

Treatment of Sleep Apnea with Herbst Mandibular Advancement Splints

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Abstract

Sleep apnea and obstructive sleep disorders represent a danger for the cardiovascular system and metabolism. They also give rise to somnolence, which can cause accidents at work or road accidents. Along with positive pressure ventilation, oral mandibular advancement devices are today regarded as reliable forms of treatment. Unfortunately, not all patients adhere fully to the treatment, particularly over time. Some even abandon it entirely. The reasons generally put forward to explain this poor compliance are discomfort, pain, occlusal problems and poor psychological disposition (Figure 1). Orthosis over three years showing the high levels during the first months of treatment.

Keywords: Obstructive sleep apnea; Mandibular advancement device; Compliance; Manufacture

Analysis of Publications 2004-2011

Twenty-three referenced articles concerning the efficacy of the Herbst appliance for the treatment of obstructive sleep apnea have been studied: Table 1 lists a selection of articles on the Herbst appliance, presented methodologically [1-25]. Also listed are three doctoral theses presented in two French medical schools (Table 2) [26-28]. Table 3 lists 23 articles presented in terms of efficacy of treatment of respiratory disorders. A summary report on the subject of sleep presented to the French Ministry for Health and Solidarity in December 2006 (Appendix Ch. 2.2.3.), concluded in these terms: "Currently only made-to-measure orthosis have proved their efficacy in controlled trials. Herbst mandibular advancement splints, used in orthodontics since 1980, remain the most widely- studied systems."

This review of the literature is illustrated by the captions accompanying figures derived from these articles (Figures 2-12); adverse and parasitic effects: the discomfort caused by the Herbst advancement splints is no different from that described with other types of oral orthosis or with ventilators. But, unlike other models [29], they remain well positioned on the teeth.

While TMJ pain is only temporary, tooth pain persists if it is linked to the initial state of the mouth or to movements caused by the orthosis. Pain in the facial muscles is more often the result of poor adjustment of the amplitude of propulsion. As for breakages, they are due to faulty manufacturing methods (Table 4).

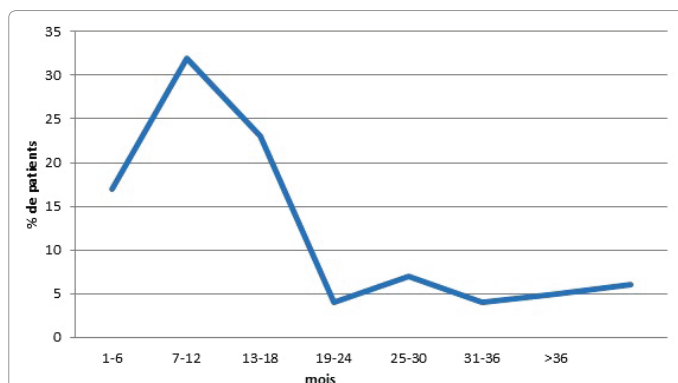


Figure 1: Curve of compliance with treatment by mandibular advancement.

Prescriptions and Contra-Indications

The economic filter

Patient selection represents a radical approach to the reduction of failures of compliance. The difficulty is to find an infallible method to avoid excluding patients with a favourable profile. In France, the conditions for reimbursement of costs are laid down by law: patients can only benefit if the treatment by orthosis:

- is second-line treatment (after refusal of CPAP);
- is first-line treatment for an index of between 15 and 30,
- without excessive somnolence or severe cardiovascular comorbidity;
- and is prescribed by a sleep specialist. However, no provision is made for the reimbursement of dental and stomatological procedures and consultations!

The Initial Dental State

Today, too many orthoses are still prescribed despite the presence of periodontal disease, dislocation, desmodontitis, ankylosis of the temporal-maxillary joints, multiple missing teeth, broken or carious teeth, etc. According to Petit et al. [30], 50% of patients requiring an orthosis have periodontal abnormalities, 31% have more than 10 missing teeth and 20% have bridges that complicate the insertion of an orthosis. More than 50% of patients present with malocclusions that expose some of them to a risk of irreversible occlusal modification caused by the side effects of the orthosis: subjects in Class I, Class III and with overbite are more at risk than those in Class II without overbite.

