

REVIEWS

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Tongue Function Correction Appliances. The Current State of Knowledge and Therapeutic Possibilities Including a Device of Own Design – Review of the Literature

**Aparaty korygujące funkcję języka.
Aktualny stan wiedzy i terapeutyczne możliwości
z uwzględnieniem aparatu własnego projektu – przegląd piśmiennictwa**

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation;
D – writing the article; E – critical revision of the article; F – final approval of article

Abstract

The appropriate scheme of the development and articulation of the whole dental system is determined by the right development of physiological functions. The subject of muscle homeostasis has been analyzed by many researchers. Forces exerted by the tongue, lips and cheeks influence occlusion. In terms of muscle balance, clinicians all agree, the lack of it leads to the development and consolidation of malocclusion. Moreover, it is stated that only treatments following a procedure which incorporates muscle activity in the oral-facial complex have a positive therapeutic effect and stable treatment results. The aim of this research was to describe the available fixed and removable appliances used for tongue dysfunction treatment. In addition to the presented, pre-existing tongue cribs, the authors' original TPC (Tongue Position Changer) device was also included. In this article the devices used for the treatment of tongue malpositioning and tongue function correction were discussed and systematized. The shape, structure and application together with the treatment time and results were taken into consideration. Tongue cribs are the documented tongue dysfunction treatment method with special regard to partial anterior and lateral open bite at the time of late deciduous, mixed and permanent dentition (**Dent. Med. Probl. 2015, 52, 2, 227–234**).

Key words: open bite, dental spurs, tongue crib appliance, swallowing.

Słowa kluczowe: zgryz otwarty, aparaty korygujące funkcję języka, polykanie.

Tongue dysfunction (oral-facial dyskinesia), i.e. inappropriate tongue rest position and its position during swallowing, can be observed among 100% of patients with partial anterior open bite and also among those with anterior-posterior and vertical dysfunctions [1–6]. As stated in scientific literature, a tongue dysfunction most often leads to open bite in the frontal part. It is a distortion of complex etiology, caused by both innate and environmental fac-

tors. It is developed by the above-mentioned tongue dysfunctions as well as by genetic factors, the adverse patient's height, the oral air tract connected with tonsillar hypertrophy, a deviated septum, narrowing of upper airways, impaired neuromotor tongue function, finger or teat sucking and inappropriate position [7–21]. The etiology of inappropriate tongue rest position and its position during swallowing is complex and requires further study.

A sucking habit is noticeable in the 14th week of a fetus' life. During the first period of the infant's life this reaction is dominant. Its impairment can be observed between the 6th and 7th month of life, when it is gradually replaced by mastication movements. This should happen in parallel to the changes in diet. It disappears between the first and second year of life and transforms the infantile (immature, visceral) swallowing type into an adult one (somatic, mature) [22]. In the available academic literature, there are discrepancies between the time of the change of infantile swallowing into somatic. According to Masgutowa and Regner [22], the change of swallowing type appears in the 16th month of life. It is due to the eruption of milk canines. The adult swallowing type, as Orlik-Grzybowska [23] states, is developed between the 2nd and 3rd year of life. Graber [24] claims that it happens at the soonest between the 3rd and 4th year of life, and most often between the 9th and 10th. In research conducted by Proffit et al. [25], it was found that the adult swallowing type is formed around the 3rd year in some children, but in the 6th among the majority. Author also observed that among around 10–15% of children, the somatic swallowing type is not developed at all.

The frequency of swallowing, according to different authors, varies between 1000 and 2000 times per day [8, 10]. The tongue apex, during the adult swallowing type, is placed on the hard palate, next to the papilla incisiva. It should not touch the palatal/lingual surface of either the upper or the lower incisors whilst during the infantile act of swallowing the tongue is located in-between the incisors and presses them for 1 to 3 seconds [8, 10, 11]. It gives a total contact time between 60 and 90 minutes a day and, according to Justus, it is enough to become the main factor leading to malocclusion [8]. Feu et al. [17] adds that a force of small volume but frequent occurrence can contribute to the creation of such deformations. Tongue thrust during the swallowing act and also its frontal resting position can be the cause of anterior open bite. That is why the modification of tongue position may have a crucial influence on the stability of therapy effects. Proffit et al. [25] presents a slightly different approach, negating the influence of inappropriate swallowing tract on the formation of orthodontic problems. This author points at limited contact time between the tongue and teeth in the above-mentioned activity. However, he noticed a deforming influence of incorrect resting position. When a tongue adjusts to existing conditions, it creates an anterior seal. This prevents food from coming out of the mouth while eating [25].

