

Sleep disorders  
... dentistry?

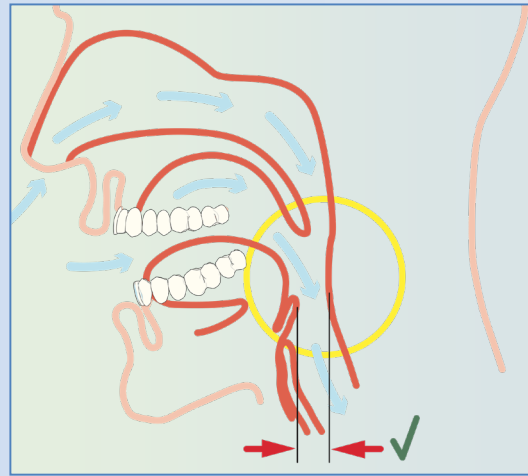


## Sleep disorders ... dentistry?

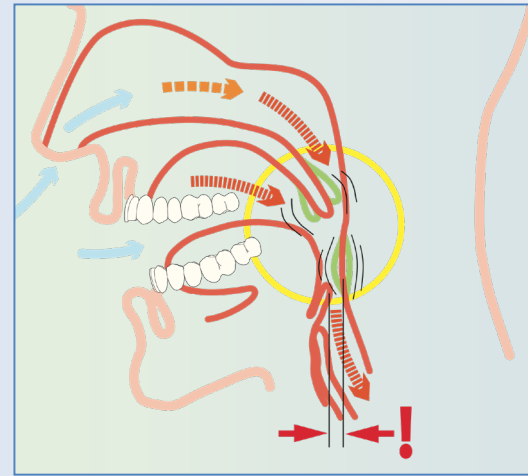
Snoring and the obstructive sleep apnea (OSA), the interruption of the respiration during the sleep, belong to the most common sleep disorders.

In western industrialized countries approx. 10 % of the 20 years old men and 50 % of the 50 years old men snore. Women come up to two third of these data.

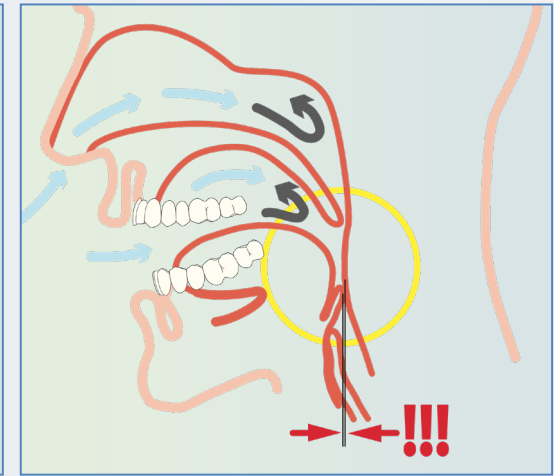
These sleep disorders can be successfully treated or at least be positively influenced in dentistry.



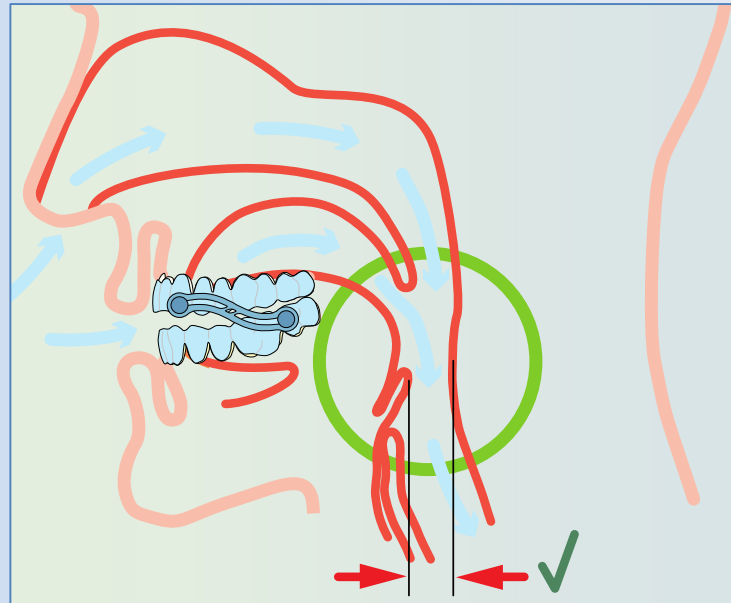
open respiratory tracts



narrowed respiratory tracts:  
snoring



collapsed respiratory tracts:  
obstructive sleep apnea (OSA)



open respiratory tracts: Silensor-sl,  
mandibular advancement splint



Some illustrations of this presentation originate from publications and advertising materials of different authors, manufacturers and distributors. These illustrations must not be used without permission.

## Topics of this lecture

1. Sleep disorders

2. Apnea during sleep

3. Therapy:

1. NCPAP (Nasal Continuous Positive Airways Pressure)

1. Surgery

2. Oral appliances

1. Tongue retainer

2. Protrusion splints (MAS, mandibular advancement splint) splints that advance the lower jaw



Silensor-sl

Terms on somnology:

primary snoring → light snoring

rhonchopathy → upper airway resistance syndrom (UARS) = obstructive snoring

Apnea → pauses in breathing

obstructive apnea → relocation of the upper respiratory tract

central apnea → stoppage of the respiration reflex

Hypopnea → air flow reduced by more than 50 %

AHI → apnea/hypopnea index

RDI → respiratory disturbance index = disorder of the respiration

arousal → reaction of awakening (no waking state)

somnography → examination of the sleep quality

SBAS → sleep-related breathing disorder





# Sleep disorders

## External sleep disorders

Disturbance of the sleep quality by external reasons, noise, bad bed, bad room air etc.

noise:



bed quality:



bruxism:



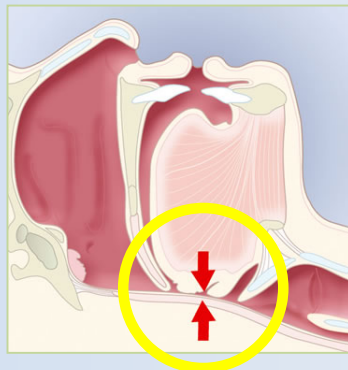
snoring and sleep position:



## Internal sleep disorders

Disturbance of the sleep quality by internal reasons, teeth grinding (bruxism), indigestive food, medicaments, drugs, snoring, sleep apnea, pain and other diseases.

sleep apnea:



rich meal:



drugs etc.:



... and other diseases



# Snoring

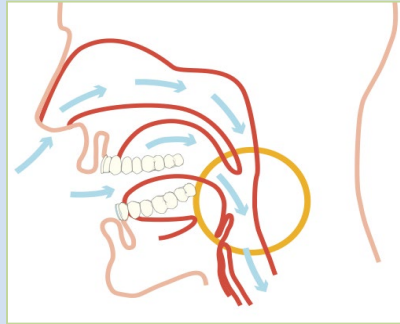
Snoring is generated in the upper respiratory tract.

By the decreasing of the muscle tone during sleep the lower jaw falls backwards.

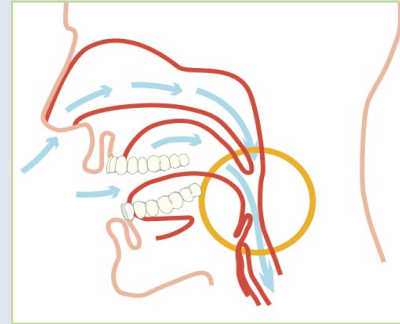
The result is a narrowing of the respiratory tract.

The air flow will be accelerated and soft tissue (velum, uvula and other) start to vibrate and cause the snoring noise.

open pharynx,  
no noise

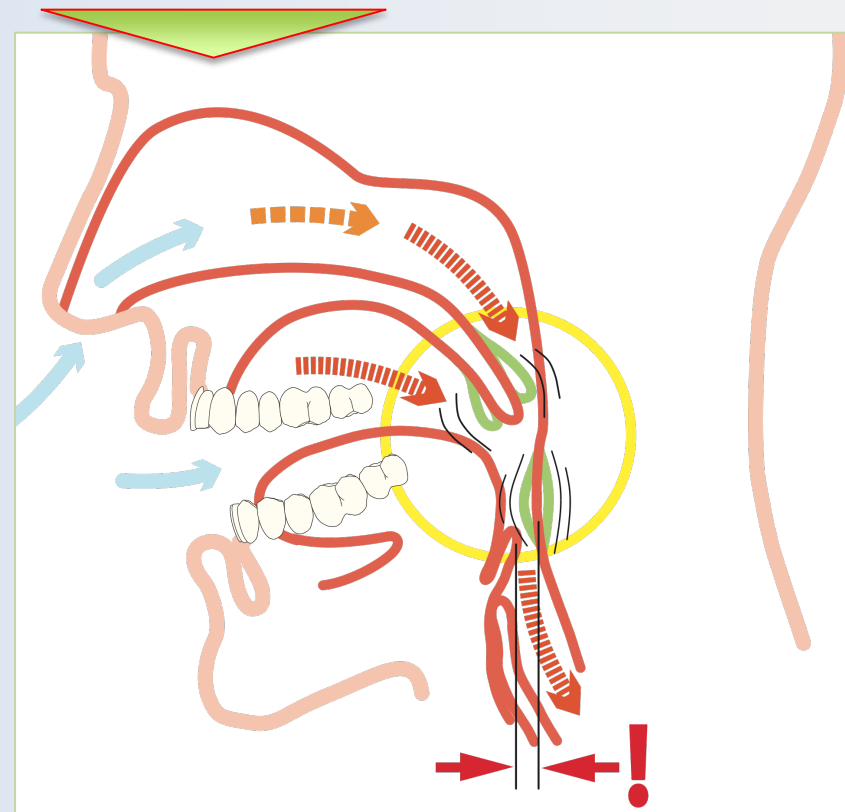


narrowed pharynx,  
accelerated air flow at the same air volume,  
noise caused by fluttering, vibrating structures



Snoring is a mechanical process that can be counteracted mechanically. This is where the dental therapy comes into action.

Contrary to the rhonchopathy, the abnormal snoring, the light or primary snoring does not have a negative influence on the cardiovascular system and the oxygen supply.



# Snoring

→ Abnormal snoring:

Rhonchopathy, obstructive snoring, snoring with airway resistance. Upper airway resistance syndrom (UARS)

→ Primary snoring:

Snoring harmless to health

abnormal snoring:		harmless, primary snoring:
frequency snoring every night	————	frequency snoring from time to time
loudness of snoring very loud, audible in the next room	————	loudness of snoring, moderately loud to loud, harmonious
sound explosive, hard, with high frequency, stertorous	————	sound low frequency
respiration irregular, possibly with pauses (breaks)	————	respiration regular, without pauses
sleep patterns restless sleep, frequent awakenings	————	sleep patterns quiet sleep

# Commercial offers against primary snoring

On the market there are numerous devices against snoring available.

In case of very light snoring a success might be achieved but some products are rather questionable.

These auxiliaries are available to anyone but cannot always be considered as being harmless.



Auxiliaries to avoid a dorsal position.



Nostril spreader, the reason for snoring, however, is mostly in the pharyngeal area.



Pillow Silensor (Canada), let the head tilt to the side.

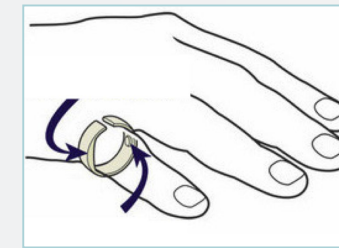
(This pillow is the reason why the Erkodent Silensor is called Silent Nite in North America.)



nose inserts for stimulation



acupressure ring



spray to „grease“ the mucosa



spray to stiffen the velum by foaming



## The apnea and hypopnea

The apnea is a complete respiratory stop. The obstructive apnea (OSA) is a mechanical relocation of the respiratory tract. In case of a central apnea the central respiration reflex stops.

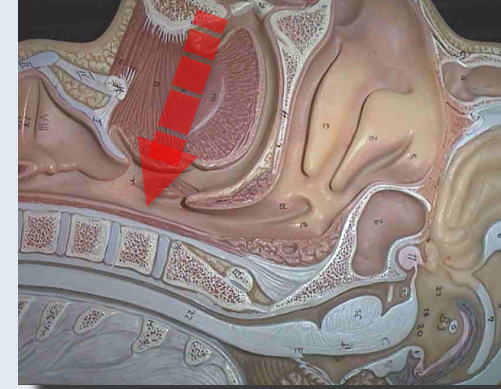
The hypopnea is a reduction of the air flow by more than 50 % (reduced oxygen saturation.)

