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SYSTEMATIC REVIEW

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Orthodontic treatment in patients with atypical swallowing and malocclusion: a systematic review

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Abstract

This review aimed to analyze the correlation between atypical swallowing and malocclusions and how this dysfunction can be treated. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was followed to conduct this systematic review, and the protocol was registered at International Prospective Register of Systematic Reviews (PROSPERO) with the CRD42024499707. A thorough search was conducted on PubMed, Scopus and Web of Science to find papers that discussed myofunctional and orthodontic treatment for patients with atypical swallowing and malocclusion from 01 January 2003 to 27 November 2023. The search yielded 2554 articles, of which only 12 records were selected for qualitative analysis. The analysis of these articles revealed that orofacial myofunctional therapy, criab appliance, Habit corrector™, and soft tongue restrainers are potential therapies for treating atypical swallowing and malocclusions. The tongue's position affects muscle behavior, leading to malocclusions that can be treated with various therapies, resulting in effective clinical outcomes. However, more research is required to delve deeper into the topic.

Keywords

Atypical swallowing; Tongue thrust; Deglutition; Swallowing; Atypical deglutition; Malocclusion; Orthodontics; Speech therapy; Logopedic

1. Introduction

Swallowing is a complex physiological process involving bolus, saliva and liquids moving from the oral cavity to the stomach [1–3]. This essential function requires a sophisticated neuromuscular mechanism activated by nerve impulses transmitted by the sensory receptors of the tongue and lips [4, 5]. In infants, the tongue is positioned between the bone bases [6–9], while in adults, the tip of the tongue is located at the level of the retro-incisor papilla [10–12]. The transition usually occurs gradually over 15 months, coinciding with tooth eruption [7, 8]. However, infantile swallowing may sometimes persist when children have orofacial malformations, digit habit behavior, airway compromise, or allergies [13–24]. This condition is known as atypical swallowing (AS), a pathological condition that occurs when there is no transition from infantile to adult swallowing [25–27]. In AS, the tongue's posture is altered (Fig. 1), with the tongue's tip touching the front teeth' palatal surface or between the dental arches rather than the palate. Additionally, the back of the tongue is curved downwards [28, 29], and the base touches the back of the palate and the anterior pharyngeal wall [30, 31].

This condition results in reduced contraction of the jaw elevator muscles and increased activity of the perioral muscles (absent in physiological conditions) [20, 32–48]. Tongue thrust, along with lip sucking, nail and digit sucking, and mouth breathing, from an oral habit behavior that results in a learned pattern of muscular contractions [17, 49–53].

There are two types of AS: primary and secondary [51, 54]. Primary AS has a psychological cause and occurs when a child swallows in an infantile manner during emotionally significant moments [55]. In severe cases, psychotherapy may be necessary, mainly if the child develops habits such as thumb-sucking [5, 56–58]. Secondary AS is caused by external factors [17] such as thumb sucking, nail biting, bruxism, excessive use of a pacifier [18], prolonged artificial feeding and weaning, short frenulum, hypertrophic adenoids and tonsils, allergic rhinitis, the abnormal posture of the head, lower jaw, and tongue [16, 59–71]. This habit is often associated with malocclusions, particularly skeletal problems such as open bite, ante-inclination of the upper jaw, and post-inclination of the mandibular plane [52, 72], as well as dental issues such as diastema, protrusion of the maxillary incisors, increased overjet, and decreased overbite [73–75]. Due to its complex etiology, high incidence, and resulting dental-skeletal problems, AS is of interest from an orthodontic standpoint [76, 77]. This literature review assesses the relationship between AS and malocclusion and

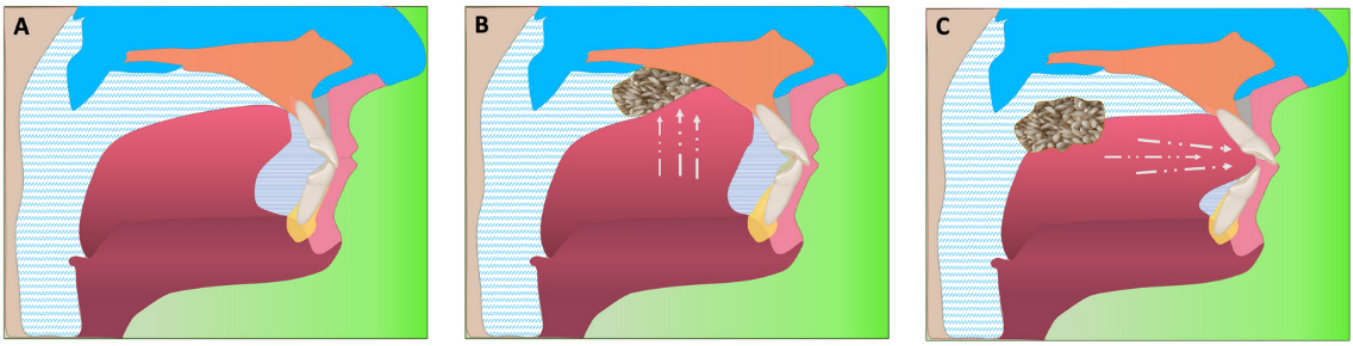

FIGURE 1. Tongue posture. (A) The physiologically correct resting position. (B) The normal swallowing position. (C) The atypical swallowing position.

possible therapies [78–96].