Despite some differences in opinions regarding the etiology of open bite, clinicians are unan-

imous that this defect is difficult to treat and long-term therapeutic effects cannot always be achieved. Research results presenting a relapse in treatment suggest that the described tongue dysfunction may cause the failure [26–28]. Cribs, defined as appliances that change the position and function of the tongue, are acknowledged to be one of the effective methods of treating this abnormality. Parker [29] and Rogers [30] were the first who used tongue crib appliances. They proved that, apart from their main usage, tongue cribs also help fight the finger, lip and object sucking habit. These appliances make the results of partial open bite treatment stable and long-lasting.

The aim of this research was to describe the available fixed and removable devices used in tongue dysfunction treatment. In addition to the presented, pre-existing tongue cribs, the author's original TPC (Tongue Position Changer) device was also included. The analyzed material comes from the National Center for Biotechnology Information (NCBI), Medline, Embase and Pubmed. The sample contained 37 publications issued between 2000 and 2014. The key words entered to the browser were: tongue crib appliance, dental spurs, open bite, orthodontics, swallowing and their Polish equivalents: zgryz otwarty, połykanie and ortodoncja.

With regard to the type of fixing in the oral cavity, the appliances for tongue function correction can be divided as follows:

- Components of additional elements for plate appliances such as: wire cribs, acrylic cribs and tongue practice beads.
- Components of a self-standing element soldered to orthodontic rings and placed permanently on the first molars.
- Components of a self-standing element glued directly to incisive upper and lower teeth.

Devices Composing Additional Elements of Appliances

The cribs made of metal or acrylic or in the form of a tongue bead are mounted in removable appliances to an upper or lower plate of the device, depending on the patient's needs. It is necessary to take detailed impressions so that the crib is precisely adjusted by a technician [2, 3, 19]. A crib made of 0.8 mm steel wire has an accordion shape, stretching from the right canine to the left one. There are usually 6–8 bends of heights around 15–25 mm. The height depends on individual conditions in the oral cavity. The crib can-

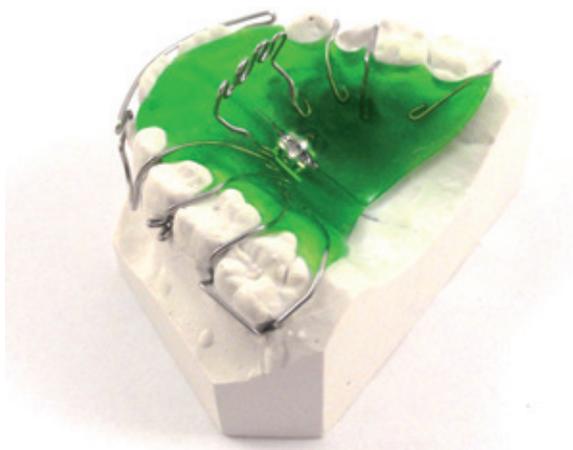


Fig. 1a. Crib made of metal



Fig. 1b. Acrylic crib

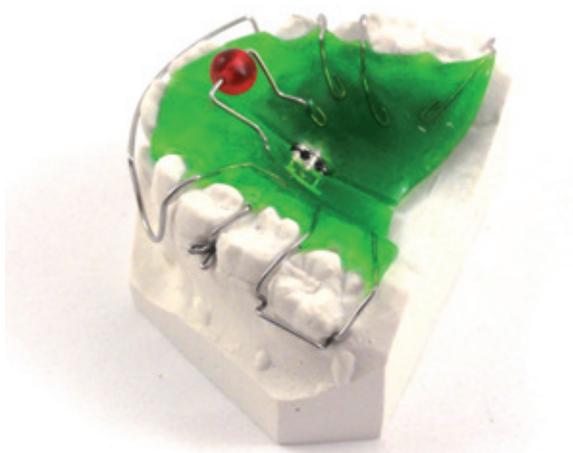


Fig. 1c. Bead for tongue exercise

not touch the palatal/lingual surfaces of either the upper or the lower teeth. It runs up to 15 mm posteriorly to the upper incisors. The crib should be constructed in such a way as to not distract occlusion and to not cause bedsores on the mucosa [19]. In the middle intersection of a crib, there is a screw to widen dental arches. A tongue bead and

acrylic cribs can only be used as a part of the upper plate of an appliance. Fixing rules, retention elements and additional elements do not differ much from those applied with wire cribs. This type of a crib is additionally bisected along the middle line. Otherwise, the activation of a screw would be impossible. Therapy with the use of a tongue practice bead is based on the everyday, several-minute practice of putting the tongue apex on an acrylic bead and, without disconnecting the tongue from the bead, the patient should exercise swallowing of saliva. Patients are instructed to wear the devices presented above for 18 hours a day. It is advised to remove them only for eating and brushing the teeth. Minimal therapy time is around 14 months (Fig. 1a–c).