Since more than 50% of the population suffers from occlusal asymmetry, and since some cases of hyperdivergence can easily be worsened, the widespread use of advancement devices is not without certain consequences. After being worn for some time, mandibular

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SL No.	year	1 st author	Orthotics	Comparators	Pop.	Study type	NP
1	1994	Eveloff	Herbst	PSG	14	12 m, Retro.	CIII
2	1994	Sjöholm	Herbst/Relax musc	PSG, n acriv	12	2 m, Prosp.	CIII
3	1999	Johal	Herbst	Cal. aérien	37	Prospect.	CIII
4	2000	Bloch	Herbst/monob./T	PSG, subj.	24+T	156j, Random.CO	BII
5	2000	Shadaba	Herbst	satisfaction	132	2 m, Retrospect	CIV
6	2000	David	Herbst/posit/QuietK	PSG, ronfl.,ceph.	15	cephalometry	
7	2000	Clark	Herbst	Ports Ef. parasites	65	Investigation	
8	2001	McGown	Herbst/silensor	PSG	166	22 m, Retrospect	CIV
9	2001	Fritsch	Herbst/piece	Effets secondaires	24	30 m, Prospect.	CIII
10	2002	Pételle	Herbst/prototype	PSG	7	12 m, Pilote	CIII
11	2002	Millman	Herbst/piece	PSG	45		CIII
12	2004	Fleury	Herbst	PSG	40	17 m, Prosp.	CIII
13	2005	Johal	Herbst	endoscopie.	19	25 m, Cohort Prosp.	CIII
14	2005	Lawton	Herbst/block dick	PSG, subj.	16	15 m, Prosp, Non randomisé	CII
15	2005	Battagel	Herbst	Mvt. dent.	192/30	42 m, Retrospect.	CIII
16	2005	Battagel	Herbst	Endoscopie	27	Cohort.	
17	2006	Johal	Herbst	Effet /Qual. de vie	120+95t	25 m, Non random	CIII
18	2007	Johal	Herbst	Electromyo.	107 (T)	25 m, Cohort	CIII
19	2007	Itzhaki	Herbst	oxymétrie	16+6t	12 m, Prospect.	CIII
20	2010	Martinez	Herbst/piece	effets secondaires	50	Retrospect	
21	2011	Barros	Herbst	association avec trait odf	16 de 840 de 9 à 14 ans	12 mois, Multic.	CIII
22	2011	Johal	Herbst	Psycho-social	75 (40+T)	3 m, Prosp.	CIII
23	2011	Vezina	Herbst/PPC/Narval	PSG, mvy dent, lg.	162/50	24 m,Retrospect.	CIII

Table 1: T: control population; CO: Crossover; PPC: Continuous Positive Airway Pressure (CPAP); PSG: Polysomnographic Results (apnea-hypopnea index, oxygen saturation, etc.); Somn: Subjective Somnolence Test; NP: Level of Evidence; A1: Randomized, Null Hypothesis Rejected less than 0.05; BII: Randomized with Errors Deriving from Volume Studied; CIII: Competitor or Non-randomized Cohort; Historic or Non-randomized Cohort; CV: Case Series.

SL No.	year	Author	University	Title
1	2002	Pauron	ParisVI	Traitement du syndrome can be triggered by the type of drugs that are available in the following areas: 6 cas 7 témoins, 1 an.
2	2003	Roussel	Rouen	Search for cephalometric factors predictive of the effectiveness of a mandibular prosthetic orthosis (Herbst rods) in the treatment of obstructive sleep apnea syndrome in adults, 8 cases over 50 months,
3	2004	Lavis	Rouen	Cephalometric and polysomnographic analysis of 32 patients with moderate obstructive sleep apnea syndrome treated with Herbst's mandibular advancement orthosis. 32 cases, 15 paired, over 53 weeks.

Table 2: French dissertations on the Herbst appliance.

advancement orthoses modify occlusion, according to Almeida et al. Doff et al. [32], the most visible man-ifestation of these changes is the advancement of the lower teeth. While these movements may be beneficial for some subjects who are initially in Class II, for the others (44.3%) they cause permanent discomfort. Over a period of 5 years this is alleged to be the main cause of abandonment of treatment by mandibular advancement splints. Pancherz and Hansen [33] sought to reduce these parasitic movements by changing the support, but without success. Weschler and Pancherz [34] noted that whether they were cast or banded, splints always induced this movement (11.8° W 3.7° for the former, 9.3° W 2.9° for the 107 latter).

