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Modern optoelectronics and computer-assisted reconstruction and therapy

Electronic functional analysis Electronic functional therapy

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Introduction

The aim of every dental restoration is to reinstate the natural function of the gnathostomatic system within the functionally impaired or functionally treated masticatory organs. The following criteria must be fulfilled in order to achieve this goal:

☐ the origin of the movement must be precisely reproduced

- ☐ each individual mandibular movement must be registered accurately
- ☐ the actual movement process must be known
- ☐ the values obtained from the measurements must be reproducible on a device (simulator or articulator)
- ☐ the device (simulator or articulator) used must reproduce the movements as accurately as possible in all degrees of freedom
- ☐ a waxing up concept

(NAT/NFR) must be used with a system that allows for optimal reconstructive reproduction

Computer-assisted registration methods yield a wealth of information that to date has been used for diagnostic purposes (functional analysis) and only partially for therapeutic purposes (condylar path parameters).

Computer-assisted production of check records in the electronic positioner

Computer-assisted pantography

- ☐ provides clues about the nature of the functional impairment of the masticatory organ
- ☐ and thus evidence indicat-



Fig. 1 Electronic pantography of the patient

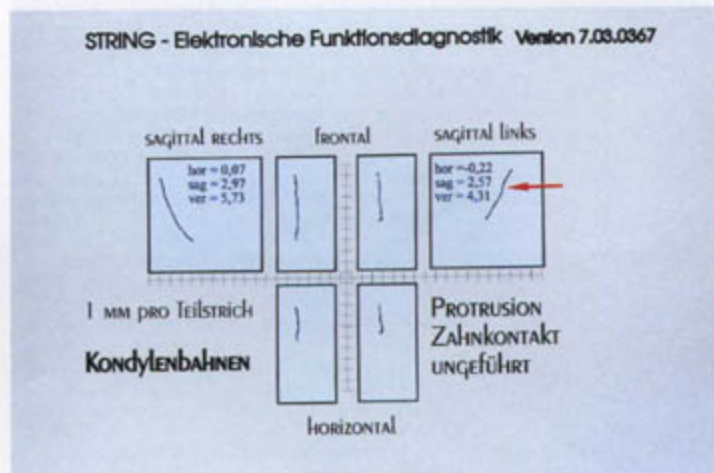


Fig. 2 Electronic registration of the mandibular movement



Fig. 3 Congruency between CAR and patient



Fig. 4 The CAR system equipped with measuring heads and reflectors

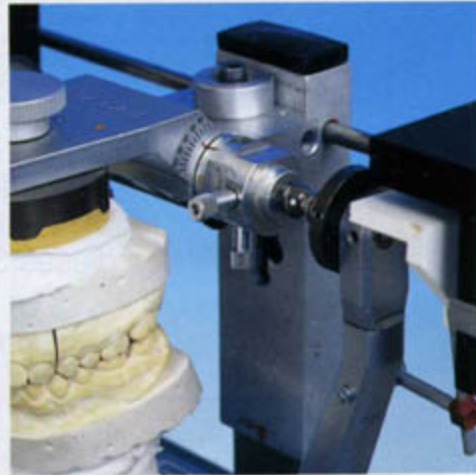


Fig. 5 Mechanical stages for condylar positioning on the CAR system

ing the direction and the extent of how the condyles need to be repositioned by splint treatment.

The precision of contact-free mechanical registration of movements over time and space is far superior to that of other diagnostic methods (imaging, X-ray, NMRI, clinical functional analysis).

The superiority of this method, previously only used in diagnostics, would suggest that it can also be used in therapy for condylar positioning in the