Index, AHI (RDI) is the degree for the severity of the disease.

An apnea/hypopnea lasts at least 10 sec. The apnea per hour sleep are counted, 10 apnea per hour result in an index of 10.

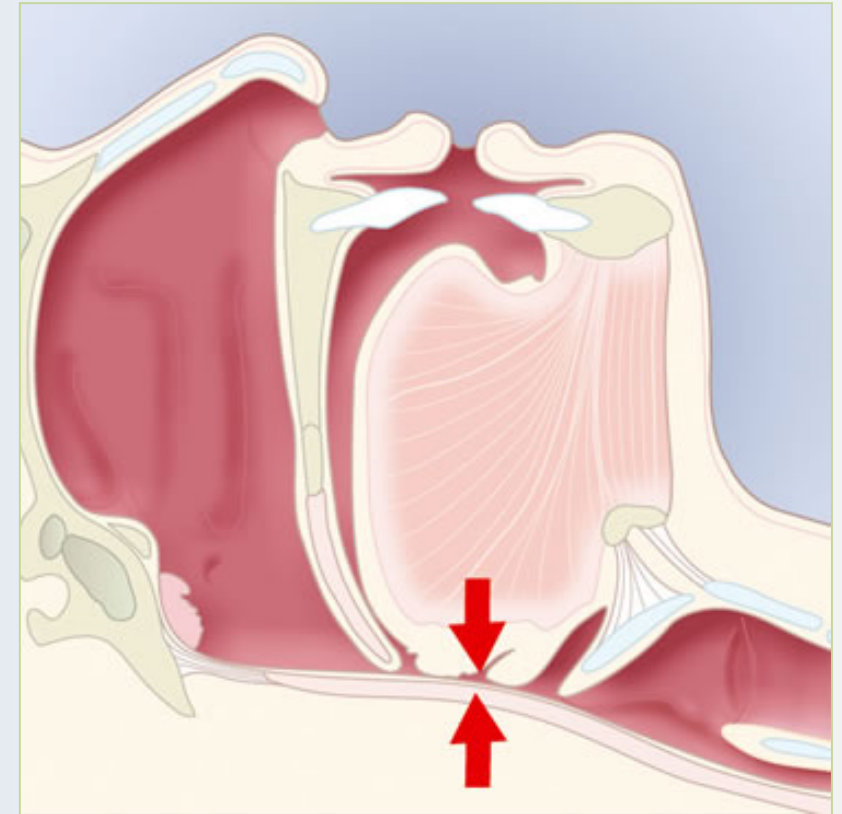
An index of 0 to 5 is normal, when the index is 5 to 10 there is a median disease and at an index of 20 and more there is a severe disease. In other countries the graduation is slightly different.

An obstructive apnea is characterized by an interruption of the very noiseful rhonchopathy. A central apnea runs without external signs.



area of the obstruction

obstructive sleep apnea, obstructed pharynx



## Symptoms and consequences of the OSA

The main symptom of the obstructive sleep apnea is a loud, irregular snoring, the rhonchopathy.

Family members might also report of pauses in breathing that are ended by the „arousal“, a loud „implosive“ restart of the snoring.

A non-treated OSA leads to mostly chronic cardiovascular diseases.

### Further symptoms of the OSA:

- restless sleep with difficulties staying asleep
- tiredness during the day, microsleep, strong desire to sleep
- headache and vertigo after awakening and getting up
- dry mouth
- sweating during the night
- increased urge to urinate during the night (nycturia)
- lack of concentration
- depressive mood
- impotence (erectile dysfunction)

### Health consequences of the OSA:

- hypertension
- myocardial infarction
- apoplectic stroke
- sudden cardiac death with increased probability
- cardiac arrhythmia
- depressions
- stomach ulcer, hearing loss and other stress diseases
- diabetes mellitus

## Diagnostic investigation:

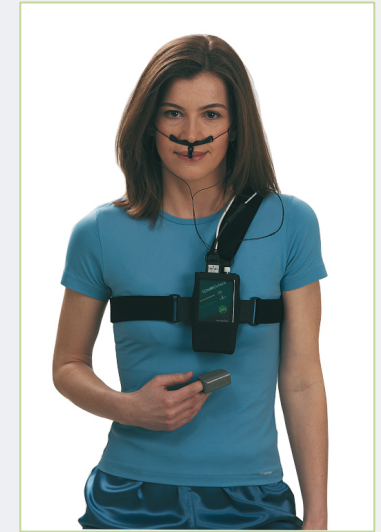
### Ambulatory snoring investigation:

Home screening, mostly an investigation for one night at home.



Diagnostic apparatus usable at home, in familiar surroundings, for collection of:

- air-flow and snoring
- heart rate
- oxygen saturation
- body position
- thoracic and abdominal movements



### In-patient polysomnography:

In a sleep laboratory, mostly for two nights in order to minimize influences of the unfamiliar surroundings.



Extensive investigation in a sleep laboratory for collection of:

- electro-encephalogram of the brain (EEG)
- rhythm of the heart (ECG)
- oxygen level of the blood (pulse oxymetry)
- body temperature
- air-flow (mouth and nose)
- respiratory movement
- muscle tension (EMG)
- leg movement
- eye movement (EOG)
- body position





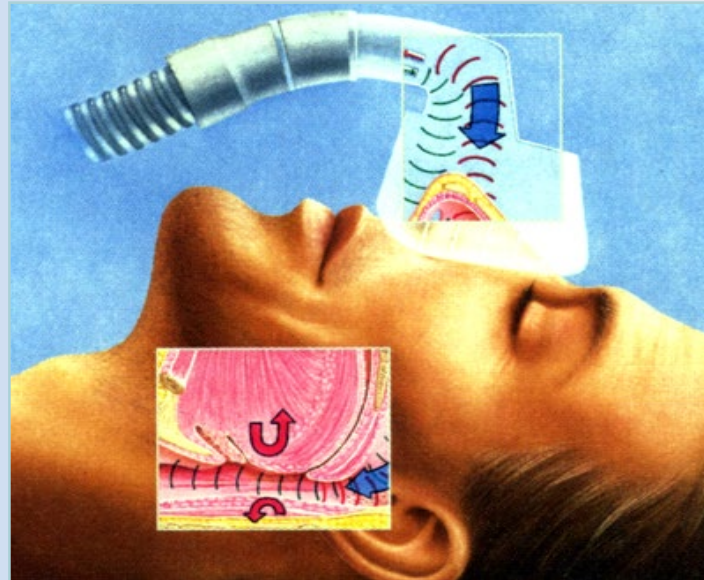
## Therapy

(N) CPAP (Nasal) Continuous Positive Air Pressure.

Continuous (nasal) positive pressure of the respiratory air during the sleep.

The NCPAP respiratory mask is the therapeutical „gold standard“ in case of an obstructive sleep apnea.

The side effects like irritated nasal mucosa and pharynx by the desiccative air flow, irritated conjunctiva caused by leakages, pressure points and skin irritations, however, lead to a low acceptance (compliance), especially in case of a not severe disease.



NCPAP function: Opening of the pharynx by continuous positive pressure of the respiratory air.

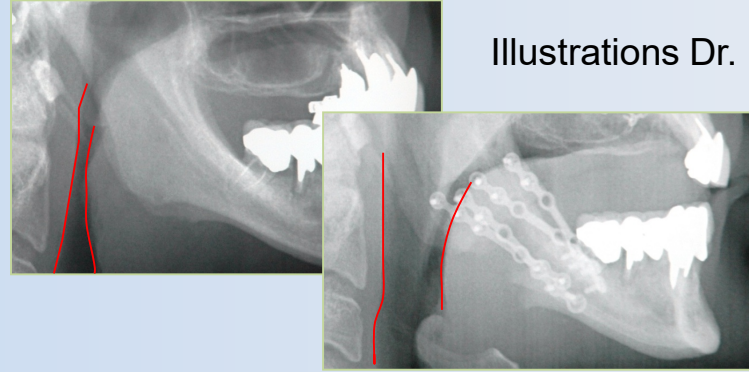
Modern units adapt the pressure to the respective airway resistance, also the Cheyne-Stokes-respiration is included.

The Cheyne-Stokes-respiration often occurs during the night at patients with advanced cardiac insufficiency (central sleep apnea syndrome). The result is a periodically recurring rise and fall of the respiration with changing respiratory frequency and respiratory pauses.



# Therapy

Surgery:  
surgical correction of a retrognathism.  
Complex, effective surgery.  
In very rare cases executed because of an OSA.



Illustrations Dr. Pelosi, Parma

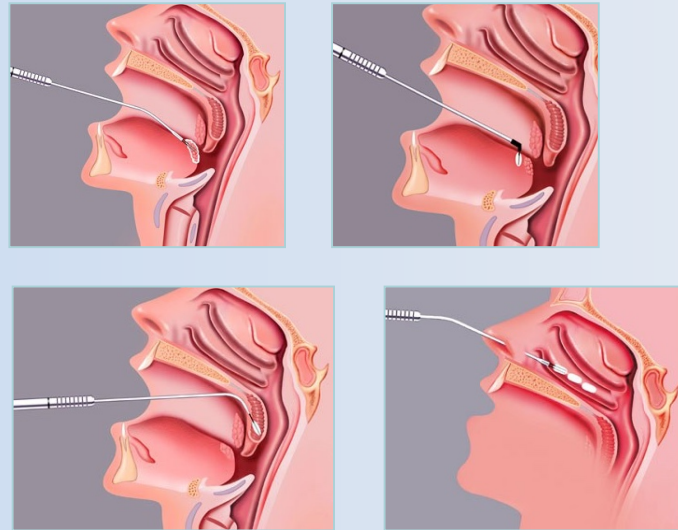
The correction of the uvula and the ending soft palate is acceptable.  
The effectiveness, however, is evaluated very differently.



UPPP  
(Uvula-Palato-Pharyngo-Plastic)

Laser- and radio frequency ablation:  
Cicatrization to tighten the soft palate and correction of the uvula and the ending soft palate.

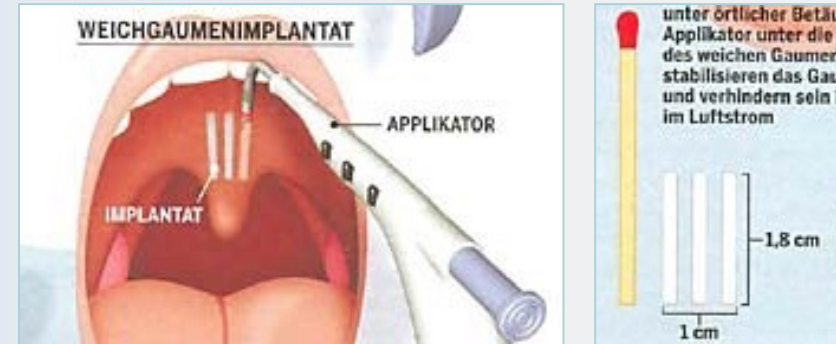
(for radio frequency ablation please see <http://www.dr.aschmann.de/de/behandlung.htm>)



The total removal of the uvula has to be seen very critically because of the very inconvenient side-effects.



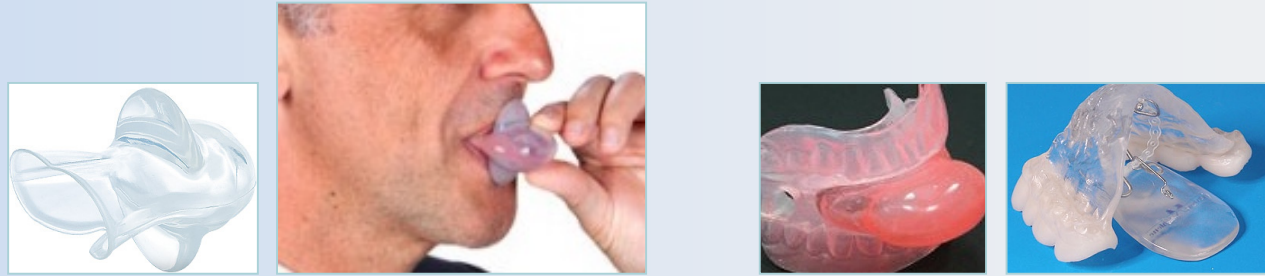
Implantive surgery, plastic rods are implanted to stiffen the structures.





