlusal morphology.

THE BIOMECHANICAL CONCEPT ACCORDING TO POLZ

Many and very different concepts of function are being propagated today. Dentists have the luxury of being able to concentrate on a single system to guide all their treatment efforts. Dental technicians, on the other hand, are faced with having to deal with different dentists favoring different concepts—or no concept. In any case, dentists expect the finished restoration to create no problems, whether at the time of insertion or later. This is where the biomechanical concept according to Master Dental Technician M. H. Polz comes into play.

A frequently discussed aspect is the number of contacts to provide. The literature clearly indicates an average of 3.9 contacts per tooth.[5,6] Too many occlusal stops restrict movement, especially in the molar region, which is strongly influenced by the temporomandibular joint. This is demonstrated below on the basis of two directed movements.

One of these movements is the immediate side shift (ISS). The question has been raised whether this movement exists at all, but it has been demonstrated in various publications.[7–10] Whether it is physiological or pathological in nature is a question that must be answered by scientific research. The following two options exist in clinical practice: either the dentist believes that this movement should be disregarded because it does not exist or the dentist believes it to be pathological, taking the requisite precautions to avoid this movement. But not infrequently the dental technician will simply be confronted with the task and will have to resolve it somehow, without any additional information. The movement as such is defined as the temporomandibular joint first moving medially (inward) on the mediotrusive (nonworking) side during lateral excursions before performing the remainder of the usual mediotrusive movement. Imagining this movement and its effect on the temporomandibular joint and the molars in the frontal view illustrates the problem.

If the joint really performs this type of movement, the classical gnathological waxup scheme will soon reach its limits. Even the early gnathologists knew about this problem, and since they could not compensate for it in their waxup concept, they accommodated it with an elaborate articulation technique.[11,12]

So what do we do if we do not have the requisite information? M. H. Polz, being a keen observer of nature, was the first one to describe the morphologic structures as resembling "backpacks."[13–15] Occlusal stops would be placed on these backpacks, creating space for the respective movements. For the ISS, this would mean that the mandibular first molar has a prepended occlusal element (the backpack) on its middle (distobuccal) cusp. And it is just this backpack that is contacted by the mesiopalatal cusp of the maxillary first molar. This provides the necessary space for the excursion in the occlusal vicinity (Figs 35 to 37).

Another very important direction of movement is called laterotrusion. This term implies that the jaw

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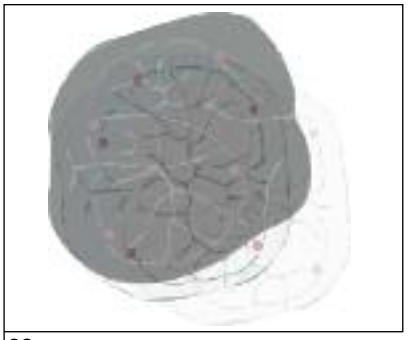
Figs 38 to 40 Laterotrusion can create facets that protect the temporomandibular joint from sliding further into the bilaminar zone.

Fig 41 The occlusal compass is an abstract pattern of movement that can be superimposed on a tooth or on any individual contact.

Figs 42 and 43 In the biomechanical concept, occlusal stops can be arranged nearly within a single plane. This means more rapid decoupling and easier occlusal adjustment.



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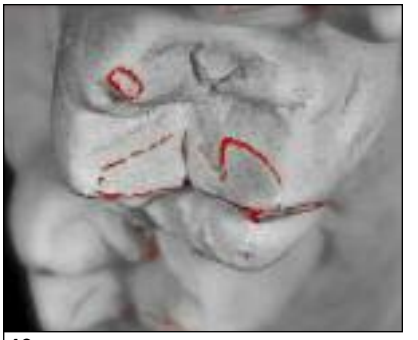

