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Does asymmetry in the stomatognathic system correlate with body posture impairments? A systematic review

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ABSTRACT

Objectives: To assess the potential correlations between anatomical and functional asymmetry in the stomatognathic system and body posture impairments.

Methods: Literature search using the Medline, SCOPUS, LILACS and SciELO databases, the Cochrane Library and a manual search. Experimental and observational studies were included with no restrictions as to the type of asymmetry. Type of asymmetry, treatment and/or recording conditions, follow-up, postural examinations, main results and clinical implication were extracted, and risk of bias was assessed.

Results: Eleven articles (including one randomized clinical trial) were retrieved. The risk of bias was medium in 6 studies and high in the remaining investigations. Only three studies, all with a high risk of bias and without follow-up, reported significant correlations between the asymmetry in the stomatognathic system and body posture impairments.

Discussion: According to the limited present evidence, asymmetry in the stomatognathic system does not appear to correlate with body posture impairments at a clinically relevant level.

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INTRODUCTION

The existence of the correlation between the stomatognathic system, referred as to the mouth, jaws, and closely associated structures, and body posture is still controversial and debated with evidence in favor [1] or against. [2-4] However, the exact knowledge of any potential effect of the stomatognathic system on body posture would have major clinical implications in the management of patients with malocclusion. Among the difficulties in interpretation of the results of the previous investigation is the heterogeneity of the study designs and data recording, lack of follow-up and control groups, and merging of different conditions, such as malocclusion and temporomandibular disorders (TMDs). [2-4] Therefore, there is no clear indication as to whether and how oral rehabilitation may concur to the improvement or prevention of body postural impairments. Apart TMDs, malocclusion is a frequent condition with high prevalence in western countries. [5] In particular, asymmetries in the stomatognathic system on the frontal plane may represent a potential source of neuromuscular impairment with consequent body posture implications. Among the causes of asymmetries in the stomatognathic systems are, for instance, the monolateral anterior and posterior crossbite with prevalence up to about 7% and 11%, respectively. [6] Moreover, even in an absence of major anatomical malocclusal traits, a mandibular shift may be responsible for an established functional asymmetry in the stomatognathic system. In spite of previous reviews [2-4,7,8] to date, none has focused on the potential correlation between asymmetries in the stomatognathic system and body posture imbalances, while more studies have been published recently. Therefore, the present systematic review was aimed at the evaluation of potential correlations between anatomical and functional asymmetry in the stomatognathic system (without signs and symptoms of TMDs) and body posture impairments. Experimental studies, in which any treatment for the asymmetry was included, and observational studies were considered, irrespective of the method used to record body posture. Ultimately, according to the retrieved evidence, the present review was aimed at addressing whether improvement or prevention of body posture impairments might be included in the indications for the treatment of the asymmetry in the stomatognathic system.

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MATERIALS AND METHODS

Search strategy

The present systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [9], used a previous systematic review as a template. [2,4] Articles were identified through a literature survey carried out through the following databases: 1) PubMed, 2) SCOPUS, 3) Latin American and Caribbean Health Sciences (LILACS), 4) Scientific Electronic Library Online (SciELO), 5) The Cochrane Library. The survey covered the period from inceptions to the last access on 27 February 2016 with no language restrictions. The search strategy used in all databases is reported in Table 1. Finally, a manual search was also performed by screening the references within the studies examined and the titles of the papers published over the last 10 years among the following major journals: 1) American Journal of Orthodontics and Dentofacial Orthopedics, 2) European Journal of Orthodontics, 3) Journal of Orofacial Orthopedics, 4) Korean Journal of Orthodontics, 5) Orthodontics and Craniofacial Research, 6) Progress in Orthodontics, 7) The Angle Orthodontist, 8) World Journal of Orthodontics, 9) The Journal of Craniomandibular & Sleep Practice, 10) Journal of Orofacial Rehabilitation, 11) Google Scholar and Research Gate database. The eligibility assessment was performed independently by two blinded authors (BDB and GP). The inter-examiner reliability in the study selection process was assessed through the Cohen k test assuming a threshold value of 0.61. [10] Conflicts were resolved by the discussion of each article until consensus was reached. A third Author (LC) was consulted if necessary. An attempt to contact the corresponding Authors of the included studies was made to retrieve any missing information or clarification of specific items.