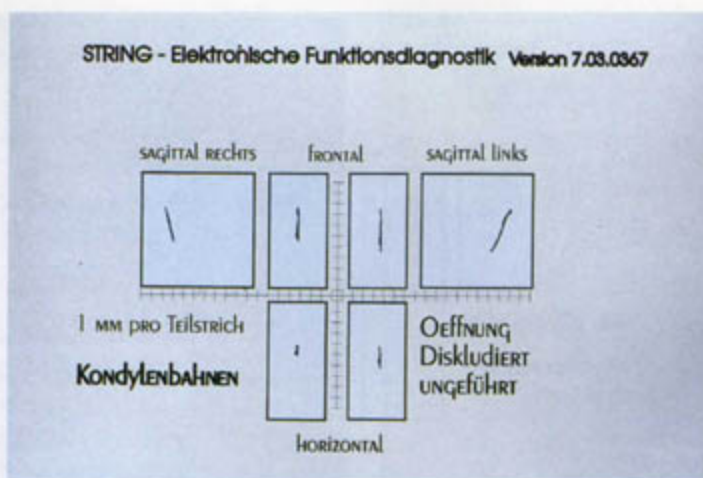


Fig. 6 Registration of limited movement

5. Each repositioning can be performed independently of the practitioner or of the muscular status of the patient.
6. The therapeutic results achieved by various practitioners can be correlated.
7. The bite does not have to be blocked while preparing the check record.

Instrumentational prerequisites

It is imperative that the mechanical adjustment of the

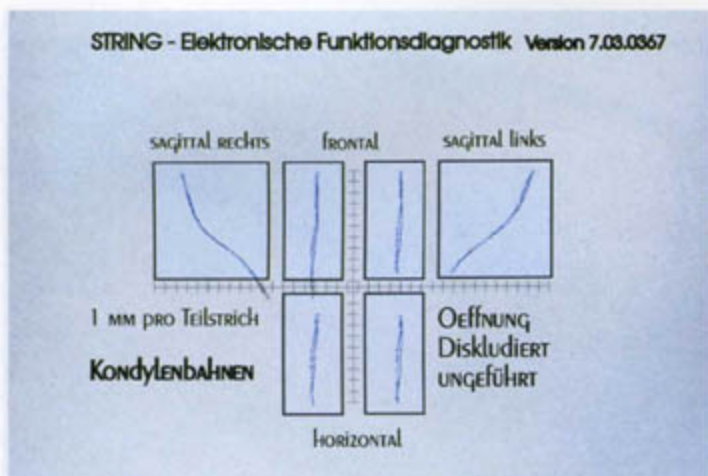


Fig. 7 Unlimited opening with pain on the left-hand side (Note the minor deviation between excursive and incursive movement)

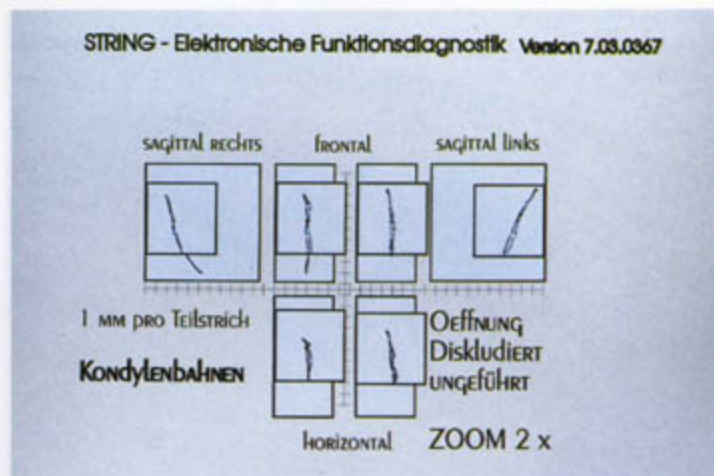


Fig. 8 Enlargement of the time lag upon protrusion with tooth contact

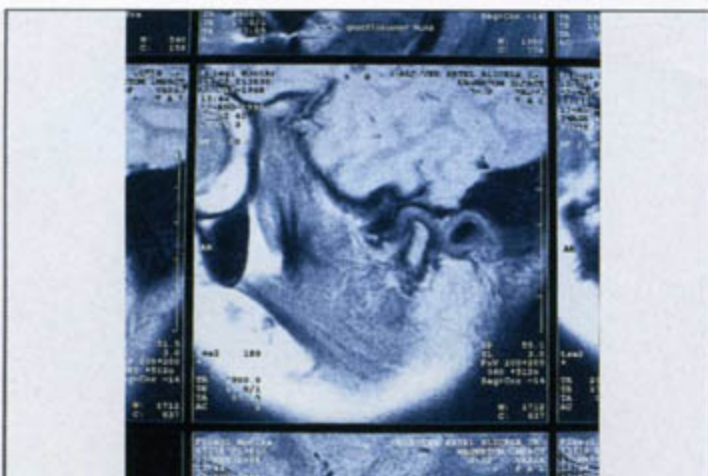


Fig. 9 Note the rostral pullout of the condyle



Fig. 10 Using the mechanical stages and a transversal adjustment option, we shift the mandibular cast against the maxillary cast ...

functionally impaired masticatory organ or to determine the extent and nature of the condylar movements during reconstruction. The check record for therapeutic condylar positioning is thus no longer prepared **intraorally**, but using an **analog position-**

er under computer guidance.