TPC (Tongue Position Changer) Appliance

This new device was created to correct tongue malpositioning and tongue functions with minimal engagement required by the patient. The aim was also to eliminate placing the tongue over or under the crib. This phenomenon was commonly observed when wire or acrylic elements were used. It happened due to the incommensurate length or inappropriate shape of those elements. This led to the continuity of a habit – in the resting position, the tongue was still placed between the teeth or the touched surface of the lower incisors and held in an anterior position. The therapy did not provide any effective results despite long-term treatment. The use of palatal plates with practice beads requires a great patient's engagement. The treatment includes a few steps and is based on everyday, several minutes' practice of putting the tongue apex on an acrylic bead and without disconnecting the tongue from the bead, a patient should exercise swallowing of saliva. Speech therapy exercises are also recommended (Fig. 2 a, b).

The original concept of an additional element relies on adding an acrylic tunnel (a ramp) to the upper, active palatal plate. It aims at directing the tongue position into the frontal part of the palate, just behind the upper incisors. The tunnel from the outside has a half vertical course in the direction of the lower molars. When viewed from the side, the ramp stretches up to the premolars. In the case of lateral open bite treatment, there is a possibility of widening so that it embraces molars. The ramp is designed in such a way that it touches the bottom of the oral cavity but at the same time it does not touch the mucosa and does not cause bedsores. In the upper part it finishes next to a hole of diameter of 0.5–0.7 mm cut in the upper plate in the section of the papilla inci-



Fig. 2a. TPC appliance



Fig. 3a. TPC appliance with lip bumpers

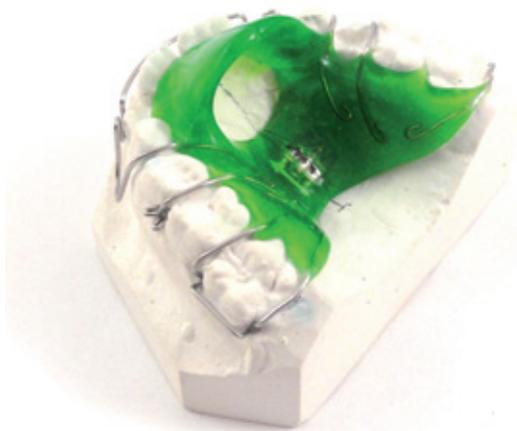


Fig. 2b. TPC appliance



Fig. 3b. TPC appliance

siva. A TPC device can be fitted in an extension screw located on the palate, with wire retention elements and lip arch according to a dentist's measurements. It can also be equipped with additional wire and acrylic elements depending on the individual treatment plan. Those elements include, among others, springs, lip bumpers, slopes used to correct crossbite, etc (Fig. 3a, b).

The tunnel for the tongue was mainly created for the upper palatal plate, but can also be used as a part of other removable devices. The results, based on our observations, show that it can successfully support a therapeutic effect in terms of an appropriate tongue resting position, while swallowing and re-education of speech. Additionally, the appliance is perceived by patients as more comfortable in comparison to the devices equipped with wire cribs that limit the freedom of tongue movement. These tunnels create support for the device and shape a new posterior position. They do not require any modification during treatment, contrary to wire cribs that need to be cut or splayed to not limit extension of the appliance during screw activation. Distinctively from the above-mentioned devices, the appropri-

ate position is forced by the ramp from the moment of fixing the appliance in patient's mouth, without his awareness of this fact. In the remaining types of cribs, such a possibility does not exist. Undoubtedly, it can be considered as an enormous advantage.

The appliance has been positively approved by the Department of Orthodontics, Medical University of Łódź, Poland. It is claimed to fulfill its function properly and to be safe for the patients treated in the Dentistry Institute. The device has also been reported to the Office for Harmonization in the Internal Market. It received a registry certification of Community Industrial Design named: Tongue Positioner, medical tool no. RCD 002522268.

According to Meibodi et al. [2] as well as Ah-rari et al. [3], a removable appliance with built-in wire crib is an effective method of malocclusion treatment when this defect is caused by complicated tongue dysfunction. Depending on the place where the device is fixed, i.e. on the upper or lower plate, it is possible to provoke anterior mandible or dental complex movement as a result of transferring the pressure which is produced by the tongue in a resting position and being leaned against the

crib. Meibodi et al. [2] treated 23 patients at the average age of 10–11 years who had distocclusion with incisor protrusion, tongue thrust and anterior open bite with this type of appliance. These authors achieved the following: correction of facial features, retraction of upper lip, decrease of lip tension due to retraction of upper incisors and significant anterior mandibular movement. Minimal treatment time was 14 months and 6 days when the appliance was worn for 18 hours a day [2].