The literature proposes various therapeutic approaches for the early treatment of anterior open bites, which can have a dental or dentoalveolar origin or be of a skeletal type [97, 98]. In most cases, both dental and skeletal characteristics are present. Therapeutic modalities for early correction of an anterior open bite include functional, fixed, and removable appliances [99–101]. Functional, fixed, and removable appliances aim to prevent mechanical factors such as thumb-sucking or tongue thrusting from keeping the bite open and limit excessive vertical growth of the craniofacial skeleton [102–105]. Various orthodontic devices are available to treat AS. These devices include the Fraenkel and Bionator, devices for eruption guidance, elastodontic appliances (Fig. 2), lingual spurs, fixed lingual or palatal grids, speech therapy and myofunctional therapy (MFT) [72, 106, 107].

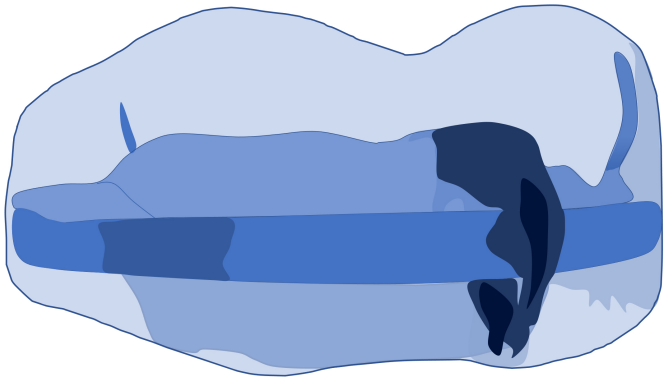

FIGURE 2. Elastodontic device for open bite.

2. Materials and methods

This systematic review was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The protocol was registered with PROSPERO under CRD42024499707.

A PubMed, Scopus and Web of Science search was conducted to find papers in English that matched the topic of myofunctional and orthodontic treatment in patients with AS and malocclusion, ranging from 01 January 2003, to 27 November 2023. The search strategy utilized the following Boolean keywords: ("atypical swallowing" OR "tongue thrust" OR "deglutition" OR "swallowing" OR "Atypical deglutition") AND ("malocclusion" OR "orthodontics" OR "Speech therapy" OR "logopedic") (Table 1).

The following criteria were considered for inclusion in the study: (1) studies that examined the treatment of myofunctional and orthodontic problems in patients with AS and dental malocclusion; (2) randomized clinical trials, retrospective studies, and case reports; (3) only English language studies; and (4) full text.

Papers that did not meet these criteria were excluded. The review was conducted using the PICOS criteria:

- Participants: Children of both genders without pathologies or syndromes with AS and malocclusion who received orthodontic treatment.
- Interventions: Orthodontic and myofunctional treatment.
- Comparisons: Pre- and post-treatment analysis of patients with AS and dental malocclusion.
- Outcomes: Treatment with orthodontic devices leads to a more physiological lingual posture.
- Study: Randomized clinical trials, retrospective studies, and case reports.

TABLE 1. Database search indicators.

Articles screening strategy	KEYWORDS: A: atypical swallowing; B: tongue thrust; C: deglutition; D: swallowing; E: Atypical deglutition; F: malocclusion; G: orthodontics. H: speech therapy; I: logopedic.
	Boolean Indicators: (A OR B OR C OR D OR E) AND (F OR G OR H OR I)
	Timespan: 01 January 2003 to 27 November 2023
	Electronic databases: PubMed, Scopus, WOS

WOS: Web Of Science.

The study excluded animal and *in vitro* studies, off-topic works, reviews, letters, comments and non-English language studies.

Two reviewers, MC and VC, independently searched the databases to gather relevant studies. These studies were then evaluated based on specific selection criteria to rate their quality. The chosen articles were saved in Zotero (version 6.0.15). In case of any disagreements among the three authors, they were resolved through discussion with a senior reviewer (FI).

Two reviewers, RF and EI, evaluated the quality of the included papers using a tool called ROBINS. This tool is designed to assess the risk of bias in non-randomized studies that compare the health effects of two or more interventions. They evaluated seven points and assigned a degree of bias to each one. In case of a disagreement, a third reviewer (FI) until an agreement was reached.