The advantages of the CAR method (computer-assisted registration):

1. The baseline position of the patient's condylar path is documented metrically.

2. Precise reference of the therapeutic condylar position in relation to the baseline position and thereby
3. The ability to accurately reposition based on the therapeutic outcome.
4. Targeted, but minor corrections enhance patient compli-

cast be completely identical to the patient's situation so that the condylar paths measured with the Condylcomp correspond to the movements of the mandible and to the mandibular cast.

Specifically:

- ☐ Transferal of the maxillary cast with reference to the sensors using a precisely drawn transfer bow
- ☐ Allocation of the mandibular cast with or without check record (intercuspatio position) (see photo)
- ☐ Correction of the measurements after axial determination

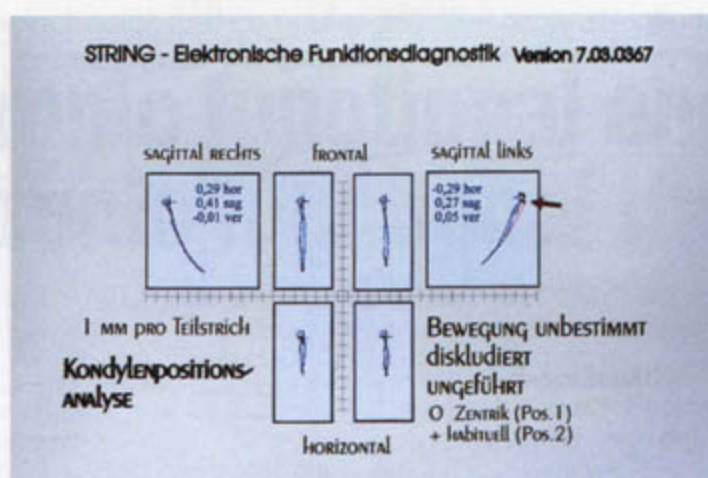


Fig. 11 ... in order to achieve the therapeutically fabricated position (red arrow)

were attached to the mandibular frame of the articulator so that they were also adjustable (authors' own modification).

Procedure

After transferal of the maxillary cast, the mandibular cast was articulated using a check record in median intercuspatio position. Under the program item condylar position analysis string CAR (Condylomcomp "computer assisted registration"), the condylar posi-

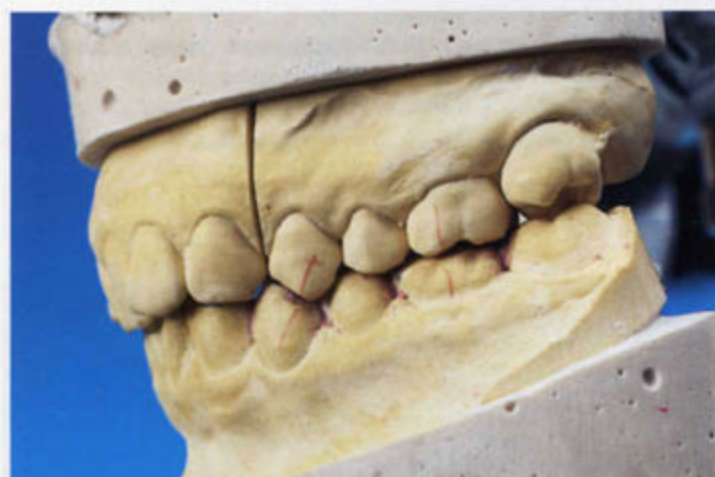


Fig. 12+13 By changing the cast position only slightly (starting position on the left, therapeutic position on the right), we achieve freedom from pain and unimpaired articular movement

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Artikulatorprogrammierung

KaVo EWL

Kondylarbahneinsatz
Camper'sche Ebene

Kondylarbahneinsatz
Frankfurter Horiz.