Table 1. *The search strategy used in the literature search for each database*

Key words
#1 body posture OR body sway
#2 transvers* discrepanc*
#3 mandibular deviation
#4 mandibular shift
#5 occlusal asymmetry
#6 crossbite OR cross bite
#7 scissor bite
#8 frontal plane
#1 AND (#2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8)

* *indicates truncation*

Eligibility criteria

According to the results of previous reviews [2,4] studies were included irrespective of being controlled or not, longitudinal or cross-sectional. Subjects included in the studies had to be negative for TMDs and, if a study included at least one group of subjects eligible for inclusion, only this portion of the results was taken into account.

Regarding the stomatognathic system examination, no limitations were followed as to the recording procedure such as: 1) clinical examination; 2) dental cast measurements; 3) radiographic or cephalometric analysis; 4) electromyography; 5) kinesiography. Regarding postural examination, also no limitations were followed as to the recording procedure including both static and dynamic posturographic methods: 1) physical examination; 2) postural platform; 3) body photographs; 4) rasterstereography (i.e. three-dimensional photography); 5) dynamic tests of gait or stepping or 6) electromyography. Both experimental and observational study designs were included in the review. The studies included were thus classified as follows: 1) randomized clinical trials (RCTs); 2) controlled and non-controlled clinical trials (CCTs and NCCTs, respectively); 3) cohort/case-control studies; 4) cross-sectional studies. Publications such as case reports, case series, reviews, and opinion articles were excluded, and the detailed exclusion criteria are listed in Table 2.

Table 2. *Exclusion criteria used in the present review*

1. Case series with no statistical analysis, case reports, comments, letters to the Editor, reviews
2. Studies on animals
3. Studies in which the compared groups showed differences in any parameter at the beginning of the study, or their matching in age and gender was not declared or derivable from the published data
4. Studies limited to the investigation of the correlations between the stomatognathic system and head-neck region
5. Studies that evaluated the mandibular posture in response to body position changes
6. Studies limited to the investigation on the morphological correlations between the craniofacial complex and the vertebral spine
7. Studies limited to the investigations on the effects of temporary induced occlusal interferences without proper follow-up
8. Studies on pathologies not related to the stomatognathic area (i.e. obstructive sleep apnea, vestibular disorders)
9. Clinical trials testing the effects of self-care postural training on the stomatognathic system muscle pain/ function, if this training included also head and neck posture exercises
10. Studies with major bias in the statistical analysis, i.e. dependent data treated as independent
11. Studies with patients positive for any type of temporomandibular disorder

Data items

The following data were extracted independently by two authors (BDB and GP): study design, prospective or retrospective enrolment, sample size, gender distribution, age, type of asymmetry, stomatognathic system examination and/or condi-tions, follow-up, posturographic recordings, main results and clinical implication and postural examination recommendations. Whenever reported, potential effects of the anatomical or functional asymmetry on the frontal plane was also extracted. Forms used for data extraction were mostly pre-defined at the protocol stage by two authors (GP and BDB).

Definition of the Study design

When modification of the mandibular position was achieved by using cotton rolls, gauzes or splints positioned between the dental arches, this was considered as a treatment, and the corresponding study classified as a clinical trial. On the contrary, when no device was used to influence the mandibular position, the study was classified as observational (cohort or case-control if longitudinal). Finally, studies having a repetition of the measures performed at the very same time point, i.e. posturography in two consecutive different recording conditions, were classified as longitudinal without follow-up as previously reported. [2]

Assessment of risk of bias in individual studies

No single approach in assessing methodological soundness may be appropriate to all systematic reviews. Therefore, the risk of bias in individual studies was assessed according to the Cochrane Collaboration's Tool [11] for RCTs, and a modified Downs and Black tool [12] for non-randomized clinical trials and observational studies.

The items included in the Cochrane Collaboration's Tool [11] are defined as: sequence generation, allocation concealment, blinding, incomplete outcome data (i.e., drop-out information or cephalometric magnification), selective outcome reporting (i.e., relevant cephalometric parameters), and other risks of bias. In particular, the blinding of the personnel involved in the treatment was not considered in the assignment of the overall risk of bias being this procedure not feasible when dealing with occlusal therapy.

The original Downs and Black tool [12] is calculated by rating each study across a variety of domains including reporting (10 items), external validity (3 items), internal validity - bias (7 items), internal validity - confounding (6 items), and power (1 item) with maximum score of 31. In the present review, adaptations were followed to adhere with the studies dealing with asymmetry in the stomatognathic system and body posture impairments. These were as follows (Table 3):

1. Item 4 (Are the interventions of interest clearly described?), item 8 (Have all important adverse events that may be a consequence of the intervention been reported?) and item 9 (Have the characteristics of patients lost to follow-up been described?) were not considered as the included analyzed studies did not include a treatment (apart the use of cotton rolls during recording).