Psychological Acceptance

The articles in this selection concern samples of patients who were previously treated with CPAP ventilation. It is not surprising that this category of patients, emerging from a situation of treatment failure, should be more inclined to abandon this new treatment too. And yet it is this population that is given priority by the law in France for access to refunding of medical costs (second-line treatment)! In the context of treatment for sleep apnea, Poulet et al. [35] identified two predictive variables that would make it possible to avoid 85.7% of cases of discontinuation of treatment. These are patients' perception of their state of health, and their mental state (depression test) [36-40].

Prevention of Discomfort and Device Fragility

Complaints

Surveys of apnea sufferers treated with splints highlight the following complaints:

- Transient complaints: TMJ pain, pain in masticatory muscles, poor stability of the device, discomfort caused by lower pivots, hypersialosis;

- Long-term complaints: dry mouth, tooth pain, occlusal problems, mobility of teeth.

Standing grievances:

- Dry mouth

- Toothache

- Occlusal genes

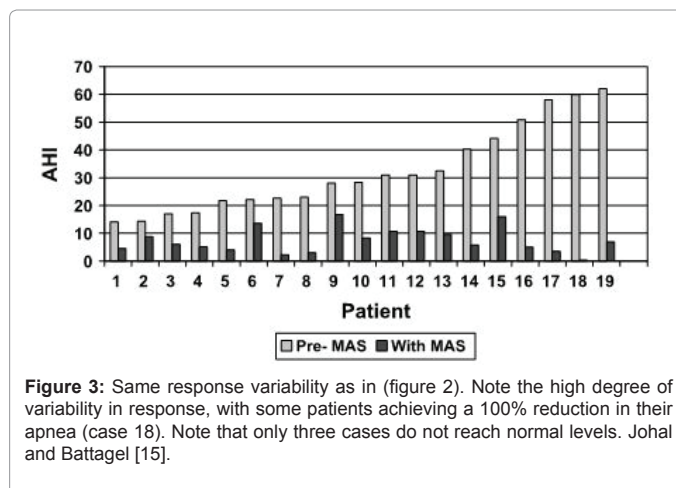
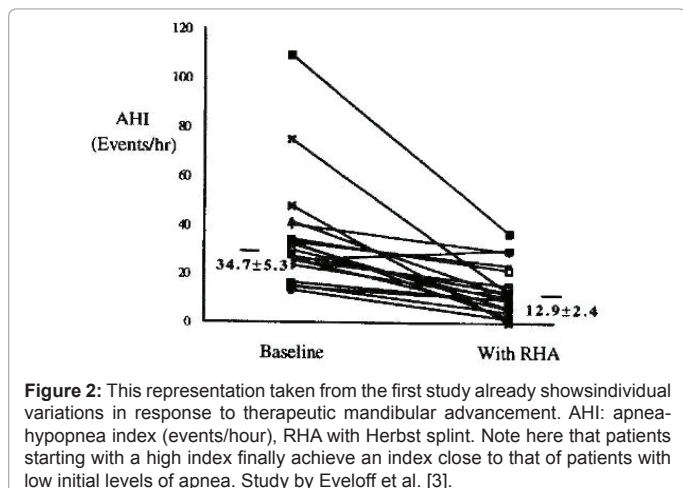
- Tooth mobility

The information obligation: Considered as "knowing", the practitioner is legally obliged to inform the patient of the disadvantages and ways to address them. The marketing of any laboratory does not absolve the practitioner's professional responsibility [41-43].