# Oral appliances

tongue retainer keep the tongue in an advanced position



Aveo TSD, also suitable for edentulous persons

protrusion splints resp. MAS (mandibular advancement splints) keep the lower jaw in a defined advancement

Lower jaw and tongue are connected to each other in the area of the frontal pharynx by ligaments and muscles. An advancement of these structures increases the passage of the pharynx and thus reduces the obstruction.

MAS can function by pulling:



Silensor-sl



TAP-T



Narval

or by pushing:

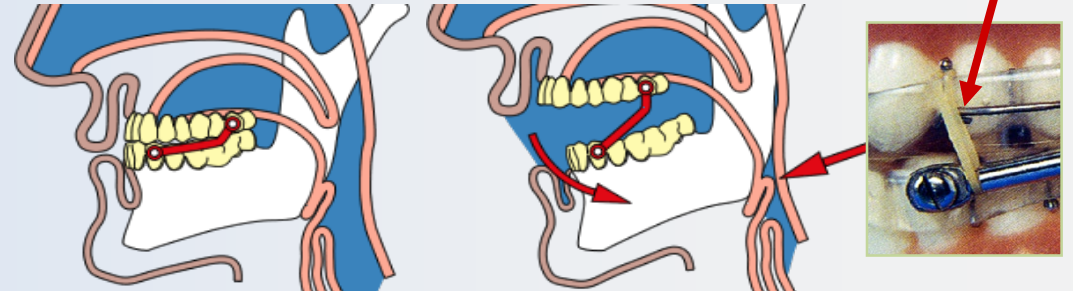


IST, modified Herbst device



Sommnodent

IST, modified Herbst device: Attention, If the mouth falls open, the respiratory tract is additionally narrowed. The device is thereby counter-productive, that means the mouth opening has to be limited (arrow)!



Protrusion splints that are realized as monobloc allow no or only little movement of the lower jaw. Studies have found that for this reason, there are slightly more TMJ (temporo mandibular joint) disorders to expect.

Therefore monobloc constructions should be rejected.



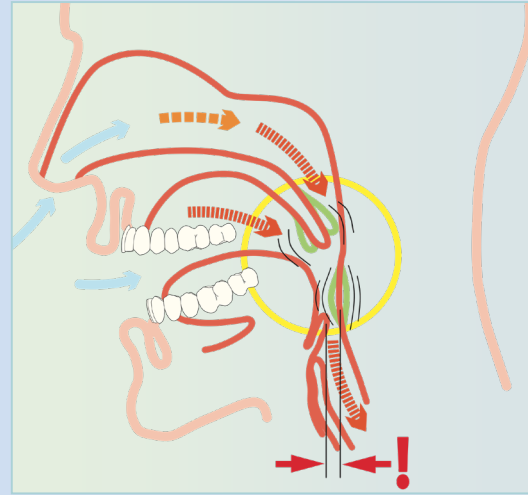


## Protrusion splints

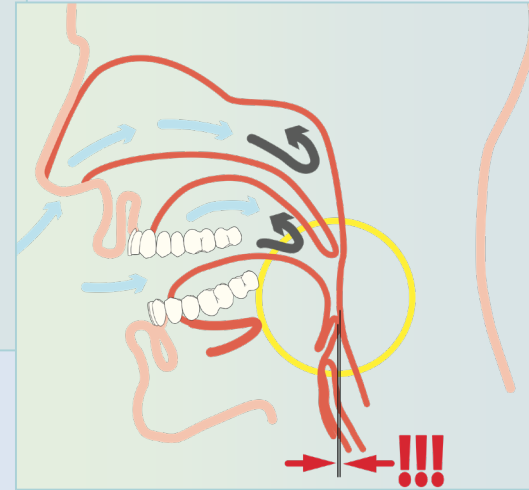
The effectiveness of protrusion splints or MAS (mandibular advancement splints) is based on the fixation or defined advancement of the lower jaw.

Protrusion splints have a higher acceptance than tongue retainers, provided that they are not very voluminous and allow jaw movements.

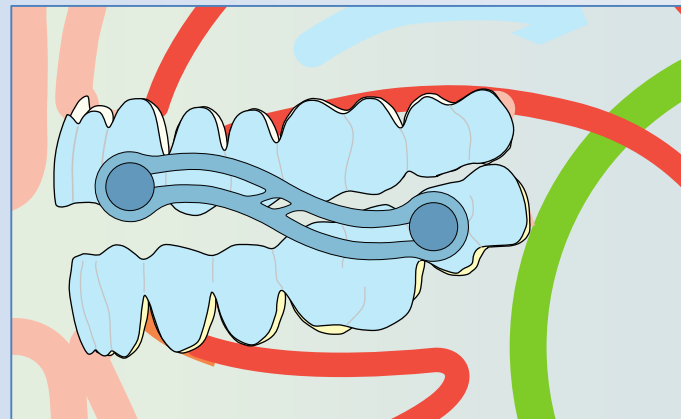
If the lower jaw is advanced by 4 mm the front wall of the pharynx moves by about half to the front.



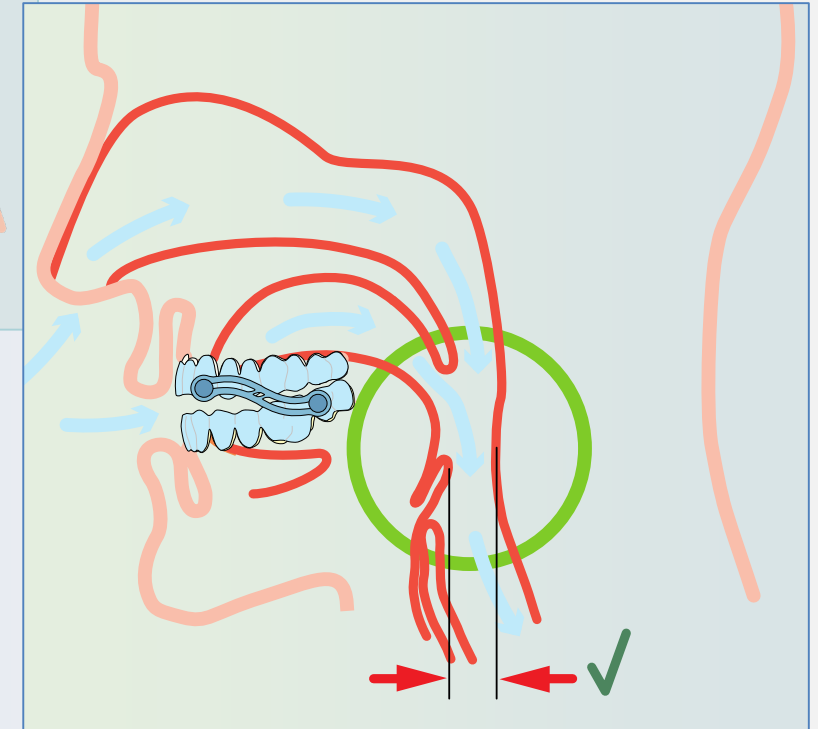
Snoring, narrowed pharynx



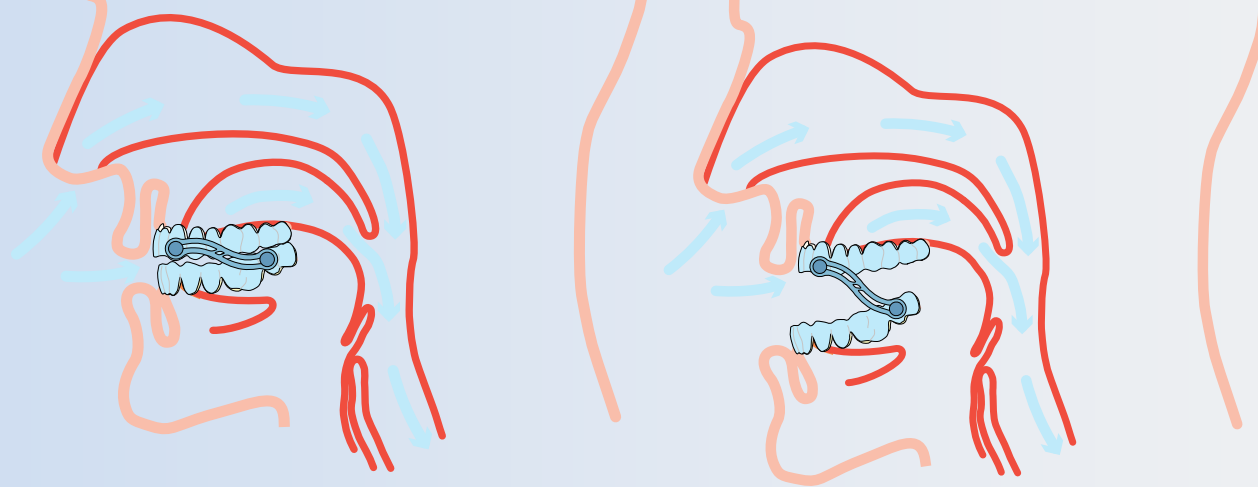
obstructive sleep apnea, closed pharynx



By advancement of the lower jaw and the root of the tongue the protrusion splint opens the respiratory tract in the pharyngeal area.



# Protrusion splints



Constructions based on pulling:

## Silensor-sl

Specially shaped connectors keep the lower jaw in a certain advancement.

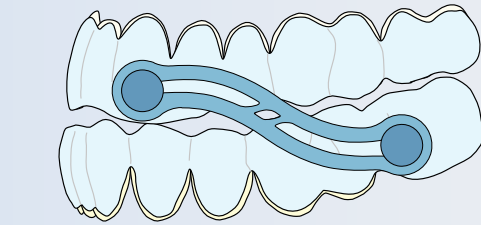
The connectors are easily replaceable. The Silensor-sl is adjustable in graduations of 1 mm.

The Silensor-sl allows relatively large jaw movements.

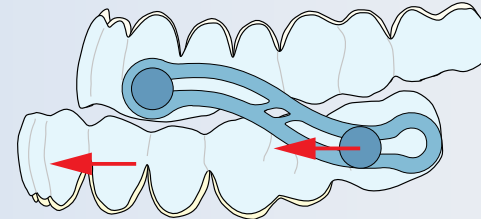
The construction is metal-free to avoid galvanic currents.

The versions that are based on pulling allow a large mouth opening and thereby additionally enlarge the respiratory tract.

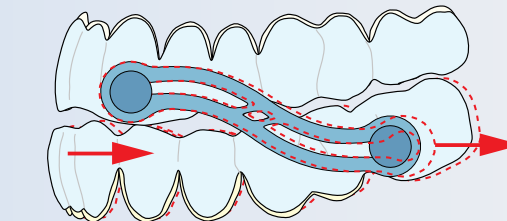
Silensor-sl:



In case of sudden propulsion movements the anchors may glide in the connectors.



The S-shape avoids a hard stop of the connectors.