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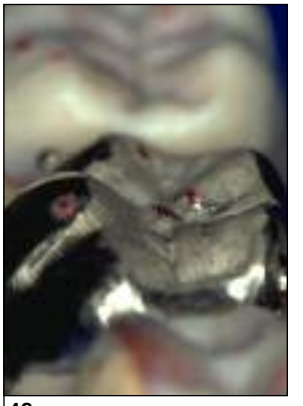

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moves backward and upward during lateral excursions. In the horizontal plane, it can be seen that the distobuccal cusp of the mandibular first molar moves toward the distobuccal cusp of the maxillary first molar. Because this movement is three-dimensional and has a cranial aspect, wear facets are frequently the result—now often viewed as protective facets in the literature in that the cusp ensures that the temporomandibular joint does not slide even further into the dorsocranial region (Figs 38 to 40).[16–19]

In an Angle Class II situation, or in similarly structured anomalies, the posterior teeth thus serve to protect the temporomandibular joint. The "occlusal compass" is nothing but a representation of the movements in the form of an abstract bar code of the respective cusps on the occlusal stops (Fig 41).

The backpacks allow the cusp-fossa relationships to remain relatively level in that all occlusal stops can be kept almost on the same plane. At the same time, not only does this concept result in an esthetic and natural morphologic appearance, but it also facilitates fast and complete disclusion. A stable centric relation and the necessary clearance in the immediate occlusal vicinity are additional advantages that neither occlusal records nor articulators can represent. To this day, there is practically no way to record the true movements as they occur directly on the tooth. For this, one would have to resort to a stereographic record (functionally generated pathway)[20,21] with all its benefits but also with its disadvantages (Figs 42 and 43).

Fig 44 The Candulor can be used to check the relationship between the occlusal planes and the cranium in a relatively quick and simple manner.

PLANES

Another aspect that is unfortunately frequently neglected is related to the various planes, of which the most important ones are defined as follows:

- *Occlusal plane:* A plane supported by the mandibular central incisors and the distobuccal cusps of the mandibular second molars.
- *Occlusal line:* The sagittal curvature of the dentition relative to the masticatory plane, ie, the anatomical curve formed by the teeth, called the curve of Spee (named after Ferdinand Spee, who described this curve in 1890). Behind the mandibular canine tip, this curve drops down slightly, turning to horizontal in the region of the first molars and ascending in their region of the second molars.[22,23]
- *Esthetic plane*[24] ("glass-plate plane"): If we visualize the occlusal plane as a glass plate on which we place the maxilla, ideally the teeth will be in contact as follows: central incisors, yes; lateral incisors, no (lateroprotrusion); canines, yes; first premolars, yes (buccally); second premolars, yes (buccally and palatal); first molars, yes (mesiopalatally); second molars, no.

The occlusal plane and the so-called occlusal line are important because they are responsible for correct disclusion and for the correct transfer of forces to the entire cranium and the body as a whole.[25]

How can we ensure that the occlusal plane can be checked immediately and integrated directly into our procedures? Probably the simplest method is the use of the Candulor bite fork (Candulor AG, Rielasingen/Worblingen, Germany) When fitted to the patient, as shown for the maxilla in Fig 44, it serves to check the so-called esthetic plane, which must be in harmony with the occlusal plane. The esthetic plane should run parallel to the bipupillary line. As Fig 44 clearly shows, this is not the case for the patient depicted. The issue is whether this is an anatomic problem or a challenge that needs to be resolved prosthodontically. Looking at the patient's smile, additional serious visual deficiencies become apparent. They are best resolved by using provisional therapeutic restorations, allowing the patient to become accustomed to her new appearance, phonetics, and function. The definitive restoration would then simply implement the result in ceramics and add the final touches (Figs 45 to 49).

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Figs 45 to 49 Planes are used for reference and can be finalized in temporal sequence, using therapeutic provisional restorations. Dentist: M. Schlee.

Figs 50 to 51 The Head Lines unit is ideally suited for analyzing the various planes. These two photographs show the same patient before and after comprehensive prosthetic restoration of both jaws. Dentists: S. and B. Vanderborght.