Ahrari et al. [3] recommend reverse placing of a crib, i.e. on the upper plate, to correct class III with different intensity levels. They describe a case of an 8-year-old patient with Angle class III and anterior crossbite. A removable appliance with this modification stimulated mandible movement forward. It is especially recommended for patients with primary teeth or early-mixed dentition. Stable treatment results were achieved after 15 months of active therapy. The device could be removed only during eating and brushing the teeth [3].

The models in place up to now had to be cut along the middle line not to limit the extension of dental arches and dental bases. It caused frequent buckling and breaking of metal cribs. In the case of the suggested solution, i.e. the TPC appliance, there were no fractures. The appliance is more effective and durable. The tunnel element also provides the possibility of tongue muscle exercises by putting the tongue apex together with its body into the tunnel. It also enables exercises with a stretch-type spatula. The other objective of the TPC appliance is the opportunity to place the tongue in a different plane running forward and upward and different from the crease or muscle compression on a wire crib. Such position is more comfortable and physiologically required due to the fact that it is the actual tongue resting position, i.e. the tongue apex touches the anterior part of the hard palate [8–12, 17–19, 26–28].

Appliances Composing a Self-Standing Element Soldered to Orthodontic Bands and Fixed Permanently on the First Molars of the Mandible or Maxilla

A tongue crib placed on bands is applied in the lower or upper dental arch. In a standard version, metal tailor-made bands are attached on the second primary molars or the first permanent molars. An emerging steel wire of 0.6–0.8 mm width runs along the tooth necks of the molars and premolars. From one canine to the opposing one, the wire forms a combination of different types of cribs

varying from a shape of 6–8 bended arches to a double arch with transverse spacing bars and a single arch with spurs for the tongue. The crib should be moved 1 mm away from the palatal incisive surface of the upper teeth. The upper edge of the crib placed in a patient's mouth, when dental arches are closed, reaches the mandibular teeth from the lingual side and goes to the edge of the gingiva behind the lower incisors. The appliance should not impair occlusion. To prevent this, a wax occlusal record is taken from the patient. In this type of a device, it is advisable to place the tongue just behind the crib during the act of swallowing as well as during the tongue resting position [8–12, 17–19].

The therapy of such type usually lasts between 18–24 months and is divided into 2 or 3 steps of equal length, i.e. 6–8 or 12 months: active therapy, a retention phase in which the appliance is worn for 24 hours a day, and a night retention phase [8–12, 17–19].

Hybrid Habit Correcting Appliance (HHCA) is a standard wire crib in the shape of bended arches. In the middle part, i.e. next to the papilla incisiva, it has a practice tongue bead. In the area of the molars there are U-shaped arches. The approximate treatment time with this appliance is 12 months (6 months of active therapy and 6 months of retention) [11] (Fig. 4a, b).



Fig. 4a. Hybrid Habit Correcting Appliance (HHCA)



Fig. 4b. Hybrid Habit Correcting Appliance (HHCA)

Mandibular Lingual Arch and Spurs (MASP) is a crib attached to the first molars in the lower arch. There are 6 little metal pieces of different thickness soldered to the lingual arch. Each of these pieces after mounting is adjacent to the lingual surface of 6 mandibular teeth (from one canine to the opposing one). The approximate therapy time is 14 months (8 months of active therapy and 6 months of retention) [12].

Sohinderjit et al. [10] modification is comprised of a double arch placed in the jaw. The approximate therapy time is 21 months. The active therapy lasts between 6–8 months and after that there is a retention phase of the same length. Next, the authors advise the patient to wear the appliance only during the night for another 6–8 months.

Appliances Composing Self-Standing Elements Bonded Directly to Upper and Lower Incisors

Bondable Lingual Tongue Spurs (BLTS, Tongue Tamers, Ortho Technology, Tampa, Florida, USA) are bonded to the lingual/palatal side of the incisors and the lateral mandibular and maxillary teeth. The method of positioning and placing cribs on the teeth is not very different from the one used by placing orthodontic brackets in all types of fixed appliances. The approximate therapy time is 6.5 month [14].

Lingual orthodontic (LO) are braces of 7th generation (Ormco Company, Orange, California, USA) adjusted to be bonded in a lingual method. They contain little hooks which prevent the tongue from being placed anteriorly. During the treatment, a patient is obliged to do postural tongue exercises. The approximate treatment time is 12 months [15].