# Protrusion splints

Silensor-sl:

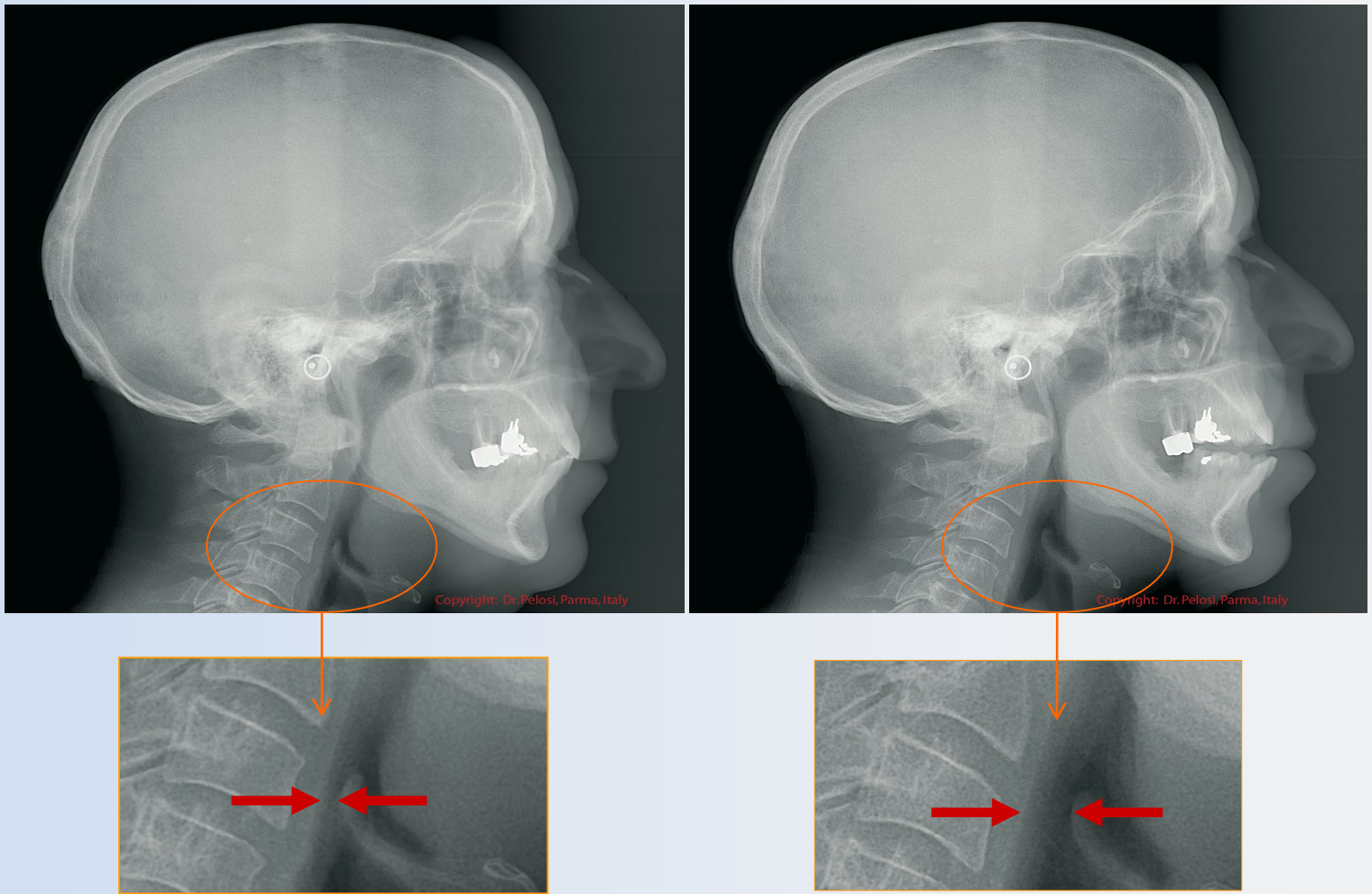
Therapeutical efficiency

X-ray examination of the University in Parma.

Advancement Silensor-sl:  
4 mm

without Silensor-sl

with Silensor-sl





## Protrusion splints

Therapy with protrusion splints:

To avoid failures and to minimize undesired side effects there are some conditions and requirements to be observed.

The dentist should have experience in the splint therapy, evaluate the oral situation and know possible side effects.

On suspicion of an apnea disease the patient should be transferred to specialists.

### The patient:

Contraindications for the therapy with the Silensor-sl:

Apnea-index higher than 20 (more than 20 pauses in respiration per hour during sleep).

Inflammatory, painful temporomandibular jaw problems.

Loose tooth anchorage.

Less than 8 teeth per jaw.

Prognathic bite, protruding lower jaw, an advancement of the lower jaw is mostly not possible.

BMI (Body-Mass-Index) higher than 30. If the BMI is higher, the effect decreases continuously.

(BMI= body weight (kg) divided by body size<sup>2</sup> (m))

The same applies if the neck size exceeds 44 cm.

### The splint

should fulfill the following requirements:

All teeth are included.

No stiff connection of the jaws.

Individual adaptation with firm fit.

The advancement is adjustable.

Because of the needed acceptance the appliance is as comfortable as possible.

Metal free constructions are to be preferred.

## Protrusion splints

Therapy with protrusion splints,

the side effects:



The most important side effect are tooth movements, the splint should therefore compass all teeth, a firm attachment apparatus is required. Self control and control by the dentist is necessary.

Unpleasant, dragging sensation in the joint area that, however, decreases with the time.

Morning malocclusion, after removal of the splint the patient feels a more or less considerably changed bite situation until the reorientation of the masticatory musculature. It is very individual how long this lasts. However, this does not have any consequences according to several studies.

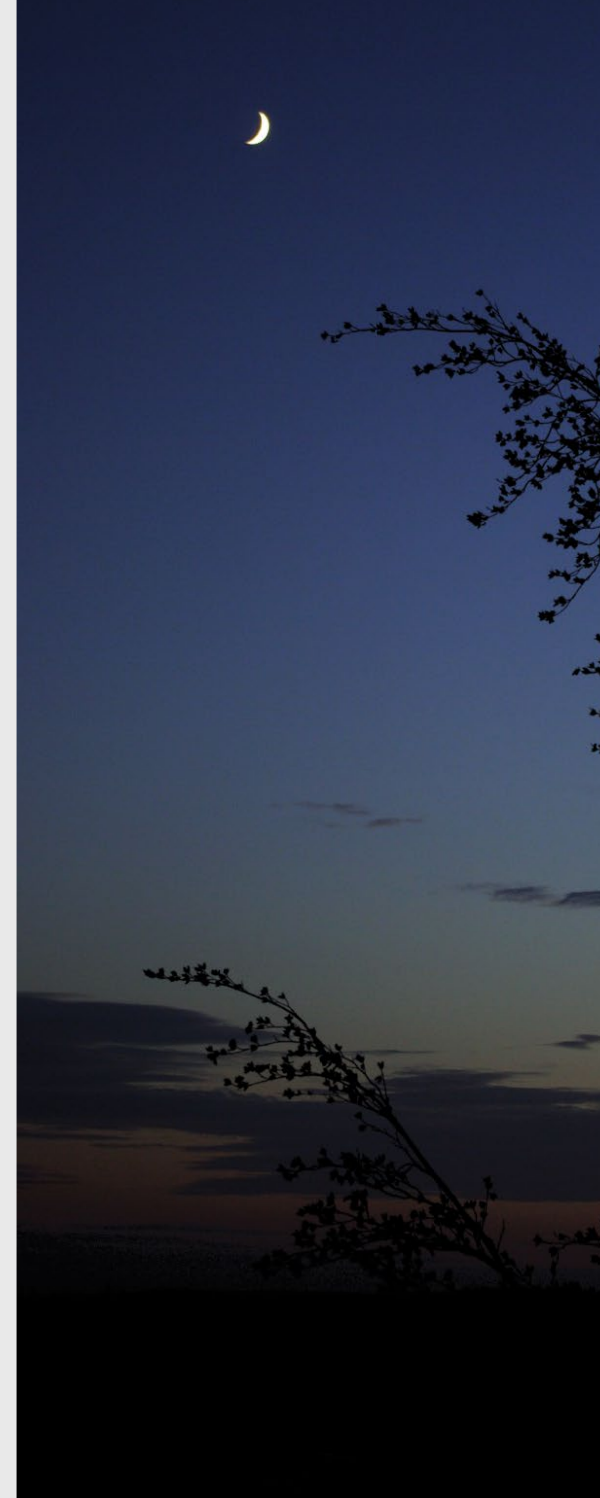
Periodontic pain, pain in the periodontium, the splint is too tight.

Excessive salivation, the more voluminous the construction is the stronger the salivation is. After a certain time of wearing, however, a reduction of the salivation can be assumed.

## Findings

The questionnaire of the Silensor-sl flyer shall help to clarify the intensity of snoring and if there might be a sleep apnea.

The result gives recommendations for a further clarification and treatment.



# Fabrication

The questionnaire gives a trend information on the sleep patterns of the patients, the capability of treatment and the adjustment of the Silensor-sl.

	no	sometimes	often	yes
Do you feel stiffness in the area of the temporomandibular (jaw) joints?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do your facial muscles feel strained or tense in the morning?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you grind or clench your teeth?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
If your dentist confirms these findings a Silensor-sl can be used.			A Silensor-sl can only be used after successful therapy.	

	no	sometimes	often	yes
Do you feel stiffness in the area of the temporomandibular (jaw) joints?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do your facial muscles feel strained or tense in the morning?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you grind or clench your teeth?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
If your dentist confirms these findings a Silensor-sl can be used.			A Silensor-sl can only be used after successful therapy.	

	no	sometimes	often	yes
Do you feel stiffness in the area of the temporomandibular (jaw) joints?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do your facial muscles feel strained or tense in the morning?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Do you grind or clench your teeth?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
If your dentist confirms these findings a Silensor-sl can be used.			A Silensor-sl can only be used after successful therapy.	

Do you also snore on the side?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you snore every night?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Do you snore noisily?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you feel tired on waking up?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you sleep fitfully, is your bed crumpled in the morning?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you wake up with headache?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you have problems concentrating for long periods?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Does sleep suddenly overcome you during the day?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you snore noisily with irregular interruptions?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Does your breathing stop (apneas) at any time during sleep?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Do you also snore on the side?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Do you snore every night?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Do you snore noisily?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Do you feel tired on waking up?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you sleep fitfully, is your bed crumpled in the morning?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Do you wake up with headache?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Do you have problems concentrating for long periods?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Does sleep suddenly overcome you during the day?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you snore noisily with irregular interruptions?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Does your breathing stop (apneas) at any time during sleep?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Do you also snore on the side?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Do you snore every night?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Do you snore noisily?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Do you feel tired on waking up?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Do you sleep fitfully, is your bed crumpled in the morning?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Do you wake up with headache?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Do you have problems concentrating for long periods?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Does sleep suddenly overcome you during the day?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Do you snore noisily with irregular interruptions?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Does your breathing stop (apneas) at any time during sleep?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Presumably you only suffer from primary snoring without impairment of your health. The Silensor-sl can be fabricated in the normal bite situation.

The Silensor-sl has to keep your lower jaw in an advanced position.

The Silensor-sl has to keep your lower jaw in an advanced position.

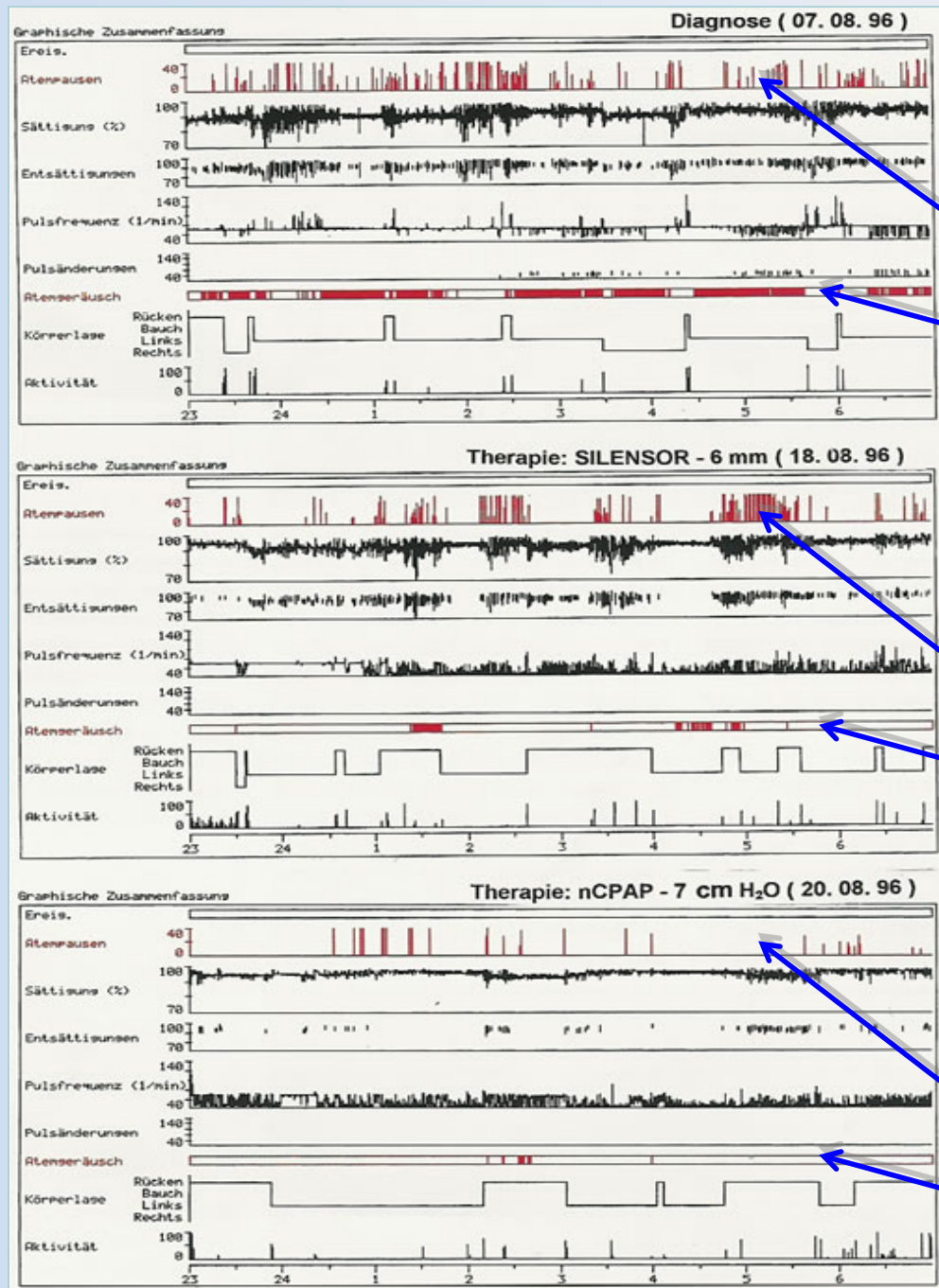
Upon suspicion of a sleep apnea a specialist in sleep medicine has to be additionally consulted.