Table 3. *Modified Downs and Black tool used for the risk of bias analysis of non-randomized clinical trials.*
Judgments and scores for each item as follows: No (0); Not applicable (whennecessary, 0); Yes (1).

Reporting
1. Is the objective of the study clearly described?
2. Are the main outcomes to be measured clearly described in the Introduction or Methods section?
3. Are the characteristics of the patients included clearly described?
4. Are the distributors of principal confounders in each group of subjects to be compared clearly described? a
5. Are the main findings of the study clearly described?
6. Does the study provide estimates of the random variability in the data for the main outcomes?
7. Have actual probability values been reported for the main outcomes except where the probability value is less than 0.001?
External validity
8. Were the patients asked to participate in the study representative of the entire population from which they were recruited?
9. Were those subjects who were prepared to participate representative of the entire population from which they were recruited?
10. Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive?
Internal validity bias
11. Was an attempt made to blind those measuring the main outcomes of the intervention?
12. If any of the results of the study were based on "data dredging", was that made clear?
13. Were the statistical tests used to assess the main outcomes appropriate?
14. Was the main outcome assessment accurate (valid and reliable)?
15. Was a longitudinal monitoring performed?
16. In case of longitudinal design, was a proper follow-up considered?
Internal validity confounding
17. Were the patients in different intervention groups recruited from the same population?
18. Were study subjects in different intervention groups recruited over the same period of time?
19. Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?
Power
20. Prior estimate of sample size (or a posteriori power analysis)

a, Judgments and scores as follows: No (0); Not applicable (0); Partial (1); Yes (2).

2. Item 14 (Was an attempt made to blind study subjects to the intervention they have received?) was not considered for reasons reported above.
3. Item 17 (In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-

control studies, is the time period between the intervention and outcome the same for cases and controls?) and item 26 (Were losses of patients to follow-up taken into account?) were not considered as studies were mostly cross-sectional or longitudinal without lacked follow-up.

4. Item 19 (Was compliance with the intervention/s reliable?) was not considered due to the lack of treatments.
5. Item 23 (Were study subjects randomized to intervention groups?) and item 24 (Was the randomized intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable?) were also not considered as the randomized studies were not assessed by this tool.
6. Item 27 (Power) was simplified as 'Prior estimate of sample size (or a posterior power analysis)'.
7. Finally, two items regarding longitudinal monitoring were added as no. 15 (Was a longitudinal monitoring performed?) and 16 (In case of longitudinal design, was a proper follow-up considered?) to adhere to the study designs herein retrieved.

Domains of the modified tool were as follows: reporting (7 items), external validity (3 items), internal validity - bias (6 items), internal validity - confounding (3 items), and power (1 item) with the maximum score of 21. The overall risk of bias was defined as follows:

1. High: total score ≤12
2. Medium: total score >12 to ≤18
3. Low: total score >18

The evaluation was performed without blinding by two Authors (BDB and GP) and conflicts were resolved by discussion. A third Author (LC) was consulted if necessary.

RESULTS

Study search

The results of the electronic and manual searches are summarized in Figure 1. According to the automatic and manual search, a total of 1,056 articles were retrieved. Among the 29 articles assessed in full text, 18 were excluded with details summarized in Table 4. The remaining 11 studies [13-23] were judged eligible for inclusion and are listed in Table 5.

Study designs

These studies included 3 experimental and 8 observational studies, classified as follows: 1 RCT with 1.1 years of follow-up [20], 2 CCTs without follow-up [13,15], 2 case-control studies without follow-up [18,21], 1 Cohort study without follow-up [19] and 5 cross-sectional studies. [14,16,17,22,23]

All the studies included both females and males. In a few cases, details on the gender distribution were not reported for some groups. [14,15,17,23] The age of the subjects was generally similar among studies and between also variable, with some studies including children [20,21], others including adolescents [14-19,22] and the rest studies including young adults. [13,23] Most of the studies were focused on the posterior monolateral crossbite [14-22] or other occlusal traits such as asymmetrical dental Class. [13,14,19] The only RCT [20] was focused on the body posture effects of the treatment of monolateral crossbite by slow maxillary expansion. Finally, only one study [23] included subjects with major skeletal asymmetries irrespective of the presence of a crossbite.