Bennetteinsatz

Frontzahn-
Führungsteller

	rechts	links
Kondylarbahneinsatz Camper'sche Ebene	26°	40°
Kondylarbahneinsatz Frankfurter Horiz.	41°	55°
Bennetteinsatz	ISS -0,4 Ben -2°	ISS -0,1 Ben 6°
Frontzahn- Führungsteller	17° Teller unten	

Fig. 14 Articulator programming for the KaVo Protar II based on the values measured in the Condylomcomp



Fig. 15 Articulated maxillary cast based on the jaw relations

Description of the device

The basic device used was the SAM articulator, version 3 with mechanical stages being used instead of condylar boxes. The mechanical stages al-

low for adjustments in the x/z direction. Positional changes in the horizontal direction are possible by transverse adjustment of the axis (authors' own modification), the articulator is hung and mounted in the frame of the Condylomcomp, thus enabling the movements

of the cast to be analogous to those of the patient. The sensors on the Condylomcomp are arranged analogously to the patient. We used a self-designed transfer bow for maxillary transfer in relation to the sensors. The reflectors were adjusted in the usual way and

tion of the intercuspatio position-coded cast appears as a cross. By adjusting the screws on the mechanical stages or the transversal screws, we positioned each "condyle" separately within the condylar path as well as outside of it. We manipulated this on



Fig. 16 Suretrans adjusted to the settings for horizontal and vertical movements and transversal settings



Fig. 17 Therapeutic check record on the patient

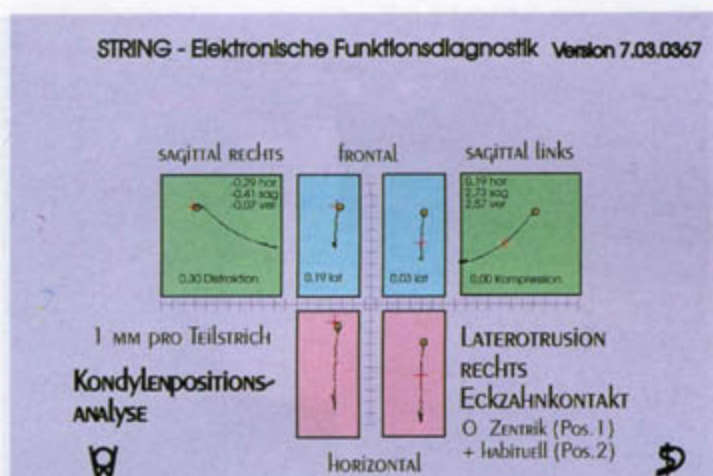


Fig. 18 Registration of the settings for waxing up (NFR), here for the right-hand working side



Fig. 19 Suretrans with angles pasted on the lower member of the articulator and extra-fine threaded screws for adjusting the retrusion/surtrusion

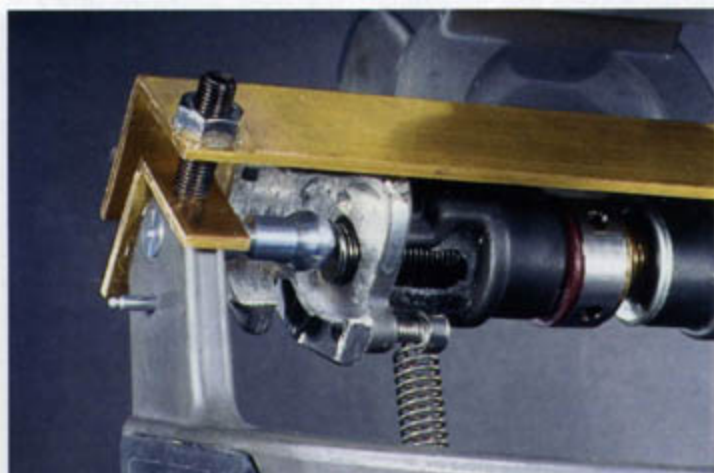


Fig. 20 Transversal adjustment of the Suretrans

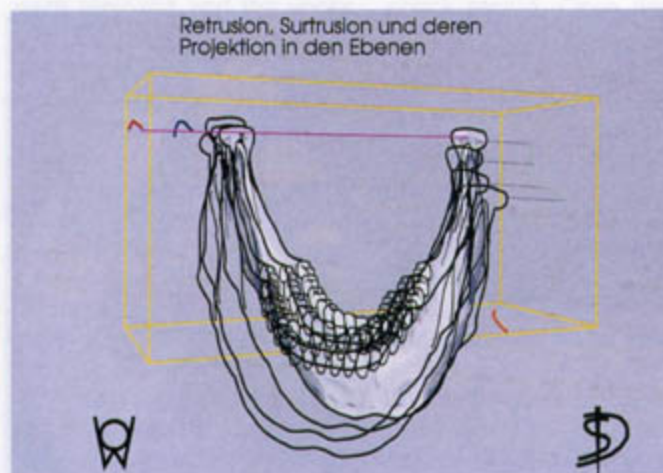


Fig. 21 Actual movement of the mandible with retrusion/surtrusion on the working side