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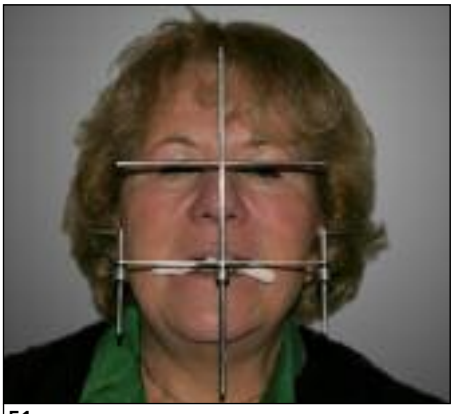

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The Head Lines unit[26] (**Au: Please provide manufacturer name and location)** may be used as an alternative to the Candulor bite fork. The underlying idea is the same as for the Candulor bite fork, but this unit additionally features a parallel indicator for the bipupillary line and two nanorough height-adjustable arms that, depending on the respective setting, can provide information about Camper's plane (Figs 50 and 51).

Correct arrangements of the planes can greatly enhance the patient's esthetic satisfaction.

CASE 1 (Figs 52 to 61)

Fig 52 Patient presents with implants in the maxillary right quadrant that are less than ideally placed.

Fig 53 [Author: Please provide individual figure legends for this case to describe the image. Some have been written by copyeditor when possible; please check these.]

Fig 54

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Fig 56 Maxillary arch immediately prior to definitive restoration.

Fig 57 Occlusal view of definitive restoraton.

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CASE 1

Complex cases require a broad arsenal of ideas and tools. The requirements are as diverse as the solutions to be provided, which must be found and provided individually for each patient.

Special difficulties arise if there are various problems in one patient that must be resolved with different types of restorations. This patient presented with implants in the right quadrant that had been provided elsewhere. While they had been inserted according to the treatment plan, the plan itself was deficient. The problems were so complex that the patient required a complete oral rehabilitation. She had been promised that the prosthetic work would involve only her right quadrants; understandably, she was not very happy at the end of the first consultation. Treatment planning was adjusted to provide for the rehabilitation of the maxilla first, postponing the mandible for the time being and thus distributing the financial burden. The implant system used (right quadrant) did not leave much room for either an attractive emergence profile or for gingival grafts to achieve better soft tissue harmony. Ultimately, it was necessary to resort to a combination of an implant-supported fixed partial denture, veneers, metal-ceramic crowns supported by natural teeth and by implants, and ceramic onlays. For esthetic reasons, zirconia abutments were used on the two anterior implants (Figs 52 to 60).

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Figs 58 to 60 Extraoral views of definitive restoration.

Fig 61 At baseline (*left)* the patient's left eye is located above the Head Lines plane. This is not the case after the rehabilitation *(right).*
Dentists: S. and B. Vanderborght.

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A comparison of the baseline planes with the planes after rehabilitation showed important differences in the details. At baseline, the patient's left eye was located above the Head Lines plane (Fig 61). The positions of the lateral arms were nearly perfect. This is an excellent way, and really the only way, to check the completed prosthesis on the articulator and, of course, directly on the patient.

CASE 2 (Figs 62 to 81)


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Fig 62 Preoperative smile. **[Au: Please check these legends; they have been rewritten to describe individual images.]**

Figs 63 and 64 A waxup was produced, and a thermoformed film was used to create a mockup to help the patient and treatment provider visualize the future restoration.

Fig 65 to 67 Planes, intercuspation, and guidance, as well as esthetic aspects were taken into account.

Figs 68 to 71 The mandibular canines received only small incisals "chips," while the maxillary canines received circular veneers, both with the intention to provide guidance.


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CASE 2

This patient also required a complex rehabilitation. A plastic mockup was created for the patient and the treatment provider to get a first overall impression. The treatment plan provided for a combination of veneers, ceramic onlays, and metal-ceramic crowns, supported in part by natural teeth and in part by implants. The mandible was restored first. Of course, the planes were continuously checked both during and after the placement of the restoration. The maxilla was essentially restored in the same manner. The completed restorations were inserted and cemented (Figs 62 to 75).