# Case example

Patient with an AHI of 76!

Almost complete reduction of the rhonchopathy with the Silensor-sl but insufficient reduction of the apneas!



Initial situation:  
 pauses in respiration (apnea)  
 respiratory sounds (snoring)

Silensor-sl:  
 pauses in respiration (apnea)  
 respiratory sounds (snoring)

NCPAP:  
 pauses in respiration (apnea)  
 respiratory sounds (snoring)

## Mandibular advancement splints and continuous positive airway pressure in patients with obstructive sleep apnoea: a randomized cross-over trial

Y. K. Tan\*, P. R. L'Estrange\*, Y.-M. Luo\*, C. Smith\*, H. R. Grant\*, A. K. Simonds\*\*, S. G. Spiro\* and J. M. Battagel\*\*\*

\*Department of Respiratory Medicine, University College London Hospitals, \*\*Royal Brompton and Harefield NHS Trust and \*\*\*Department of Orthodontics, St Bartholomew's and the Royal London School of Medicine and Dentistry, UK

**SUMMARY** This prospective, randomized, cross-over trial was designed to compare the efficacy of a mandibular advancement splint (MAS) with that of nasal continuous positive airway pressure (nCPAP) in patients with obstructive sleep apnoea (OSA). Twenty-four patients (20 males and four females) with mild to moderate OSA (AHI between 10 and 49 events per hour) were enrolled in the study. Each patient used both MAS and nCPAP, with the initial therapy being allocated at random. Treatment periods lasted for two months with a two-week wash-out interval between. Polysomnography was performed prior to the study and

242

purpose of the study, but assessment was carried out in a random order and with all patient identification removed.

The oral appliance. A soft, one-piece MAS was selected initially, similar to that described

by the authors. It was made of a vacuum-formed clear plastic, was cheap to construct, and was comfortable to wear. The appliance protruded forward at the level of the upper incisors, with no lateral protrusion, and with minimal jaw opening. The appliance approximated the occlusion to the original position, with no lateral protrusion, and with minimal jaw opening.



Figure 2 Modified Silensor appliance.

adjustment. The buccal connectors are available in four lengths and the mandible may be readily advanced by replacing the original connector by a shorter one. Since modification of the splint design could have had an effect on outcome, results for the two types of splint were compared both separately and for the group as a whole.

**Nasal continuous positive airway pressure (nCPAP).** nCPAP was provided using the REM Star Choice machine (Respironics Inc., Medic-Aid, West Sussex, UK) at UCLH and the Sullivan Elite machine (Resmed UK Ltd, Abingdon, UK) at RBH. A comfortable nasal mask was selected and nasal corticosteroid sprays were prescribed to relieve nasal congestion if necessary. This symptom did not require treatment during the MAS arm of the study in any individual. Correct nCPAP pressures were titrated individually.

**Diagnostic polysomnography.** All patients had a diagnostic polysomnography before entry into the study. At UCLH, the equipment was a Compumedics system (Compumedics Ltd, Victoria, Australia), which recorded sleep and its stages by electroencephalographic (EEG), electro-oculographic, and electromyographic (EMG) criteria. EEG was recorded with electrodes placed at C3–A2 and C4–A1 (according to the international 10–20 system). EMG activity was recorded from the submental muscles. A single pair of electrocardiographic chest leads was used

Y. K. TAN ET AL.

## Literature/studies

Many studies with protrusion splints inclusive the Silensor-si are available.

Statistical, many studies summarizing theses show an effectiveness against snoring of 82 % and an average reduction of the obstructive sleep apnea index of 54 %.

Treatment of snoring and obstructive sleep apnea with a mandibular protruding device: an open – label study Anette M.C. Fransson et al., sleep and breathing, vol. 5/1 2001

Oral appliances for snoring and obstructive sleep apnea: a review Kathleen A. Ferguson et al., sleep, Vol. 29/2, 2006



### Efficacy of Mandibular Advancement Splint for Treatment of OSA, Report at Three Months of a One-Year Follow-Up Study

Tea Galić, W talija I ković, Renata Pecotić, Joško Bžić, Tina Tičinović Kurir, Gugo Gn jača, Maja Valić, Goran Račić, Zoran Đogaš University of Split, School of Medicine, Split, Croatia

#### INTRODUCTION

Mandibular advancement splint *Silensor-si* (MAS) can effectively treat mild to moderate obstructive sleep apnea (OSA). It is worn during sleep to maintain the patency of the upper airway by increasing its dimensions and reducing its collapsibility. Although less efficacious than continuous positive airway pressure (CPAP) for improving the polysomnographic indexes of OSA, MAS is generally preferred by patients which ensures better compliance and may provide an equivalent health outcome. MAS have been shown to have a beneficial impact on numerous clinical outcomes, including the polysomnographic indexes of OSA, subjective and objective measures of sleepiness, blood pressure, aspects of neurophysiological functioning, and quality of life. In this study we sought to evidence the efficacy of specific mandibular advancement splint *Silensor-si* and the long-term impact on numerous clinical outcomes.

#### METHODS

- 7 patients with mild to moderate OSA
- patients were initially screened for dental status; inclusion criteria was at least 6 healthy teeth in each dental arch
- dental impressions and lateral cephalometric radiographs were obtained prior to the initiation of the treatment
- arterial stiffness, blood pressure and metabolic blood parameters were measured at baseline and after 3 months of MAS treatment
- treatment outcome was determined by polysomnography



#### RESULTS

Variable	Total	Male	Female
Patients N	7 (100)	5 (71)	2 (21)
Age yr	54.67±5.16	55.84±7.39	52.5±3.54
Height (cm)	180.3±7.7	184.0±5.3	171.0±0.0
Weight (kg)	89.43±7.74	89.6±7.02	89.0±12.73
BMI(kg/m <sup>2</sup> )	27.7±3.61	26.6±3.06	30.4±6.35
ESS score	6.29±3.40	6.6±4.1	5.5±0.71
Neck circumference (cm)	41.79±2.94	43.3±1.57	39±1.41
STOP questionnaire N (%)			
High risk (>2)	7(100)	5(100)	2(100)
Low risk (<2)	0(0)	0(0)	0(0)

TABLE 1 DEMOGRAPHIC CHARACTERISTICS OF PATIENTS Values are given as No (%) or mean±SD, unless otherwise indicated. BMI=body mass index; ESS=Epworth Sleepiness Score; STOP=snoring, tiredness, observed apnea, and high blood pressure

Variables	Baseline/before MAS treatment	At 3 months of MAS treatment	P value
ESS score	6.29±3.40	6.0±4.30	NS
AHI (events/hr)	21.79±5.78	10.76±3.98	0.0158
Minimum SpO <sub>2</sub>	84.0±5.35	86.57±2.94	NS
Mean SpO <sub>2</sub>	94.29±1.98	96.14±1.21	NS
Snoring time (min)	284.9±199.48	166.29±182.79	NS
Fibrinogen (g/L)	3.13±0.73	3.46±0.89	NS
Total cholesterol (mmol/L)	5.74±1.08	5.94±1.33	NS
Cortisol (nmol/L)	372.67±83.98	353.37±107.71	NS
FFP (mmol/L)	5.0±0.33	4.86±0.4	NS
FPI (pmol/L)	75.40±80.53	72.27±74.65	NS
HR (beats/min)	68.67±19.82	64.43±12.35	NS
Systolic BP (mmHg)	129.67±20.53	128.43±12.08	NS
Diastolic BP (mmHg)	76.0±11.58	77.14±5.37	NS

TABLE 2 EFFECTS OF MANDIBULAR ADVANCEMENT SPLINT ON CLINICAL PARAMETERS AND METABOLISM Values are given as mean±SD or No. (%), unless otherwise indicated. NS=not significant; MAS=mandibular advancement splint; ESS=Epworth Sleepiness Score; AHI=apnoea-hypopnoea index; SpO<sub>2</sub>=pulse oximeter oxygen saturation; FFP=fasting plasma glucose; FPI=fasting plasma insulin; HR=heart rate; BP=blood pressure. P value<0.05 was considered to be statistically significant.

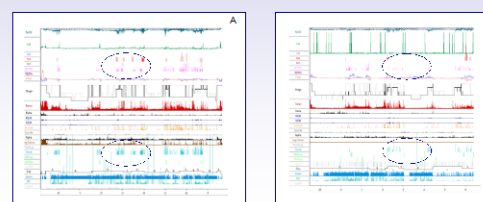


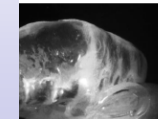
FIGURE 1 Whole night polysomnography data for patient Alice Šigostić sleep with m device; ellipses represent respiratory events. A - Prior to MAS treatment B - At 3 months of MAS treatment

#### CONCLUSION

Mandibular advancement splint *Silensor-si* may be offered as an alternative treatment with moderate improvement of OSA symptoms in patients with mild to moderate OSA. The significant changes in arterial stiffness, blood pressure and metabolic blood parameters, did not occur in 3 months of treatment but our study will be continued to 1-year treatment period.

#### REFERENCES

- Chan ASL, Lee RWW, Cistulli PA. Dental appliance treatment for obstructive sleep apnoea. Chest. 2007;132:693-699.
- Itzaki S, Dorchin H, Clark G, Lavie L, Lavie P, Pillar G. The effects of 1-year treatment with a Herbst mandibular advancement splint on obstructive sleep apnoea, oxidative stress, and endothelial function. Chest. 2007; 131:740-749.
- Phillips CL, Yee B, Yang Q, Villaneuva AT, Hedner J, Berend N, Grunstein R. Effects of continuous positive airway pressure treatment and withdrawal in patients with obstructive sleep apnea on arterial stiffness and central BP. Chest. 2008; 134:94-100.