Here are the domains evaluated in the ROBINS tool:

- Bias due to confounding.
- Bias arising from the measurement of exposure.
- Bias in the selection of participants in the study.
- Bias due to post-exposure intervention.
- Bias due to missing data.
- Bias arising from the measurement of the outcome.
- Bias in the selection of the reported results.

3. Results

An electronic database search found 2554 articles, including 1183 from Scopus, 867 from PubMed, and 504 from Web of Science. No articles were found through a manual search. After removing duplicates, 1876 studies were screened by evaluating their title and abstracts, focusing on myofunctional and orthodontic treatment for patients with AS and malocclusion. Of the screened articles, 1863 did not meet the inclusion criteria (1857 were off-topic, and 6 were reviews), leaving 13 records to be selected. One non-retrieved record was excluded, and 12 were chosen for qualitative analysis after reviewing eligibility criteria. Fig. 3 illustrates the selection process, and Table 2 summarizes the selected records.

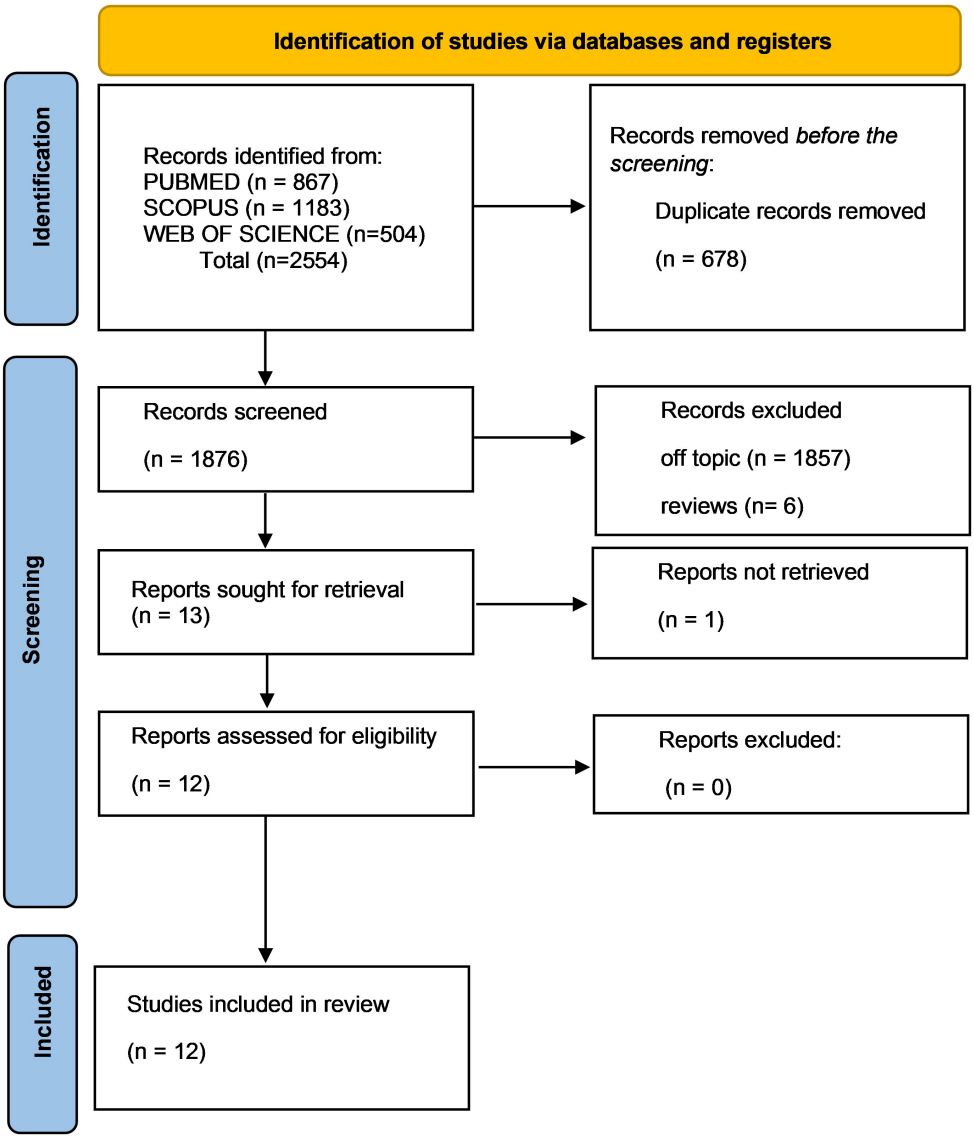

FIGURE 3. Below are the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram and indicators of database search.

TABLE 2. Descriptive summary of items selection.