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Figs 72 to 75 The patient was extremely satisfied with the result. Dentist: A. Kreisl.

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For better functional control, new impressions were taken and new casts produced. These, too, were mounted arbitrarily in an articulator, so that the overall function including laterotrusions could be checked. As a segmented cast was also provided, it was possible to remove the teeth individ-

Figs 76 to 81 [Au: Is this same patient as Case 2?] A more detailed functional check can be performed on the articulators using casts of the intraoral situation. Segmented teeth can be removed individually on the laterotrusive side, thus investigating the guidance offered by the next tooth in line, avoiding disturbances to the nonworking side. Dentist: A. Kreisl.


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ually for even more control over functional details. The result illustrates the principle of sequential laterotrusion with canine dominance.[27–30] Canine dominance means that removing the canine results in guidance by the maxillary first premolar and, possibly, the maxillary lateral incisor; if these are removed, guidance is provided by the maxillary second premolar; and if this, too, is removed, by the maxillary first molar. None of this may disturb the occlusal balance on the nonworking side. In a eugnathic natural dentition, this would mean that the maxillary canine is abraded first, then the first and second premolars, and, finally, the first molar. The principle of the distributed planes had already been taken account of by the dental technician when designing the restorations. Considering how difficult it is to adhesively cement veneers and ceramic onlays in a satisfactory manner, the challenge involved in inserting such restorations becomes obvious (Figs 76 to 81).


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Figs 82 to 87 If the patient wants "white" teeth, with no characterizations or individual shades, that is what the patient will get. Planes and positional aspects can still be correct. Personal preference on the part of the dental technician or treatment provider plays no role here. Dentist: J. Hajtó.

FUNCTION AND BRIGHT TEETH

Function and esthetics must never be treated separately. The contribution of shade is secondary. If the patient desires white teeth and does not want to see individual characterizations or complex shades, we have to comply while still providing excellent function. Patient cases may be complex in structure, mixing all-ceramic crowns, veneers, and metal-ceramic crowns while ensuring that no or next to no visual discrepancy appears (Figs 82 to 87).

Restorations supported by implants pose a different kind of challenge. Again, patients frequently request bright teeth. The dental technician will comply, but will certainly appreciate being able to provide shaded areas, natural positional textures, or similar enhancements (Figs 88 to 93).

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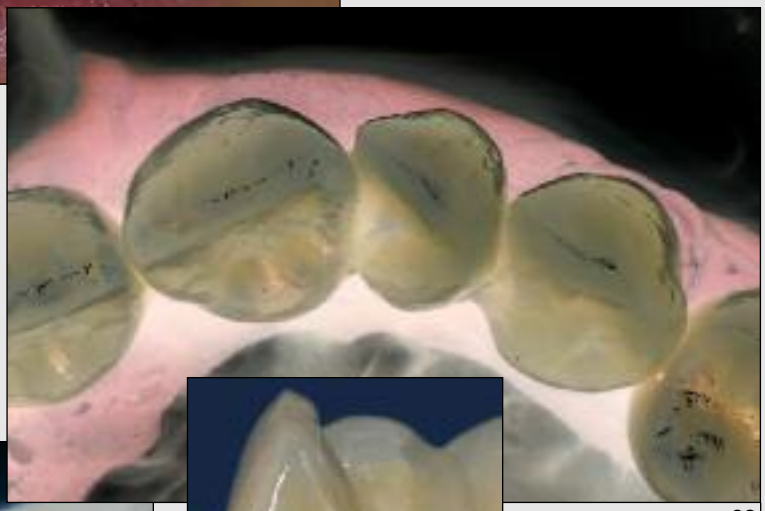

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Figs 88 to 94 Bright teeth with some individually shaded areas or textures can still give a harmonic impression despite an extremely "white" appearance. Dentists: S. and B. Vanderborght

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