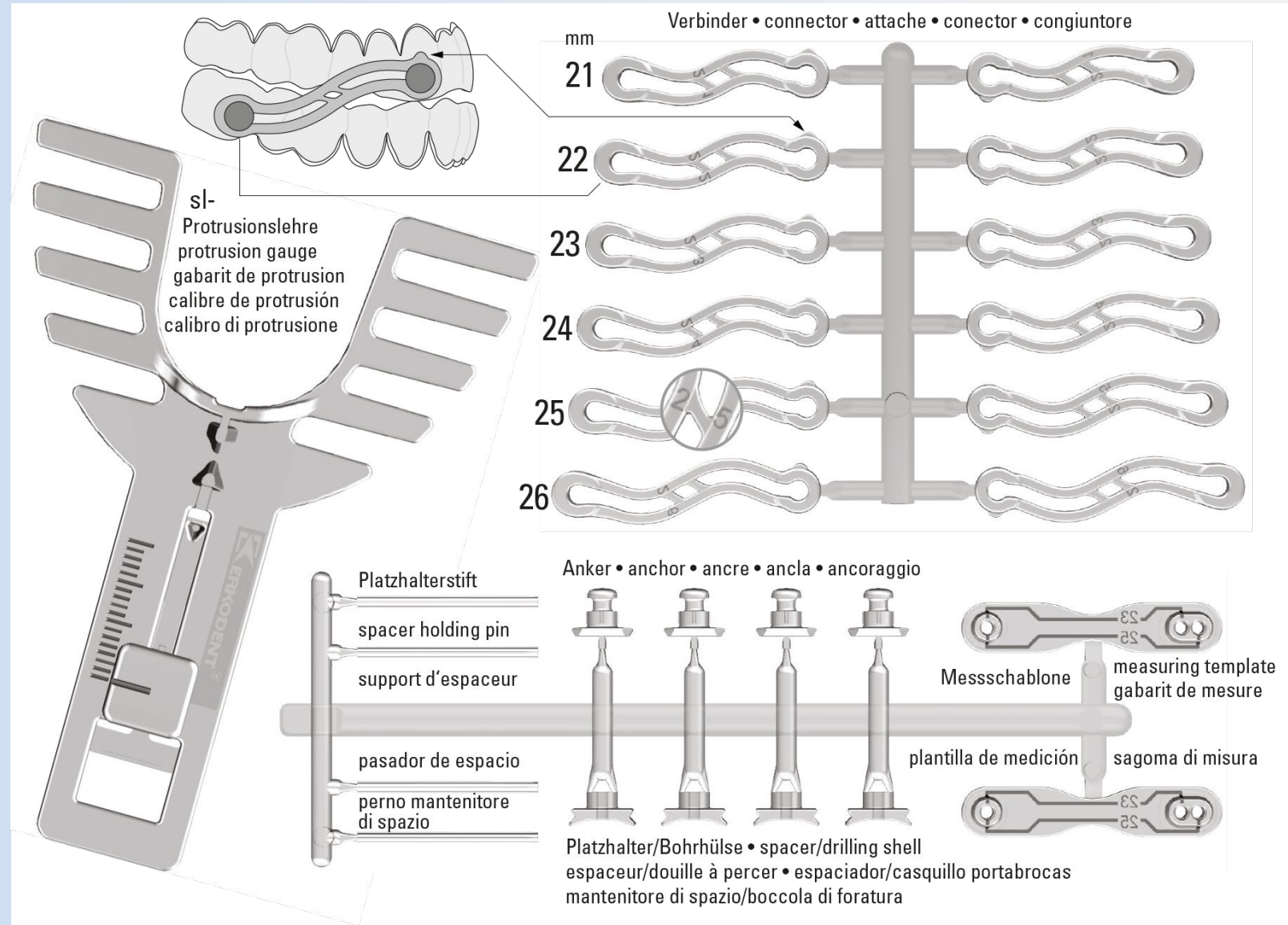


# Fabrication

sl-parts card for the fabrication of a Silensor-sl.

The Silensor-sl can be fabricated with and without registration (constructive checkbite).

The sl-protrusion gauge allows the fabrication of a Silensor-sl that exactly corresponds to the measured proportions in the mouth.

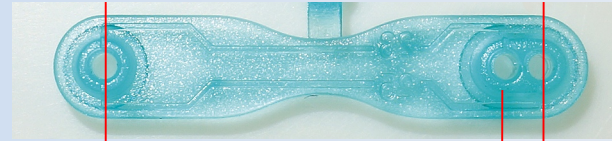




## The adjustment of the Silensor-sl

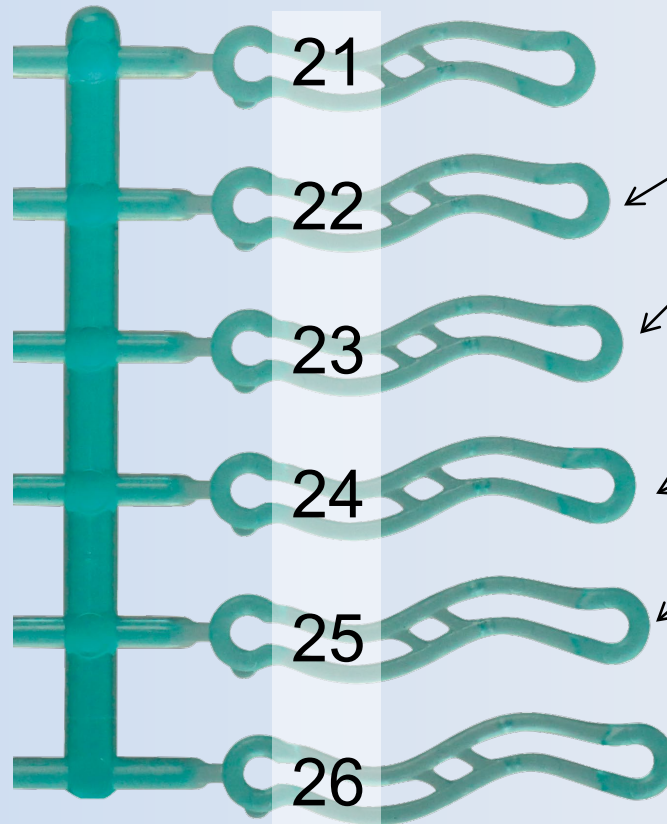
Select connector length: The connectors are easily exchangeable, for ex. if more protrusion is needed for a sufficient effect.

The shorter the connector is selected in relation to the measurement, the greater is the advancement of the lower jaw.



← 23 mm →

← 25 mm →



23 mm measured

without bite-taking select 22 mm connector

with bite-taking select 23 mm connector

25 mm measured

without bite-taking select 24 mm connector

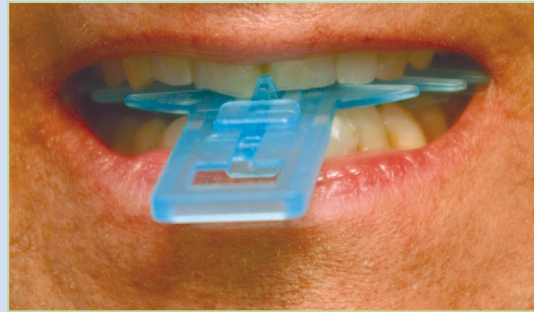
with bite-taking select 25 mm connector

The 26 mm connector is used when the patient despite bite-taking does not accept the advancement.

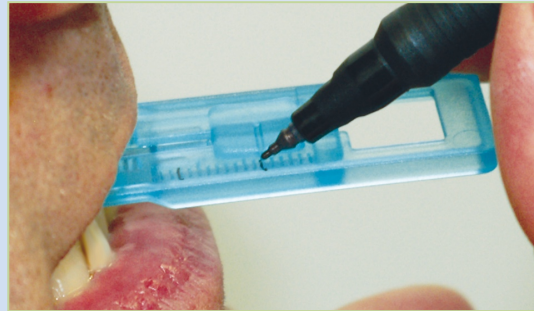
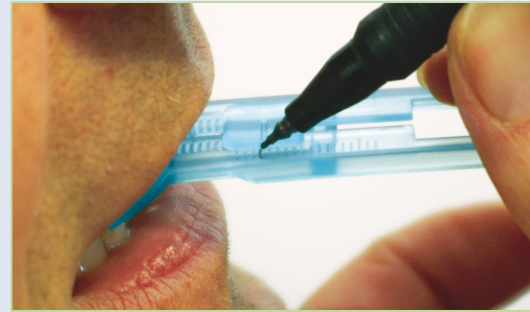


# sl-protrusion gauge

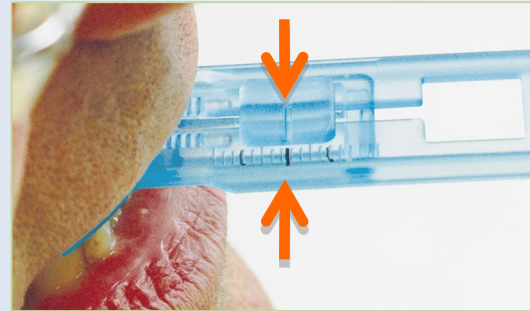
The sl-protrusion gauge allows to register in a simple way the desired or recommended advancement for the Silensor-sl.



1. Marking of the normal bite situation with the sl-protrusion gauge.

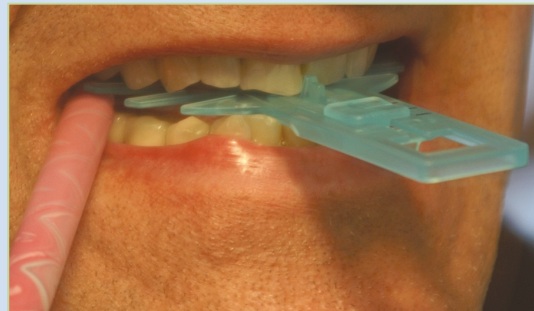


2. Marking of the maximum advancement.

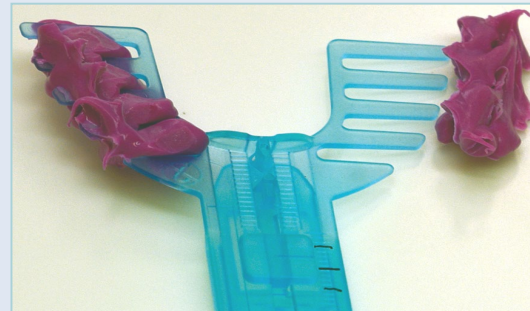


3. Marked desired protrusion.

Generally, half of the maximum protrusion is recommended as the advanced position of the lower jaw.



4. Registration.

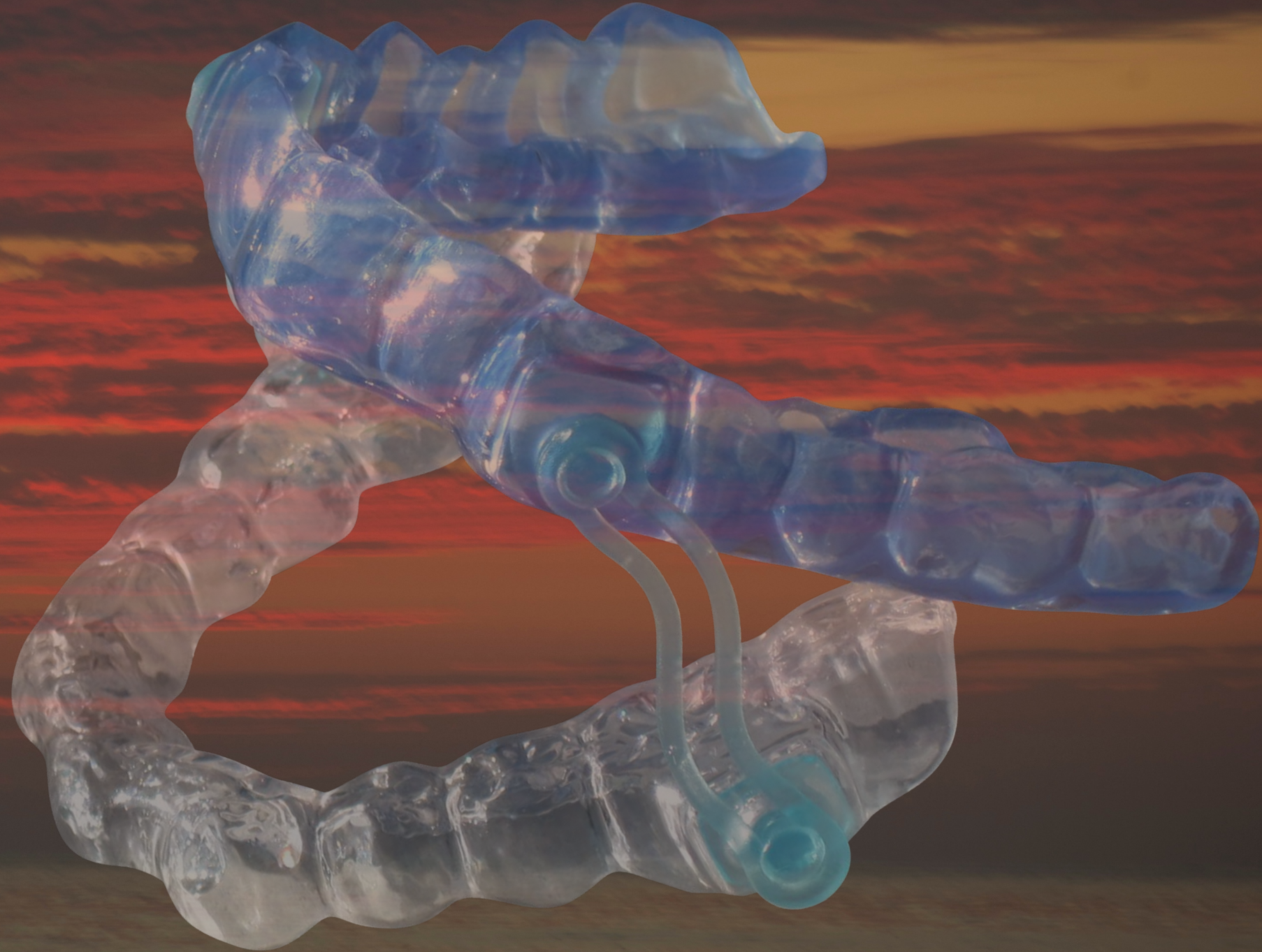




Sleep disorders and dentistry

Thank you very much  
for your attention

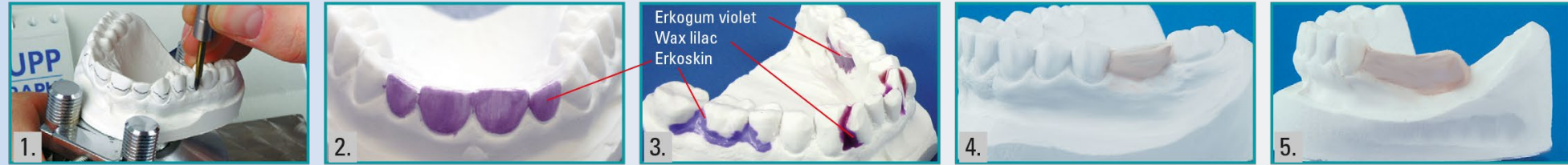
An overview of the manufacturing  
follows on the next pages.