SL No.	Author	Conclusions
1	Eveloff	42% success. A mathematical procedure can predict the respiratory therapeutic effect
2	Sjöholm	The Herbst has a much more effective action than the muscle relaxation device from a 50% propulsion. Action on oxyhemoglobin desaturation, respiratory permeability and body movements).
3	Johal	The nocturnal advancement of the mandible would avoid glosptosis, knowing that the base of the tongue tilts the epiglottis and diminishes the entry orifice of the pharynx. This forced movement initiated by the orthesis would have a mechanical role in the reduction of the pharyngeal collapse.
4	Bloch	The overall success of Herbst's orthoses is 66%, no difference between Herbst and monobloc
5	Shadaba	The most relevant argument in favor of endobuccal orthotics remains its acceptance by patients, in particular in relation to PPC ventilation
6	David	The average apnea-hypopnea index and snoring decreased significantly.
7	Clark	Efficiency of 50%, but less than the fan.
8	McGown	Long-term behavior questionnaire showing discontinuation of treatment.
9	Fritsch	Pneumosomnographic results satisfactory after 30 months
10	Pételle	71.4% of patients are fast with an index of less than and less than 20 per hour and 42.9% less than 10.
11	Millman	Postponed results that reported that 45 randomized patients giving favorable results and side effects
12	Fleury	Symptomatic benefits of progressive mandibular advancement.6 of 40 patients who rejected the use of ventilation showed improvement. The activation of the propulsion was progressive. For 18.2%, a limited response was observed (AHI, 21 ± 11 events per hour, snoring, $88 \pm 15\%$, ESS drowsiness, 6 ± 3). 25% were motivated (21 ± 10 events per hour) despite resolution of symptoms, while 20% had persistent symptoms (despite a normal measurement at 6 ± 2 events per hour). After an average duration of 17 ± 4 months, 34 patients reported that they used OA 5 ± 2 days per week for $89 \pm 19\%$ of their sleep time.
13	Johal	On 44 patients an increase in the lateral pharyngeal dimensions is observed very significant. There was an improvement in airway opening and snoring. In conjunction with a reduction in the apnea-hypopnea index from 28.1 to 6.1. Oxygen concentrations were higher the orthesis in place. They found a reduction in HAI of 28.1 to 6.1, $P < 0.001$ and improvement in somnolence was highly significant.
14	Lawton	HERBST orthotics have proved to be more effective than Twin-block devices in reducing somnolence ($p=0.04$). No significant difference in orthotics apnea index ($p=0.71$), snoring frequency ($p=0.49$), oxygen saturation ($p=0.97$), arterial pressure
15	Battagel	Mean significant decrease in mean apnea-hypopnea index (from 28.1 to 6.1, $p < 0.001$).
16	Battagel	Effect of propulsion on the oropharyngeal airway, the soft palate and the position of the hyoid bone.
17	Johal	Significant differences in energy vitality ($P=0.001$) and physical domains of role limitation ($P=0.025$) following 4 months of treatment with an orthosis.
18	Johal	Role of the mandibular advancement on the manducatory musculature initiated by the orthesis. Increased myoelectric activity would play a role in increasing the airway diameter (related to displacement of the hyoid bone).
19	Itzhaki	There is a correlation between the decrease in the apneic index and the oxygen concentration in the blood due to mandibular propulsion.
20	Martinez	Work on side effects
21	Barros	Study of changes in sleep patterns in retrognathic adolescents (free of adenopathies) during their orthodontic treatment. Improved breathing and snoring. Significant increase in nasopharyngeal, oropharynx and hypopharyngeal gauges
22	Johal	Psychosocial improvement (confidence intervals of 0.26 (0.09, 0.75) and 0.36 (0.14, 0.92) respectively for somnolence and energy of vitality, (significance of mean points of somnolence (10 [1 to 18] 1 to 14] P and energy/vitality domain (18 [7 to 20] to 19 [14 to 20] The mean apnea-hypopnea index increased from 16 [5.2 to 30] to 4.6 To 17.2] SO_2 from 11 to 0.
23	Vežina	The objective and subjective effectiveness of Herbst's "compression" rod mechanics is no different from that obtained with "stretching" devices.

SL No.	Name	Conclusion
1	Pauron	Effectiveness in decreasing confirmed HAI; Side effects: dry mouth, dental and musculo-facial pain, dental displacements (10th of mm).
2	Roussel	Effectiveness in decreasing confirmed HAI; Side effects: dry mouth, dental and musculo-facial bread, dental displacements (10th of mm). onfirmée; Side effects: dry mouth, dental and musculo-facial pain, dental displacements (10th of mm).
3	Lavis	Decreased IAH by -5.6 ± 10.2 , (for 44% of the sample), advancement of the palate, increased pharyngeal space. No break was observed

Table 3: Data similar to those of Table 2 presented according to respiratory efficacy.