The correction of the tongue dysfunction during the swallowing and rest position as well as the elimination of oral habits meanwhile leads to long-term stabilization of the anterior open bite treatment. Huang et al. [19], Justus [8] and McRea [14], who treated tongue dysfunction with the use of tongue cribs attached to the first permanent molars, confirmed these results. Huang et al. [19] ran an observation among 33 patients (26 at the age of puberty, 7 adults). All the adult patients kept the correct overbite, 17% of pubertal patients lost the appropriate contact between incisive teeth. Justus [8] applied the crib for 2 young patients (8 and 9 years) with anterior open bite and 1 adult patient (34 years) with distoclusion and incisor protrusion caused by anterior open bite. After achieving the appropriate tongue position, Justus observed

a long-term stability in the frontal part of the anterior open bite treatment. He also presents a predominance of a crib mounted to the rings over the systems glued directly to the lingual/palatal surface of the incisive teeth. In his opinion, the first method makes it possible to correct a dental arch on the level of molars [8]. It also has grapples on rings, among others, for headgear, it is cheap and easy to perform in a dental practice. McRea [14], thanks to the BLTS, gained a right overlapping of upper incisors over lower ones among 11 out of 12 patients at the age of 7–18 years with anterior open bite. Cases of the same malocclusion with tongue dysfunction treatment are also described with the use of fixed appliances. 39 patients aged 18–49 were observed during a period of 1–11 years after active therapy. Geron et al. [15] reported that the effectiveness of this method is 87.5% after 12 months. In her opinion, it gives better results than anterior open bite correction with the use of surgery or microimplants. On the other hand, the results are worse in comparison to fixed wire cribs [15]. The authors suggest that for the maintenance of results, it is necessary to retain an appropriate transversal size as well as the overjet.

In the first stage of wearing tongue cribs, both fixed and removable, patients feel a discomfort of different intensity. Araujo et al. [12] carried out surveys among patients wearing fixed cribs attached on a ring in the lower dental arch and also among patients' caretakers. 98.6% accepted the treatment method. Difficulty in speaking and chewing were the main inconveniences at the time of wearing the appliance. The esthetic aspect was also important. A metal part of the device is visible when the mouth is open. Over half of the patients described the procedure as too aggressive. The majority of subjects felt pain of different intensity lasting up to 10 days [12]. This is consistent with McRea's observations [14]. When using BLTS, patients felt discomfort up to a fortnight, but in the survey the procedure was not perceived as aggressive. There were also no problems with speaking or esthetics, because the appliance is invisible because of its position behind the dental arches. In the rest of the studies, it was assessed that getting used to the crib fixed on rings in the upper arch took from 1 to 3 weeks [8, 18, 19]. Patients reported some problems with speaking, eating and swallowing. This is consistent with Gajanan et al.'s observations [9]. He also reported tongue irritation and difficulties with keeping proper oral hygiene.

Lopez-Gavito [26] and Remmers [34] noticed a high percentage of anterior open bite relapse when the tongue cribs were not used. The former claimed that when patients were treated with the conventional fixed appliance, in 35% of cas-

es there was a relapse in the form of an overbite decrease of 3 mm after 10 years from the end of active therapy [26]. He suggested that this might be caused by inappropriate muscle work, which is why the restoration of correct tongue position and the elimination of incorrect oral habits are so important. Remmers et al. [34] achieved the correct overbite in 71% (n = 52) at the end of orthodontic treatment. In 44% of cases there was a relapse within 5 years after the procedure. Smith and Covell compared the correction of anterior open bite in patients treated conventionally and those with the support of myofunctional therapy in the form of speech therapy exercises (acc. [35]). Those exercises aimed at re-education of swallowing and strengthening oral-facial muscles. The clinicians stated that the therapy which includes the correction of tongue malpositioning and its functions, significantly influences the final treatment results [35].

One may conclude that the reason for failure in open bite treatment might be the untreated infantile swallowing type and anterior tongue resting position [26–28, 36, 37].

Conclusions

Cribs are a documented tongue dysfunction treatment method, especially with anterior open bite and lateral open bite in the period of late deciduous, mixed and permanent dentition. Permanent fixation ensures that the therapeutic effect is not dependent on the patient's full cooperation. It significantly increases the effectiveness of the therapy and long-term stability results. The cribs located in removable appliances, despite the fact they require the patient's engagement, also bring positive results. The discomfort connected with this type of an appliance is temporary and this also constitutes an advantage of this method.

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