screen by means of online measurements analogous to the patient. We fabricated the therapeutic cast on the unlocked casts in the desired position achieved upon completion of the adjustment procedure.

Clinical procedure

Case report: The patient presented with painful opening limitation on the left (incisal edge distance in mm). The woman's dental history was

taken, manual functional examination indicated that an anterior medial disc dislocation repositioning was involved, although there was no palpable or audible cracking, i.e. no evidence of total dislocation.

Neither did the computer image show the typical picture of a dislocation, but did reveal limited jaw opening movements which the patient reported to be painful. When the limitation of movement was exceeded, causing pain, a time lag in the movement was

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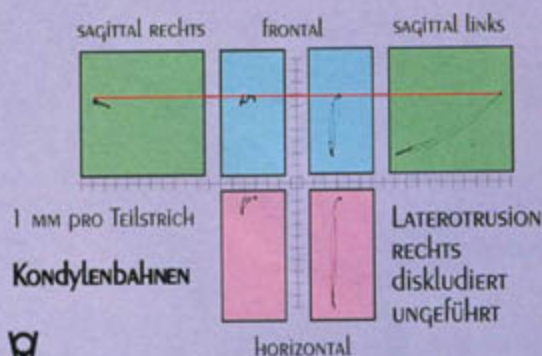


Fig. 22 Registered movements of the mandible with retrusion/surtrusion on the working side

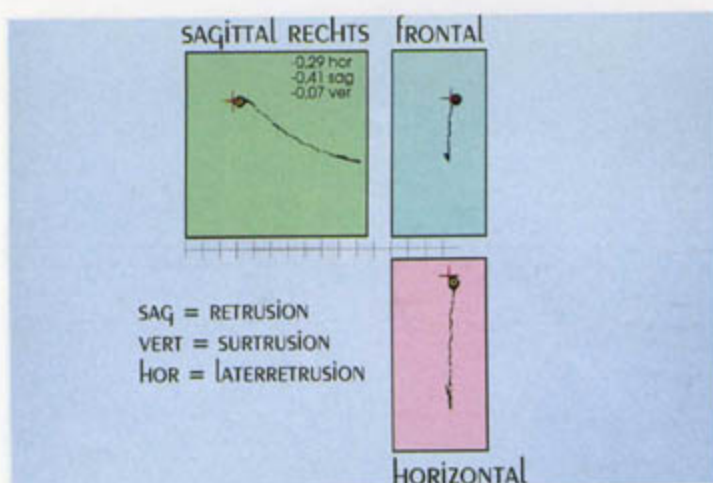


Fig. 24 Settings for waxing up (NFR), here an example of the right-hand working side



Fig. 26 After natural waxing up, the waxed reconstruction (D. Schulz)

measured at the same site. Manual techniques involving compression and translation produced no major shift in the metrically reproducible pain site.

NMR imaging confirmed the suspicion of a dislocation, but

also revealed a rostral osseous spur on the left condyle.

We now considered the following: If immersion of the rostral spur into the disc mass was responsible for the painful limitation and conse-

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Artikulatorprogrammierung UND NFR-WERTE

KAVO EWL	rechts	links
KONDYLARBAHNEINSATZ CAMPER'SCHE EBENE	26°	40°
KONDYLARBAHNEINSATZ FRANKFURTER HORIZ.	41°	55°
SAG = RETRUSION	0,41 mm	0,34 mm
VER = SURTRUSION	0,07 mm	0,16 mm
BENNETTEINSATZ	ISS -0,4 Ben -2°	ISS -0,1 Ben 6°
FRONTZAHN-FÜHRUNGSTELLER	17° Teller unten	

Fig. 23 List of techniques for programming the articulator with retrusion and surtrusion values