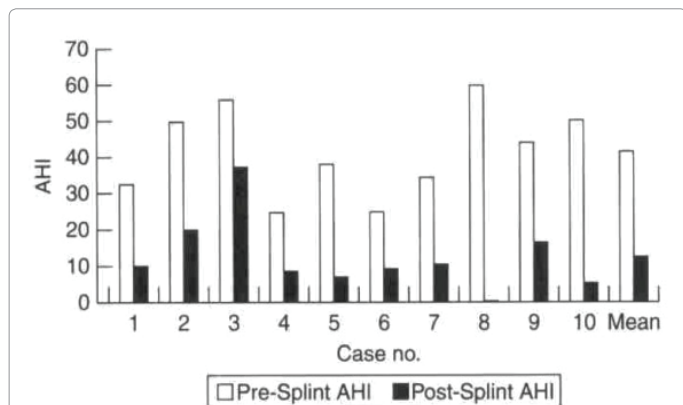


Figure 4: Table showing equally variable responses in 10 cases randomly chosen from a total of 132. Here again three cases do not reach normal levels, but the sample initially suffered from high levels of apnea Shadaba et al. [7].

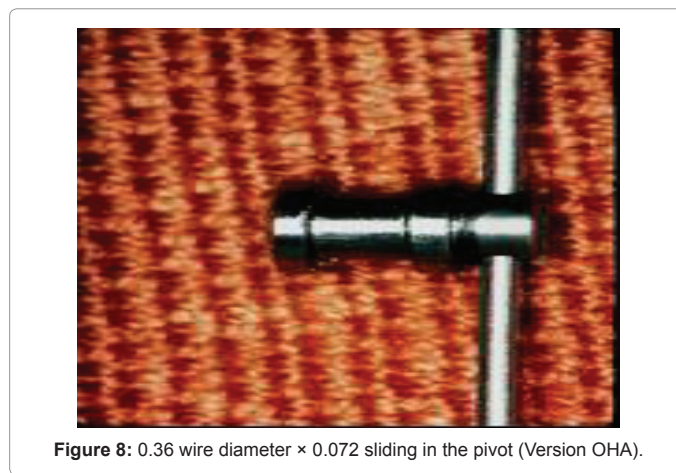


Figure 8: 0.36 wire diameter x 0.072 sliding in the pivot (Version OHA).

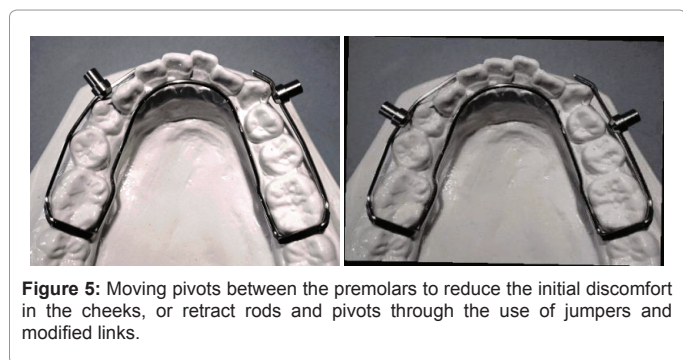


Figure 5: Moving pivots between the premolars to reduce the initial discomfort in the cheeks, or retract rods and pivots through the use of jumpers and modified links.

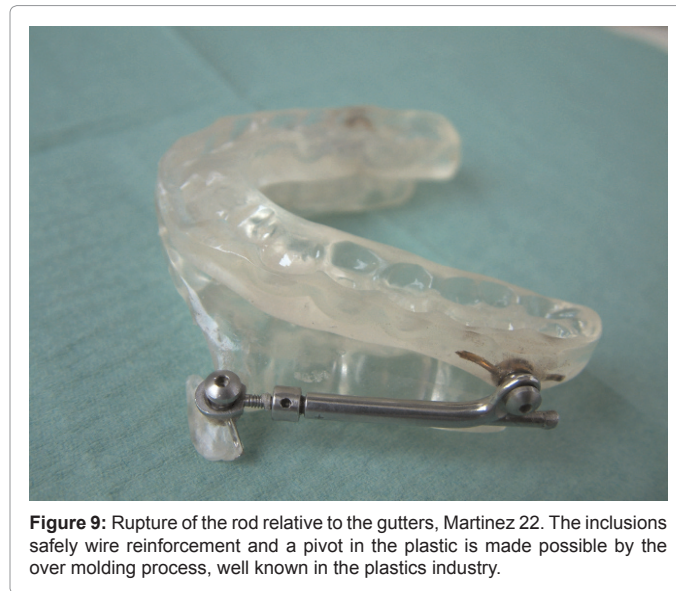


Figure 9: Rupture of the rod relative to the gutters, Martinez 22. The inclusions safely wire reinforcement and a pivot in the plastic is made possible by the over molding process, well known in the plastics industry.