Authors	Study design	Number of patients	Average age/gender	Treatment and duration	Outcomes
Di vecchio *et al.* [108] 2019	Clinical trial	370	---	MFT to correct AS. 9–12 months	This study outlines a clinical protocol using the Froggy Mouth, a myofunctional device created to correct AS.
Manzoor *et al.* [109] 2023	Case report	1	13 years Male (M)	MFT to correct AS. 6 months	The treatment involves identifying and removing the root cause, performing retraining exercises, and using mechanical restraints if necessary.
Quinzi *et al.* [110] 2020	Clinical trial	40	9–11 years 16 M–24 female (F)	MFT to correct AS. 6 months	Evaluate the impact of a functional device on facial expressions and lip strength in individuals with AS.
Begnoni *et al.* [111] 2020	Clinical trial	15	15–23 years 7 M, 8 F	MFT to correct AS. 10 weeks	The effects of MFT on muscle function and behavior in a group of patients with AS who have completed their second dentition.
Van Dyck *et al.* [112] 2016	Clinical trial	22	7.1–10.6 years 11 M, 11 F	The study group was subjected to orofacial myofunctional therapy (OMT), and tongue elevation was measured with the Iowa Oral Performance Instrument (IOPI) system—a 6-month treatment.	OMT can help improve tongue posture. Any interaction between OMT and expansion can have a positive impact.
Taslan *et al.* [113] 2010	Clinical trial	19	7–12 years	A study was conducted on 13 children using a crib appliance to measure tongue pressure during rest and swallowing over 12 months, utilizing a diaphragm-type pressure transducer.	The crib appliance conditioned tongue pressure, and the study group showed a significant open bite closure by the end of the treatment.
Anoop *et al.* [114] 2020	Case report	1	9 years F	A soft tongue restraint was inserted, and the patient was recalled for monthly follow-up treatment for six months.	With good patient compliance, a soft tongue restrainer can correct an open bite by allowing the upper front teeth to erupt.
Condò *et al.* [115] 2012	Clinical trial	50 Group 1 = 25 Group 2 = 25	Group 1: 6.37 years 10 M, 15 F; Group 2: 9.19 years 12 M, 13 F	All patients were treated with the Habit Corrector™ for 12 months due to their AS, which caused an anterior dentoalveolar open bite.	Early treatment with Habit Corrector™ produced better results in patients with primary dentition and the first phase of mixed dentition than in the late phase.

TABLE 2. Continued.

Authors	Study design	Number of patients	Average age/gender	Treatment and duration	Outcomes
Lim *et al.* [116] 2022	Retrospective study	28	8.41 ± 1.45-year-old, 13M, 15F	The patients underwent 18.14 ± 9.04 months of BioEx therapy, which included lip and tongue training and tongue elevators.	Bio-exercise and removable orthodontic appliances effectively increased tongue length and height between T_0 and T_1.
Saccomanno *et al.* [117] 2012	Clinical trial	23	5–17 years 10 M, 13 F	All patients showed AS, and 16 underwent rapid palatal expansion treatment followed by speech therapy, while 7 patients received only speech therapy.	Orthodontic therapy is highly effective in treating bad habits when combined with speech therapy. Muscle analysis using a dynamometer and surface electromyography has yielded significant results.
Ciavarella *et al.* [118] 2014	Retrospective study	24	9.46 ± 1.60 years 16 M, 8 F	The patients who had hyper-divergent Class II malocclusion with mandibular retrusion and AS were treated with swallowing occlusal contact intercept appliance for 24 months.	Radiographs before and after treatment revealed a significant increase in tongue length and height, improving tongue position and airway space.
Korbmacher *et al.* [119] 2004	Clinical trial	45 MFT group = 19 FFT (Face Former Therapy) group = 26	MFT group: 8.4 years 15 M, 4 F FFT group: 8.3 years 17 M, 9F	The MFT group received treatment from speech/language pathologists, while the FFT group underwent tongue and lip exercises using a training device called Face Former (Akkuphon®, Unna, Germany) for 6 months.	The FFT group exhibited a notable enhancement in the palatal tongue position during swallowing, and the improvement was statistically significant.

MFT: myofunctional therapy; AS: atypical swallowing; IOPI: Iowa Oral Performance Instrument.

The level of risk of bias in the studies included in the analysis is presented in Fig. 4. Most studies indicate a high risk of confounding bias, while the risk of measurement bias is low. The selection of participants in most studies has a low risk of bias, while the bias due to post-exposure cannot be calculated due to the high heterogeneity. The risk of bias due to missing data is low in many studies. The measurement bias of the outcome is low, but the selection bias of the reported results is high in most studies. Finally, the analysis indicates that six studies have a low risk of bias, 10 have a high risk of bias, two have a very high risk of bias, and the remaining studies have a questionable risk of bias.