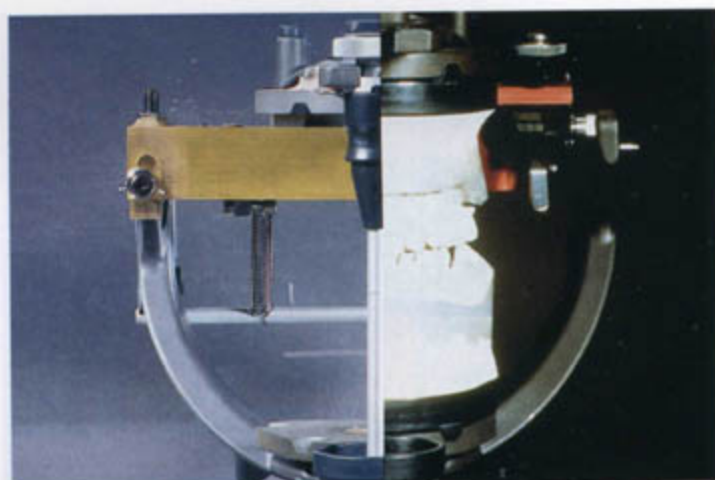


Fig. 25 The articulated casts can be used in both the Suretrans as well as the Protar II



Fig. 27 Inclusion of the occlusal abrasion pattern in the Suretrans

quently for displacement of the disc, then a condylar path to the caudal would have to enable premature rotation of the available condyle, thereby circumventing the painful immersion point. The fabricated caudal condylar path required a new baseline point, i.e. a

new condylar position, created on the EMPC device. For comparison, after a minimal change achieved by repositioning, the patient was free of pain after only one week of splint therapy as the incisal edge distance of 40 mm was within the normal range.



Fig. 28 + 29 Waxing up α the combined result of anatomical form and individual function

Reconstruction in the Suretrans SRT (Surtrusion/Retrusion/Translation)

Once the baseline point of the mandibular motion is reproduced, reconstruction can follow based on this point. This requires that the mandibular movements be reproduced as precisely as possible. After registration and calculation of the values for condylar inclination, Bennett angle, ISS and incisor guide plate, the casts in a fully adjustable articulator are transferred with reference to the joints and the articulator programmed accordingly.

Since an articulator becomes either very complicated or susceptible due to the additional possibilities for adjusting retrusion and surtrusion or it has no centric lock because of the diverse adjustment options, the idea occurred, to develop an auxiliary device that allows the registered values to be transferred for the technician and the dentist. This device, dubbed Suretrans, is calibrated to an articulator system and allows the casts to be transferred without having to rearticulate.

The advantages of Suretrans:

- ☐ The dentist and technician can keep working with their accustomed articulator.
- ☐ Waxing up is performed on

the articulator using the commonly practiced waxing-up technique

- ☐ The centric relation can always be recovered in the articulator
- ☐ Pure surtrusion and/or retrusion movements are possible
- ☐ The adjustments on the prototype presented here are possible up to a precision of 0.02 - 0.03 mm
- ☐ The device is only used for these movements
- ☐ The Suretrans can be calibrated to every articulator system
- ☐ For the first time, retrusion, surtrusion and proshift values calculated from the computer can be transferred for naturally and functionally appropriate reconstructions, whereby defined occlusal abrasion patterns can be integrated.

Instrumentational prerequisites

In order to be able to reproduce the retrusion/surtrusion and the proshift values in the Suretrans, it is important to determine a precise baseline position of the mandibular movement (therapeutic baseline position). Using a **therapeutic check record**, the mandibular cast is allocated in the articulator to the maxillary cast previously transferred according to the articular relationship. After the values

have been obtained from the path analysis in the Condylcomp, the movements can be reproduced after transferring the casts to the Suretrans.

Description of the device

The basic device used was the KaVo Protar II articulator. Its lower member, including the articulator adjustment, was left as it was and only supplemented by two right angles pasted next to the condylar balls. The condylar boxes were removed and the upper member of the articulator was modified in such a way that it was possible to adjust the upper member separately in the vertical or horizontal directions. The extra-fine threaded screws that were used rested on the right angle of the lower member of the articulator. Additionally, a transversal adjustment option of the entire upper member was incorporated for testing and control with an attached reflector bow. This will not be required in routine practice or for laboratory work since the mandible should be positioned under online computer guidance in the dentist's practice (CAR).