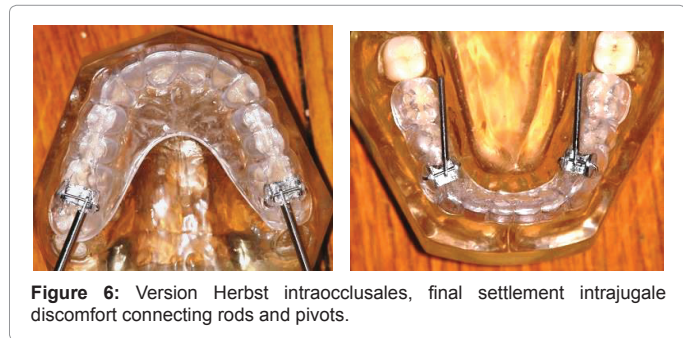


Figure 6: Version Herbst intraocclusales, final settlement intrajugale discomfort connecting rods and pivots.

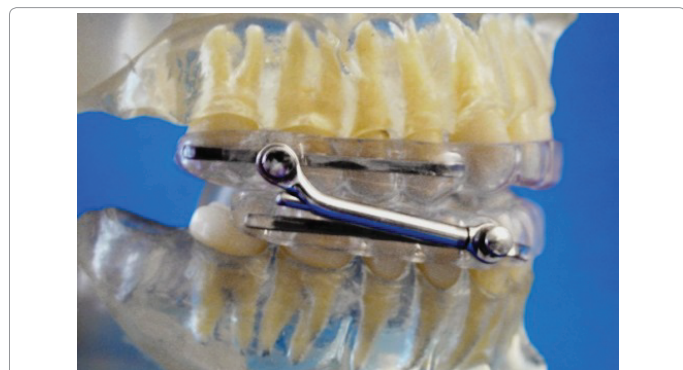


Figure 7: Orthosis progress by lower stop on the model of E. Herbst (OHA view) associated with the process of inclusion during thermo forming to eliminate the risk of desoldering, the reinforcing wire is slipped into the pivot.

Technical support

Patient comfort must be sought carefully at the first appointment. To eliminate the pains of ATM and musculature, nothing is more effective than activating the propulsion gradually. Thus, the masticatory muscles and the back-meniscal ligaments have time to become accustomed without painful reaction [44]. Postherpetic expressed in many articles (Bloch, Evenoff, Clark) could be prevented by reducing the magnitude of the propulsion from the start of treatment. Also in those first moments, the practitioner should be concerned about the retention of the orthosis: too maintained, it will require grinding; too loose, it will require a reline. A special care should be given to the adaptation of the lower lip opposite the pivots. With some forms of arches and adjacent tissues, it will not hesitate to change the location of these pins:

The manufacturing process: Breakage, lack of retention or unexpected discomfort always originally a development error. The meta-analysis of 36 Ahrens 2010 (of 1475 references) joined our opinion, “The success and subjective input depend on a variety of factors including the type of material, technical or manufacturing model devices individualized to determine the propulsion.”