4. Discussion

Incorrect tongue posture can have a significant impact on malocclusion development. When the tongue is not positioned correctly, it can affect the alignment of teeth and facial structures. For instance, a tongue continuously pressing against the teeth can push the dental arches into incorrect positions, leading to malocclusions such as overlapping, rotation, or spacing. This problem can occur mainly during childhood and adolescence, critical periods for dental arch development. Identifying and correcting inappropriate lingual posture early on prevents or treats malocclusion. This can be achieved through myofunctional therapies, orthodontic devices, and other strategies that promote correct lingual posture and better dental occlusion [29, 120]. AS is prevalent among both adults and children [77, 121]. This literature review aims to evaluate the relationship between AS and malocclusion and possible therapies.

In 2019, Di Vecchio *et al.* [108] assessed the treatment of swallowing through orthodontic appliances combined with speech therapy [108, 122–124]. They introduced a clinical protocol that uses the innovative myofunctional device, Froggy Mouth (Fig. 5), designed to correct AS. The device was used for 15 minutes daily for 9–12 months on 370 young patients. After this period, correction of the AS was observed. In 2020, Quinzi *et al.* [110] also studied the effects of the Froggy Mouth device on 40 patients with AS. They also looked at lip strength and altered facial expressions. The myofunctional

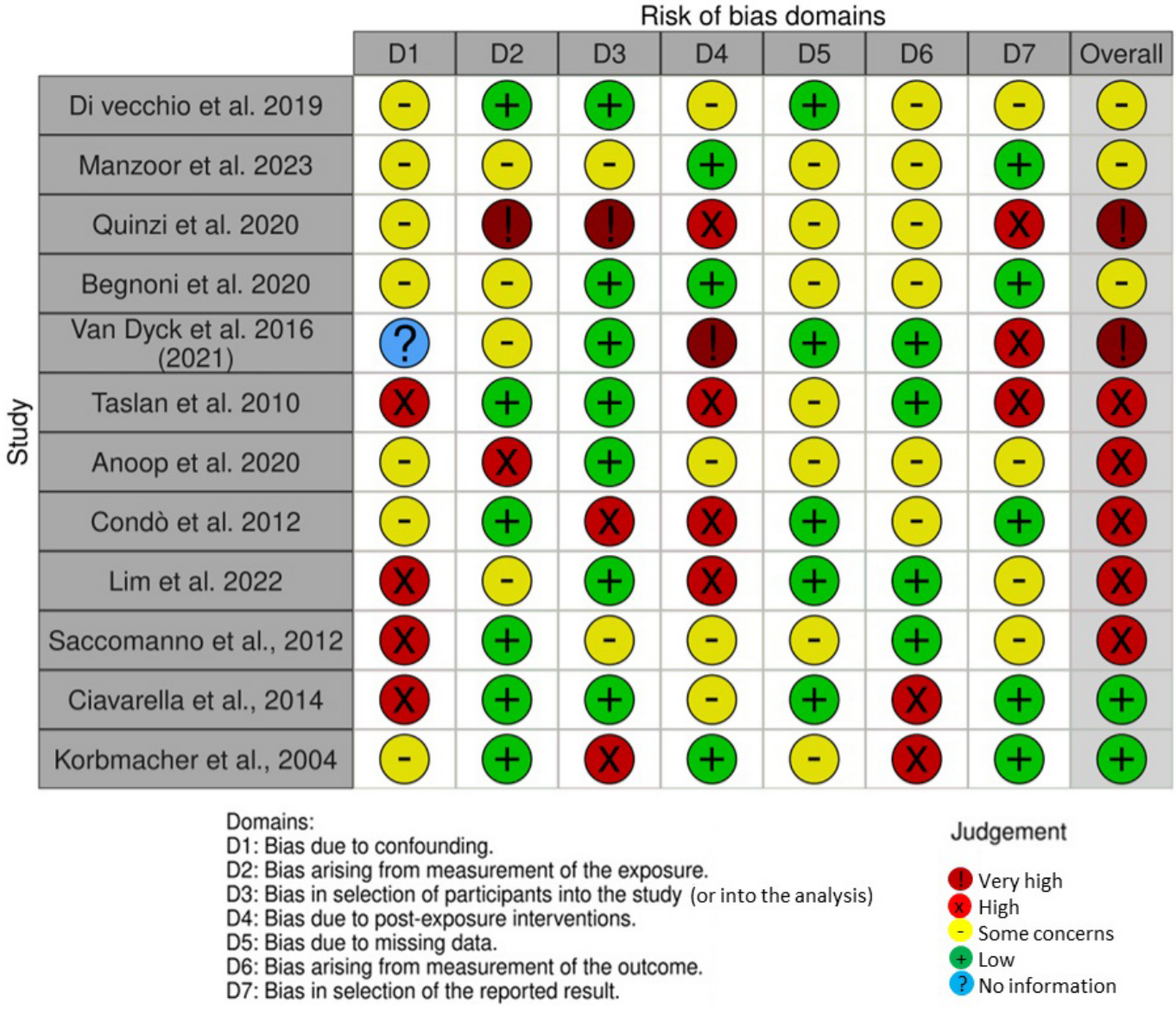

FIGURE 4. Bias assessment.

device proved effective in treating AS and correcting facial expressions and lip incompetence [110, 125–127].