Procedure

First, the movements were registered in the Condylcomp. Then, the settings for

the KaVo Protar II were obtained using the "articulator programming" software function. Using the function "path analysis" or "condylar position analysis" based on a mediotrusive movement, the values for retrusion/surtrusion and, if applicable, for proshift were obtained and documented by retracing the movement on the working side. Subsequently, the occlusal plane was transferred in condylar relationship to the articulator using the transfer bow. After articulating the maxillary mode, the mandibular cast was adjusted using the therapeutic check record. Once this has been done, work can be performed on both the articulator as well as on the Suretrans. Now, waxing up can be carried out in the articulator according to the natural technique (NAT). Thereafter, the casts are placed in the Suretrans and the obtained values set for surtrusion/retrusion and, if applicable, for proshift.

For this purpose, the technician can use a graduated scale with which he can adjust the values for each side separately. The resulting relative movements between maxillary and mandibular casts produce a defined occlusal abrasion pattern through the wax removal. Completion of the work now continues in the articulator. After fabrication is complete, the final check is done

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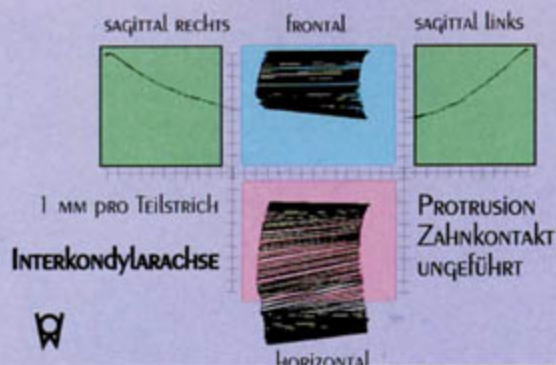


Fig. 30 to 32 Registration of the dentition-guided movements for checking the fabricated reconstruction

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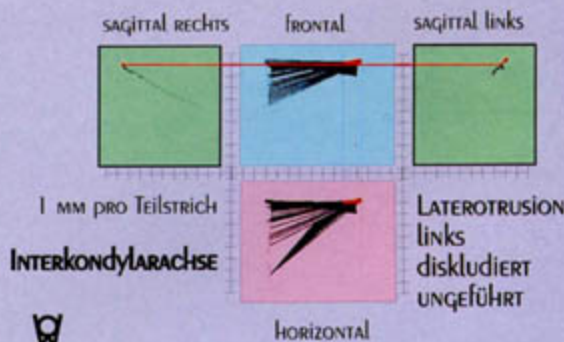


Fig. 31

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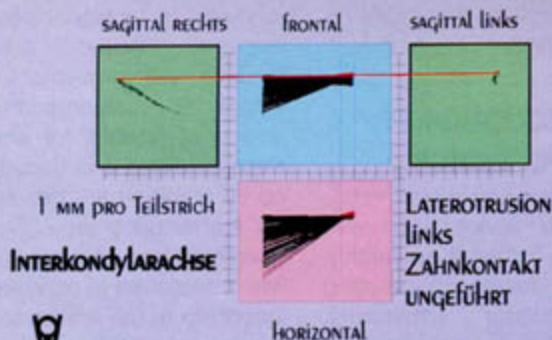


Fig. 32

in the Suretrans. As identifiable in the movement records, the values obtained with the Condylcomp can be reproduced with a very high accuracy. In our experiments, no interferences occurred in the dentition-guided movements.

We thereby hope that we have come one step further to translating the naturally and functionally oriented reconstruction into dental and laboratory routine.

Conclusion

Malpositioning caused by prosthetic work based on a poorly fabricated cast, taken intraorally, after postpreparation loss of supporting zones, represents one of the problems arising in functional therapy that should not be un-

derestimated, especially in a time when the demands are great and in which the slightest inducement is enough to parafunctionally activate the patient. Now, more than ever, it is highly imperative to render a precise diagnosis followed by the proper therapy before restoration is undertaken, and to as accurately as possible achieve good registration of the starting point of the movement and to rely exclusively on the data of the individual patient. The main focus of our attention should concentrate on the working side of the temporomandibular joint. The aim of this paper is to help contribute to developing more precise and accurate methods of preventing functional impairments, to identify and eliminate latent disorders and to correct obvious afflictions.

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