SL No.	Author	Conclusions
1	Eveloff	Discomfort at the ATM level and dental pain.
4	Bloch	Pain and discomfort of ATM, masticatory muscles and teeth
5	Shadaba	32% experienced occlusion disruption, 36% drought, 38% had ATM pain initially, 23% experienced discomfort in the atm, 35% facial discomfort, 35% Dental pain
6	David	Strong correlation between the change of the supraclusion index and ANB.
7	Clark	37% dental pain, 26% disturbance due to change in occlusion, 41% dryness, 30% feel discomfort at the atm after, 23% ATM pain,
8	McGown	49 users out of 166 complained of side effects, 67 that they snored less (p: 0.001), 97% were effective even after shutting down the device. The reasons why patients no longer bore the orthosis were: pain (52%), perceived efficacy (10%), social circumstances, dental treatment. 13% disruption of occlusion, 10% hypersialorea, 38% feel discomfort at the level of discomfort 36%, gene during sleep 16%, bad port related to discomfort 23%.
9	Fritsch	Mucosal dermatitis (86% of patients), dental discomfort 22%, dental pain (59%), hypersalorectal pain (22%), ATM pain 22%, muscle pain 22% Dental displacements: upper incisors / occlusal plane: $-1^{\circ} \pm 2^{\circ}$ after 12 to 30 Months (0.05 of p). Incisive overlap and overhang: -1 mm identical minor effects for both types of appliances
10	Pételle	Interest in regulating the mandibular advancement during the patient's fall asleep for an optimization of the polysomnographic responses.
14	Lawton	No significant difference between the two devices regarding quality of life or side effects. 5 preferred the Twin-block, 9 preferred the Herbst.
15	Battagel	Vertical and horizontal change of the incisors of 0.4 mm, correlated with an increase of the overlap, the two effects being independent of the amplitude of the propulsion.
17	Johal	A difference in energy vitality (p: O, O1) was observed following the 4 months following treatment. Orthotics have a significant effect on a limited number of quality of life domains.
20	Martinez	Subjective, permanent, transient, permanent effects over 5 years: No effect on TMJ but permanent occlusal changes.
21	Barros	Good adhesion due to fusion with orthodontic treatments.
22	Johal	Significant improvement in several emotional, physical, quality of life, vital energy perception indicators.
23	Vezina	No difference was found between MAA for subjective and objective side effects, except in an uncertain manner, greater early masticatory muscle pain (p=0.02) and residual tongue pain (p=0.04) In the compression group.

Table 4: Presentation according to complaints expressed by patients.

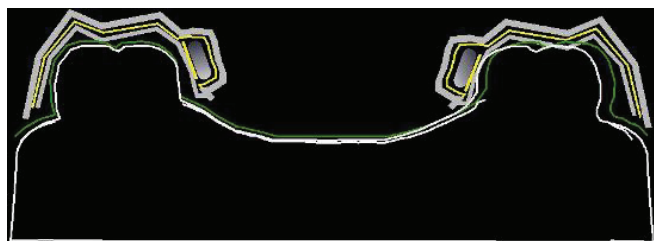


Figure 10: Gray two thermoformed sheets, the black son of reinforcing and pivots, yellow PMMA resin binder, Amoric 37



Figure 12: The diameter of the upper eyelet to the pivot allows lateral beating of branches sufficient for maximum comfort.



Figure 11: Differential between the thickness of the branches and the pivot allowing sufficient movements. The grommets are of a larger diameter than the pins to enable the lateral excursion mandibular and ensure a comfortable fit of the orthosis by the patient (v OHA).

Also remember a manufacturing protocol bringing more unreliability:

- To secure the inclusion of son and pivots, the molding technique can be used using two plates: a first formed on the model is 0.5 mm thick and a second 1.5 mm thick.

- This way allows to include completely metal and resin filling between the two thermoformed sheets. In addition, it eliminates contact between the lining and metal for comfort.
- The titration is done by reducing the length of tube or by setting calettes crimped on the axis.

Note, finally, that all the authors propose to add vertical elastic rods on the gutters to force the patient to close the mouth.

Implementation and Monitoring Treatment

The Church of study 38 concludes by noting that one-day training for a general is sufficient to control it. (Success rate 48%). Any pain, any discomfort may result in discontinuation of treatment, especially in the absence of motivation by a practitioner. A decreased range of propulsion as the grinding sound associated with a few words of comfort can go a tour status to failure.

Conclusion

If Herbst updated on gutter device is a generic method for reliable and proven mandibular propulsion. Also, the main failure of treatment with orthoses Herbst is not medical but behavioural, by

patient membership loss. It is on this crucial point that the expertise and knowledge provide the practitioner, came to the fore. Without controls, parasites tooth movement can occur and develop. How to eliminate injuries, pain and discomfort without careful control? How to avoid the abandonment, without encouragement and information from the practitioner? How to conduct suitable treatment with a faulty initial dental condition? How not to expose themselves to major failures without following a reliable and rigorous manufacturing process?

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