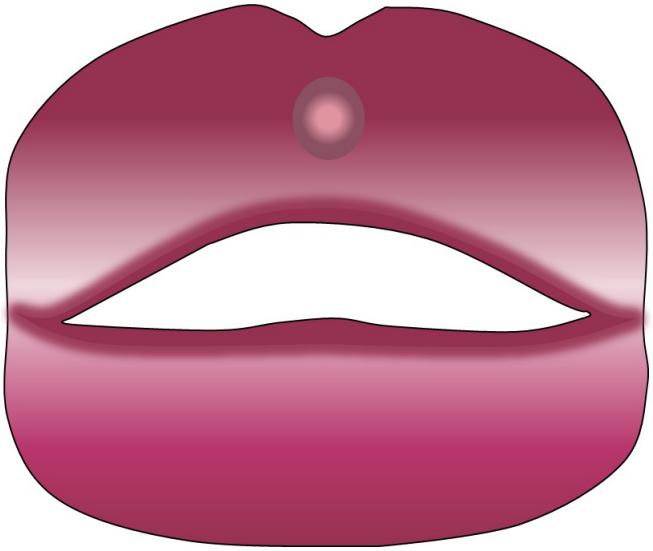

FIGURE 5. Froggy mouth device.

In 2015, Van Dyck *et al.* [112] analyzed OMT for the early treatment of anterior open bite. The study included 22 patients randomly divided into two groups, with one group receiving OMT and the other not. The therapy improved tongue posture, but no significant differences were found in the expansion [98, 112, 128–130].

Manzoor *et al.* [109], in 2023, proposed a device to correct the AS of a 13-year-old boy with a class I occlusion and open bite [125, 131–133]. The apparatus comprises a two-band grid (Fig. 6) with an acrylic ball in the center welded onto the molars. The ball keeps the tongue away from the front teeth. After 6 months of therapy, the open bite was resolved.

Begnoni *et al.* [111] (2020) studied 15 patients with AS treated with myofunctional devices. Electromyography was used to analyze the therapy's effects on patients between the ages of 15 and 23—using standardized protocols led to a significant improvement in the functionality of the oral muscles [111, 134–136].

Taslan *et al.* [113] (2015) controlled tongue pressure with a diaphragm-type pressure transducer in a study group of 13 children during 12 months of treatment with a crib appliance (Fig. 7) and in a control group of 6 children. Patients with AS have lower tongue strength. Pressure tongue results are conditioned by crib treatment [30, 43, 67]. Open bite closure has significant and significant value for the study group [30, 43, 66].

In 2020, Anoop and colleagues demonstrated that the soft tongue restrainer (Fig. 8) had better compliance than crib appliances (Fig. 7). They also showed that the upper front teeth could be successfully supra-erupted to close an open bite, resulting in positive clinical outcomes. However, it should be noted that this study was a case report conducted on a 9-year-old girl, and therefore, the results may not be generalized to other populations [52, 114, 137–140].

Condò *et al.* [115] conducted a study to evaluate the effectiveness of an orthodontic and endodontic appliance called

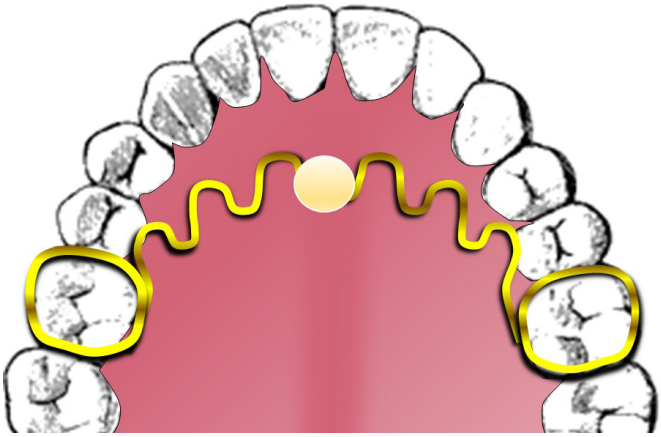

FIGURE 6. A tongue crib appliance with an acrylic ball is needed for AS correction.