# Fabrication (Extract of the instructions)

## Model preparation



In case of a very retentive teeth situation, the marking of the prosthetic equator is recommended (1.).  
 With the exception of the fixation points, the splint ends in case of large undercuts at the equator, otherwise 1-2 mm below.  
 In case of using Erkodur (hard), relieve tension from the four upper front teeth by applying Erkoskin (2.).  
 Block out undercuts and spaces with Erkogum, block out bubbles in the plaster with high-fusing wax. Relieve tension from the gingival margin in the area where the splint possibly has contact (3.).  
 If the measuring point is located on an edentulous area, this must be filled with plaster (4.).  
 In case of a free-end situation, a plaster wall is put on the ridge (5.).

## Fabrication with construction bite



**1.** Separate the measuring templates.  
 25 mm or 23 mm ?, see hints, page 1, paragraph 4 + 5.

**2.** Articulate the models using a rubber band and the construction bite that has been taken off the sl-protrusion gauge and cut to shape.

**3.** Fix measuring template as near as possible to the occlusal plane with Erkogum. Initial point is the upper canine or canine area. The lower pivot point results from the measurement (see hints).  
 Fix the measuring template with the drilling shells that way that a parallel drilling is possible.

**4.** Cut the spacer holding pins.  
 Put the marked end in the drilled holes, see **7.**



# Fabrication

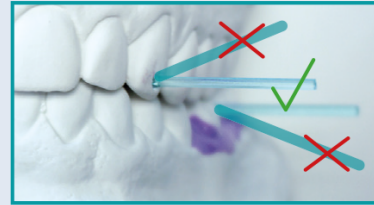
## Fabrication with construction bite



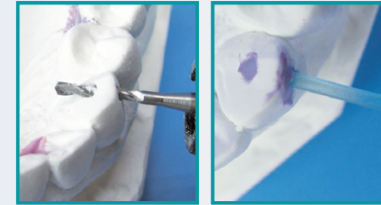
5. Drill with the 1.4 mm drill (10 000 rev./min.!) through the drilling shell into the model, first in the canine area (3 mm depth of drilled hole or more).



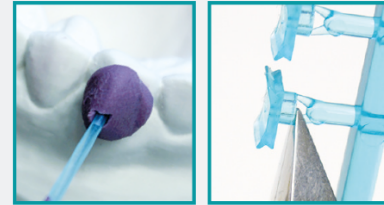
6. Immediately insert a spacer holding pin through the drill guide. Only now drill the second hole. Drill the other side in the same way. Remove pins and templates ...



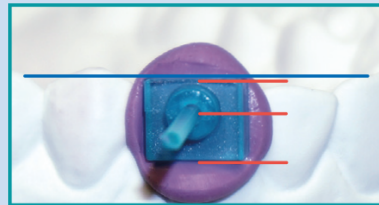
7. ... the models can now be separated. Now put all 4 spacer holding pins into the drilling holes. Strongly diverging spacer holding pins have to be adjusted.



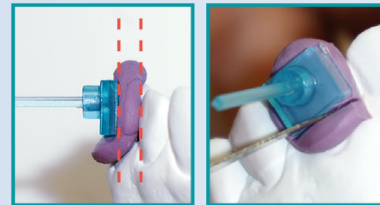
**Hint for drilling:** If the model has been drilled through, fix the spacer holding pin with Erkogum. Fix chipped plaster pieces and the pin with quick-acting glue.



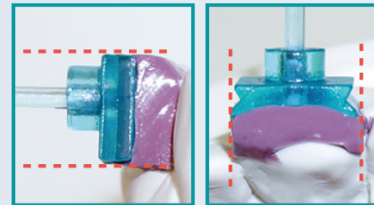
8. Put a poor quantity of Erkogum violet onto the pins. Cut the spacers without overhang.



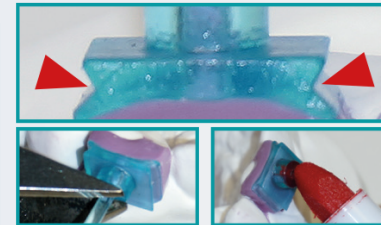
9. Push a spacer holder as illustrated onto the spacer holding pin and press it on as near as possible. The small side always points towards the occlusal plane.



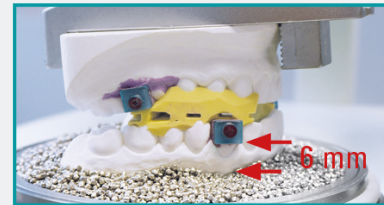
10. Pay attention to a parallelism of the modelling pads. Remove excessive Erkogum with a knife.



11. Undercuts between spacer holding pin and model have to be filled up.



12. Marked areas have to be free of Erkogum. Cut all pins. Now mark the outermost surface of each spacer with an appropriate pen.



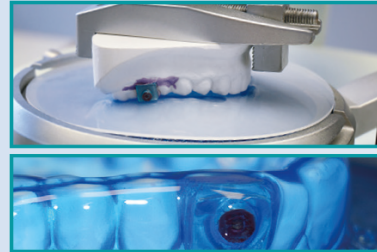
13. Articulate the models with the construction bite (Erkoform-3/3d/3d motion with Occluform-3). Leave the area below the spacer at least 6 mm free of granules.

# Fabrication

## Fabrication with construction bite



**14.** Keep the construction bite. Lower the bite at the supporting pin to a gap of app. 2 mm between the front teeth. Pull off the insulating foil of the Erkolen foil (1.0 mm) and keep it.



**15.** Now thermoform, immediately put the Erkolen foil (reusable) onto the model and close the Occluform. The result is a plane occlusal surface.



**16.** Now take a silicone key for the opposing bite (Aton-Lab 80). Put the modelling silicone in the unit onto the splint and imprint the opposing bite with the Occluform, if necessary, slightly adapt.



**17.** Take model with foil out of the Occluform model pot and roughly cut out (fissure bur > 20 000 rev./min.)



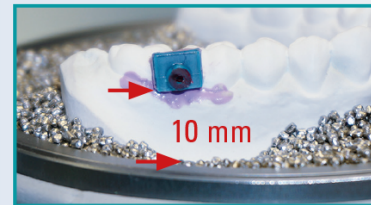
**18.** Lock the lower joint of the Occluform with the swivel screw. Fix lower jaw model in the Occluform model pot, fill up with granules and put the silicone key onto it. (Instructions Occluform)



**19.** Fix upper jaw model on the Occluform model plate. Articulate the models using the silicone key. Open the Occluform and remove the silicone key.



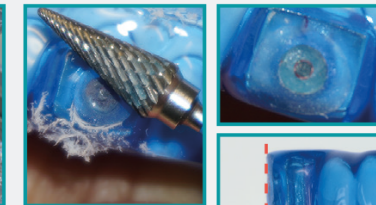
**20.** Press the cut insulating foil of the Erkolen foil with the adhesive side down on the occlusal surface of the splint.



**21.** Pay attention that at least 10 mm around the spacers are free of granules.



**22.** Now execute the second thermoforming process. As soon as the foil is adapted, close the Occluform. Allow to cool completely. Uncover all spacers before taking the splints off the model. Thereto, **carefully** grind through the plate ...



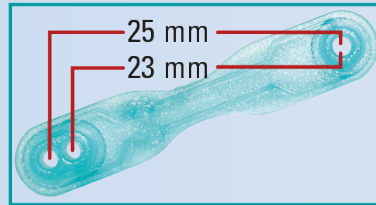
**23.** ... until the coloured marking on the spacers is just abraded, **not more and not less** (tungsten carbide bur > 20 000 rev./min.). **Ensure a plane surface.** Take the splints off the models.

continue at finishing



# Fabrication

## Fabrication without construction bite



**1.** Separate the measuring templates.

25 mm or 23 mm ?, see hints, page 1, paragraph 4 + 5.

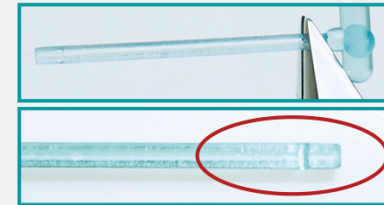
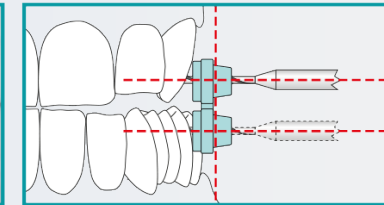


**2.** Articulate the models using a rubber band.



**3.** Fix measuring template as near as possible to the occlusal plane with Erkogum. Initial point is the upper canine or canine area. The lower pivot point results from the measurement (see hints).

Fix the measuring template with the drilling shells that way that a parallel drilling is possible.



**4.** Cut off the spacer holding pins.

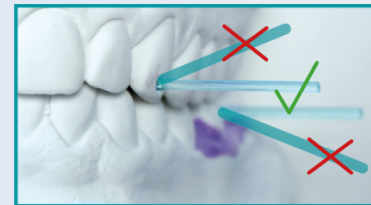
Put the marked end in the drilled holes, see **7**.



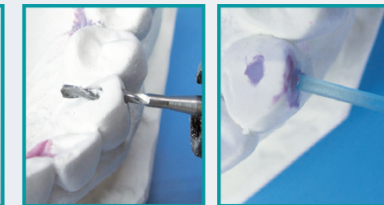
**5.** Drill with the 1.4 mm drill (**10 000 rev./min.!**) through the drilling shell into the model, first in the canine area (3 mm depth of drilled hole or more).



**6.** Immediately insert a spacer holding pin through the drill guide. Only now drill the second hole. Drill the other side in the same way. Remove pins and templates ...



**7.** ... the models can now be separated. Now put all 4 spacer holding pins into the drilled holes. Strongly diverging spacer holding pins have to be adjusted.



**Hint for drilling:** If the model has been drilled through, fix the spacer holding pin with Erkogum. Fix chipped plaster pieces and the pin with quick-acting glue.