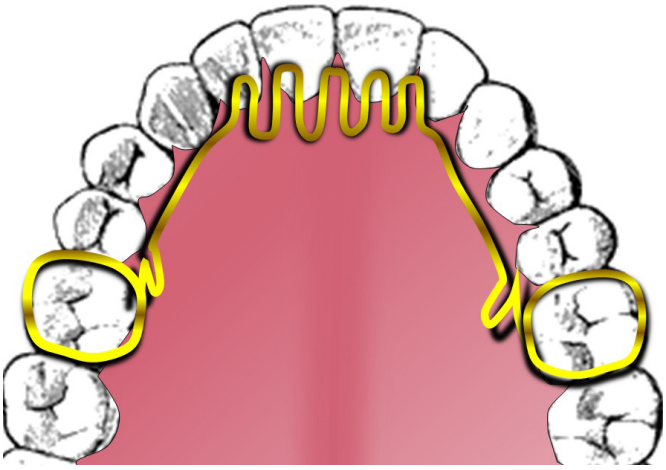

FIGURE 7. Example of tongue crib appliance.

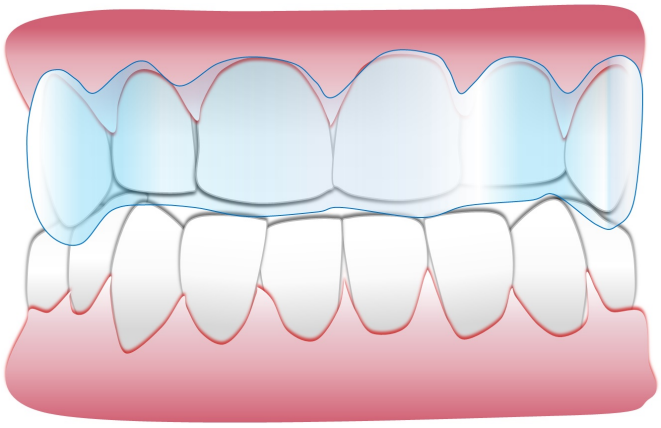

FIGURE 8. Soft tongue restrainer.

Habit Corrector™ (Fig. 9) in treating AS with open bite. The study examined patients in primary dentition, the first phase of mixed dentition, and the late phase. Habit Corrector™ is a removable appliance designed to correct dental and skeletal malocclusions in children [9, 141–143]. The study found that early treatment with Habit Corrector™ during the last phase of primary dentition and the first phase of mixed dentition was more effective in restoring physiological occlusion and growth

compared to the late phase of mixed dentition [11, 115, 144, 145].

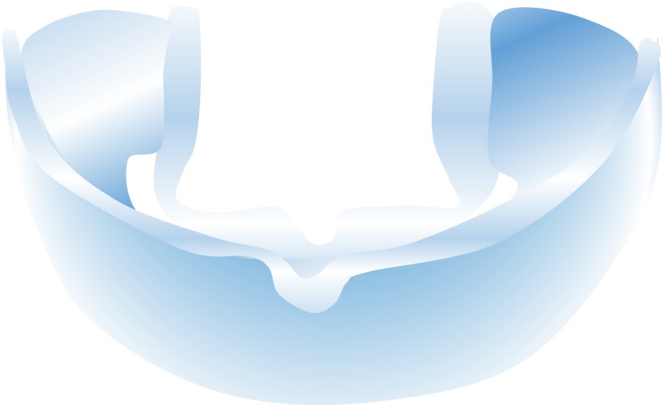

FIGURE 9. Habit Corrector device.

All treatment approaches aim to strengthen orofacial tissues, promote nasal breathing, and establish a normal swallowing pattern [146–149]. In young children, Face Former Therapy (FFT) is more effective than MFT in treating functional disorders such as AS and tongue thrust. The training device (Face Former, Akkuphon®, Unna, Germany) used in FFT resulted in a statistically significant improvement in palatal tongue position while swallowing (Fig. 10). The FFT group achieved habitual mouth closure in less time than the MFT group [119, 150].

Lim *et al.* [116] demonstrated the importance of retraining the tongue muscles to learn the most physiologically harmonious resting position and stabilizing that position with tongue elevators and lip and tongue exercises [116, 151, 152]. Orofacial myofunctional disorders are diseases or behaviors that adversely impact oral posture and activities. Throughout history, interest has focused on horizontal behaviors, particularly tongue thrusts [48, 84–86]. The lateral cephalograms were analyzed for tongue posture changes before and after treatment, and the results showed that tongue elevators combined with lip and tongue exercises increased the tonicity of the tongue muscles, resulting in a more normalized tongue. Additionally, tongue length and height increased statistically significantly between pre- and post-treatment [116].

Saccomanno *et al.* [117] treated AS patients with incorrect tongue positioning and palate contraction with rapid palatal expansion followed by speech therapy [117, 130]. Short lingual fraenum, hypertrophy of adenoids, tonsils, turbinates, and allergic rhinitis were all removed as potential limitations to therapy effectiveness. The orbicular muscle force was measured using a dynamometer before and after treatment, tongue thrust was assessed using fluorescein coloring, and the orofacial muscles were electromyographically examined. Orthodontic therapy and myofunctional treatment produced significant results in muscle analysis using a dynamometer and surface electromyography [117, 153–156].

Ciavarella *et al.* [118] demonstrated that using a swallowing occlusal contact intercept appliance (Fig. 11) for 16 hours per day for 24 months in AS patients improved tongue position and the superior posterior airway space, resulting in enhanced deglutition, phonation, and respiratory function. The data pre-post treatment on cephalometric evaluation revealed an increase in tongue length and height, supporting the repositioning of the tongue from a lower posture to a physiological position onto the palatal spot [118, 157, 158].

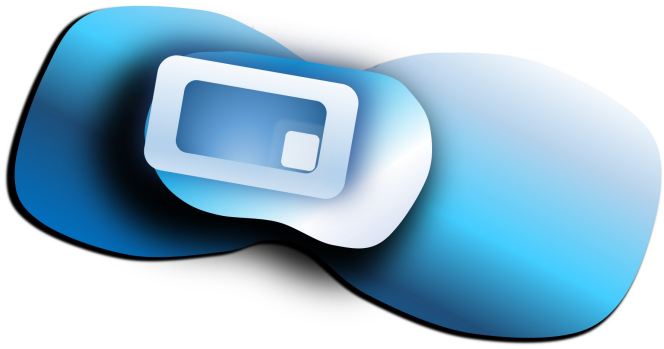

FIGURE 10. Face Former device used in FFT.

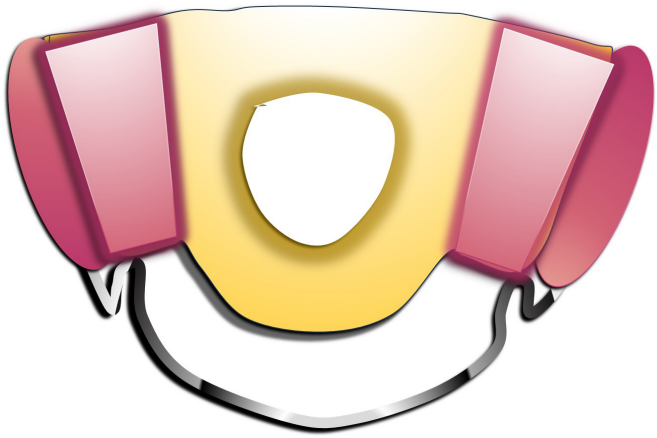

FIGURE 11. Swallowing occlusal contact intercept appliance.

The following discussion focuses on different therapies and devices used to treat AS and their implications for correcting malocclusion. Various studies have examined the effectiveness of other devices, such as the “Froggy Mouth,” lingual grills, lingual restraints, and eruption guides, in correcting AS and related problems. These therapies have significantly improved lingual posture, oral muscle strength, and occlusion parameters. Additionally, combined orthodontics and myofunctional therapy have shown promising results in treating AS and improving orofacial function. However, further research is necessary to evaluate the long-term efficacy of these therapies and to identify the best treatment for patients with AS and malocclusion.

5. Conclusions

Abnormal swallowing, also known as atypical swallowing, occurs when the tongue or other muscles in the mouth are not positioned correctly during the swallowing process. This can include the tongue touching the front teeth instead of the roof of the mouth or excessive movement of the tongue during swallowing. These abnormal muscle movements can apply constant or undue pressure on the teeth and surrounding struc-

tures during swallowing, which can affect the development and alignment of the teeth. This can lead to malocclusions such as overlapping, spacing, rotation, or tooth misalignment. Therefore, atypical swallowing can potentially cause malocclusions because incorrect muscular movements during swallowing can exert abnormal forces on the teeth and dental arches over time, thus influencing their position and alignment. Orofacial dysfunctions, such as atypical swallowing, are often associated with open bite malocclusions. Different therapies can be used to treat atypical swallowing. Conventional orofacial myofunctional appliances are safer and produce better clinical results. However, conventional appliances have a lower compliance rate. Further research is needed to clarify the intervention mechanism of the appliances and to analyze the effects obtained with these devices. In summary, atypical swallowing can contribute to malocclusions by applying abnormal forces on the teeth and dental arches during the swallowing process, thus establishing a cause-effect correlation between the two phenomena.

ABBREVIATIONS

AS, atypical swallowing; F, female; FFT, Face Former Therapy; M, male; MFT, myofunctional therapy; OMT, Orofacial myofunctional therapy; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PROSPERO, International Prospective Register of Systematic Reviews.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

ADI and MC—conceptualization. MC, FI and ADI—methodology. LF and GD—software. ED, VC and MC—validation. AP, FI and GD—formal analysis. MC, VC, LF and ER—investigation. GD, AP and AMI—resources. ADI, AP, GD, FI and AMI—data curation. GD—writing-original draft preparation. MC, VC, FI—Writing-review and editing. MC, LF and VC—visualization. AMI, ADI and GD—supervision. MC, AMI and FI—project administration. All authors have read and agreed to the published version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

ACKNOWLEDGMENT

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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