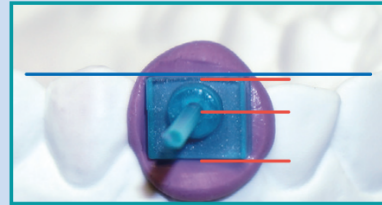


**8.** Press a poor quantity of Erkogum violet onto the pins. Cut the spacers without overhang.

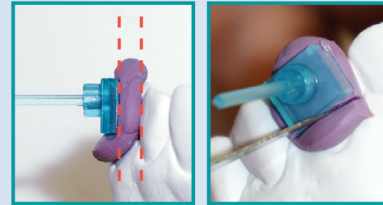


# Fabrication

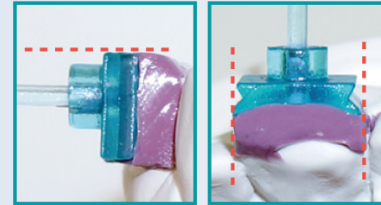
## Fabrication **without** construction bite



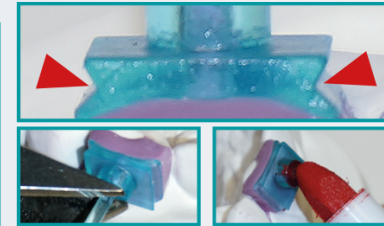
**9.** Push a spacer holder as illustrated onto the spacer holding pin and press it on as near as possible. The small side always points to the **occlusal plane**.



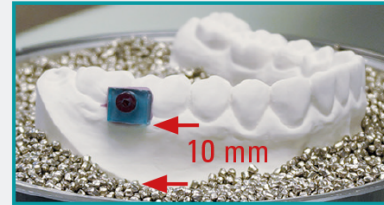
**10.** Pay attention to a parallelism of the modelling pads. Remove excessive Erkogum with a knife.



**11.** Undercuts between spacer holding pin and model have to be filled up.



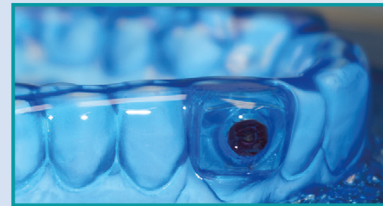
**12.** Marked areas have to be free of Erkogum. Now mark the outermost surface of each spacer with an appropriate pen.



**13.** Embed the models into the granules, leave the area below the spacer at least 6 mm free of granules. Thermoform the models one after the other.



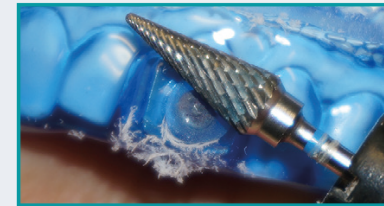
**14.** Immediately after the adaptation apply the Erkolen foil (1 mm) without insulating foil and press it on along the teeth row especially in the area of the front teeth, in doing so run with the ...



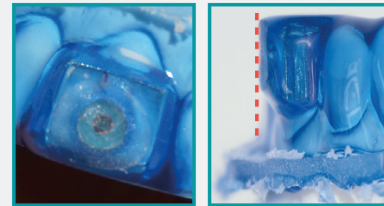
**15.** ... finger back and forth. Do not stay too long at one place, **hot!** The result is a plane occlusal surface.



**16.** Take the models out of the unit and roughly cut out before removing the splint from the model (fissure bur > 20 000 rev./min.).



**17.** Uncover all spacers before taking the splints off the model. Thereto, **carefully** grind through the plate until the coloured marking on the spacers is just abraded, ...



**18.** ... **not more and not less!** (tungsten carbide bur > 20 000 rev./min.) **Ensure a plane surface.** Take the splints off the models.

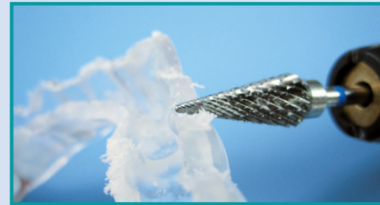
continue at finishing

# Fabrication

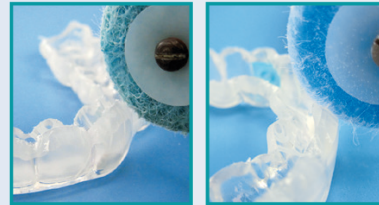
## Finishing



**1.** Cut the final form with the HSS twist drill (> 20 000 rev./min., without pressure), leave sufficient material (min. 2 mm) around the fixation points.



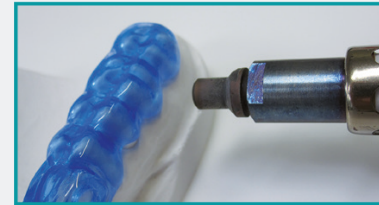
**2.** Grind the borders with the tungsten carbide bur (>20 000 rev./min.).



**3.** Smooth the borders, grinded areas with Lisko-S, narrow zones and interdental spaces with Liskoid (both 10 000 rev./min.).



**4.** Polish Erkodur with polishing agent for plastics (polishing set, 110 878).



**5.** Erkoloc-pro can be shined with the hot air burner (177 540), thereby only work on the model and do not heat the holes for the anchors (risk of deformation).



**6.** Press spacers inwards out of the splint (for ex. with the Lisko-S mandrel shank), it might be necessary to firmly press.

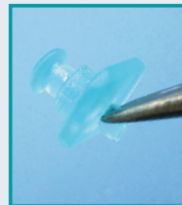


**7.** Remove the insulating/shrinkage compensation foil.



**8.** Cut the anchors as shown on the picture.

Take the anchors at the retaining lip and ...



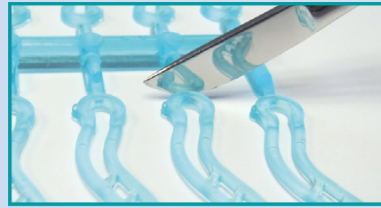
**9.** ... put them into the splint as replacement for the spacers.



**10.** Firmly press into position, if necessary, also carefully with suitable pliers.



Fabrication

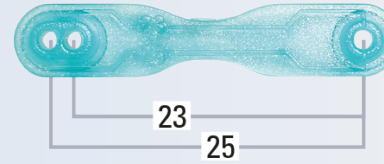


**11.** Cut the connectors, always opposing connectors have the same length.

**Choose the connector length:**

The connectors are exchangeable, for example if more protrusion is necessary for a sufficient effect.

The shorter the connector is chosen in comparison to the measurement, the larger is the advancement of the lower jaw.

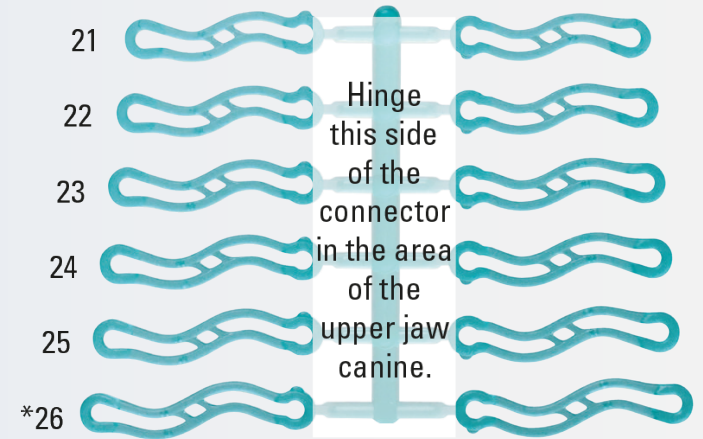


**without** construction bite: measured, 23 / 25 mm

connector, 22 / 24 mm

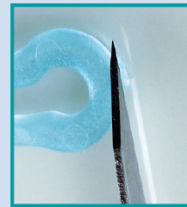
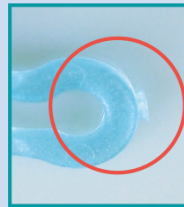
**with** construction bite: measured, 23 / 25 mm

connector, 23 / 25 mm



\*The 26 mm connector is used when the patient despite of bite taking does not tolerate the advancement.

Finishing



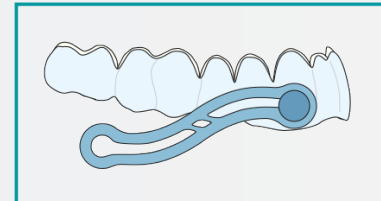
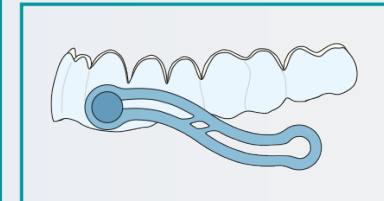
**12.** Remove sharp cutting edges!



**13.** Hinge the connectors into the long slot and pull it into its final position.



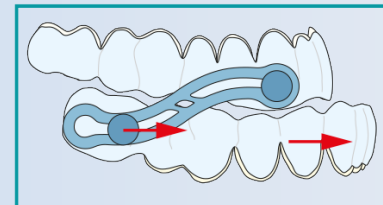
**14.** Observe upper jaw canine side of the connector.



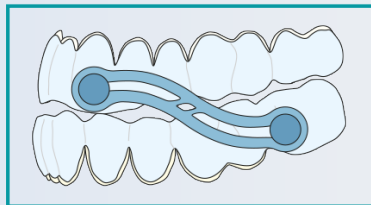
Upper jaw, obligatory run of the connectors, on the left and right.



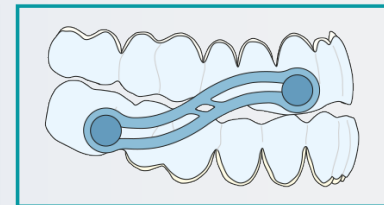
**15.** Hinge the connector into the other splint. Please check correct positioning of the splint. In case of propulsion movements (feed) the ...



**16.** ... connector shall slide out of the anchor of the lower jaw, see picture, if not, hinge the connector about-face.



Connected splints, obligatory run of the connectors, on the left and right.



**17.** Now cut the retaining lips off the anchor. Finished.

## Fabrication

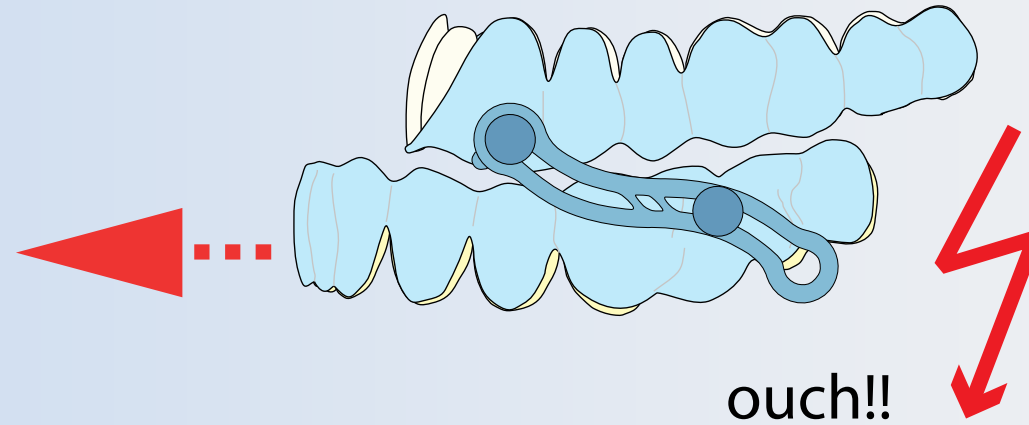
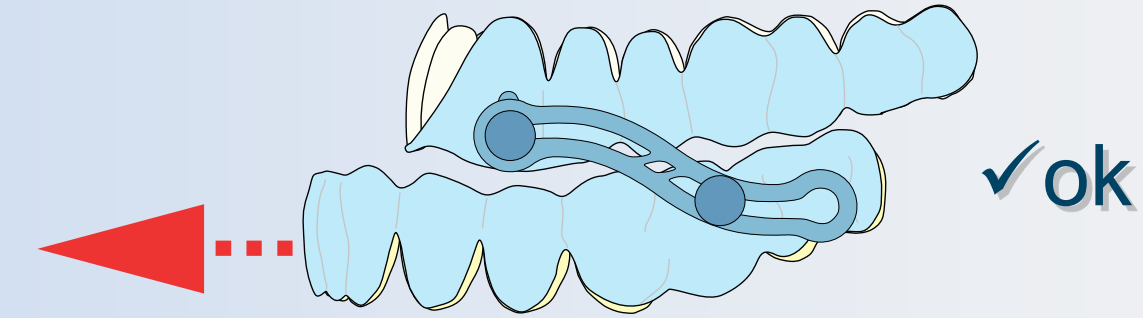
Correct fixation of the connector

The sliding end of the connector is always placed at the lower molar area.

The fixation as shown in the upper picture is correct.

The fixation as shown in the lower picture is wrong, it may cause pain at the gingiva during sudden protrusion movements.

Also there is a risk that the connector may jump out of the anchor, due to sideward moving when sliding on the gingiva.





Thank you for your attention.