Among the observational studies, recordings were performed under no particular conditions, as standing position [16,17,21-23] or under different mandibular [19] or head [18] positions. The two studies [13,15] classified as CCTs recorded body posture under different mandibular positions with and without cotton rolls between the dental arches.

Regarding the posturographic recording, all the studies recorded body posture exclusively under static conditions. Subdivided as follows: 2 studies used qualitative posturographic parameters assessed by physical examination [14,22], 5 studies used quantitative posturographic parameters related to body sway assessed by postural platform [13,15,18,19,21], The last 4 studies also used quantitative measures taken from measure of leg length inequality [16], body photographs [17], X-ray films of the full-length spine [23] and rasterstereography. [20]

Authors' main results and conclusions

In 8 studies [13,15-20,22], no significant or very minimal correlations were seen between asymmetry in the stomatognathic system and body posture impairment. The Authors of these studies concluded that the presence of a posterior monolateral crossbite is not a risk factor for leg length inequality [16] or increase in body sways [13,15,18,19], impairment of various back features. [17,20,22] On the contrary, three studies [14,21,23] reported significant correlations between the asymmetry in the stomatognathic system, defined as occlusal asymmetry (i.e. midline deviation or monolateral crossbite) [14,21] or skeletal mandibular deviation [23], and body posture impairments, thus suggesting relevant clinical implications.

Risk of bias

According to the risk if bias analysis, the only RCT was judged to have a high risk of bias (Table 6). Regarding the other studies, only in 5 investigations, the risk of bias was judged to be medium [13,15-17,19] with an overall score between 14 and 16. The remaining five studies [14,18,21-23] were judged to have a high risk of bias with two studies reaching only a score of equal [18] or lower [23] than 7 (Table 7). Items related to the internal validity (both bias and confounding) were related to such low scores with full details summarized in Tables 6 and 7.

DISCUSSION

The present review analyzed the potential correlations between asymmetries in the stomatognathic system and body posture imbalances. Only 3 out of 11 studies showed some significant associations. Moreover, the included studies showed generally a medium or high risk of bias that would limit the strength of

Table 4. *The 18 studies excluded after full-text consideration with a corresponding main reason of exclusion*

Key words	Reference	Main reasons of exclusion
Amjad et al.*	Pak Oral Dental J 2014;34:635-9	Data asymmetry not clearly reported
Baldini et al.	Clinics 2013;68:45-9	Asymmetry not evaluated
Bergamini et al.	Cranio 2008;26:25-32	Asymmetry not evaluated
Castellano et al.	Cranio 2015;7:2151090315Y0000000009	Asymmetry not evaluated
Deregibus et al.	Int J Orthod Milwaukee 2014;25:15-20	Limited to vertebral spine; asymmetry of stomatognathic system not evaluated
Sink et al.*	Cranio 2003;21:202-8	Limited to temporary induced occlusal interferences
Gogola et al.	Dev Period Med 2014;18:453-8.	Occlusion grading system not specifically discriminating asymmetries
Korbmacher et al.	Int J Orofacial Myology 2005;31:26-38.	Asymmetry not evaluated
Kovero et al.	Acta Odontol Scand 2002;60:365-9	Asymmetry not evaluated
Maeda et al.	Cranio 2011;29:194-203.	Asymmetry not evaluated
Ohlendorf et al.	Kieferorthopädie 2010;24:279-88	Asymmetry not evaluated in subjects positive for TMDs
Ohlendorf et al.	J Craniomand Func 2011;3:293-8	Limited to temporary induced occlusal interferences.
Perillo et al.	J Oral Rehabil 2010;38:242-52	Data asymmetry not clearly reported
Perinetti et al.	Prog Orthod 2012;13:273–80	Asymmetry not evaluated
Šidlauskienė et al.	Med Sci Monit 2015;21:1765-73	Data asymmetry not clearly reported
Silvestrini-Biavati et al.	BMC Pediatrics 2013;13:12	Data asymmetry not clearly reported
Sinko et al.	Int J Oral Maxillofac Surg 2006;35:312-7	Case series
Zepa et al.	Acta Odontol Scand 2013;61:149-53	Analysis of correlation limited to cervical spine

** indicate studies excluded after consultation of a third author*

evidence. Finally, in consideration of the investigated conditions of the stomatognathic system, the present evidence applies mainly to the asymmetry due to monolateral crossbite (Table 5).

Herein, both anatomical (mainly monolateral crossbite) and functional (mandibular shift) asymmetries in the stomatognathic system on the frontal plan have been considered, and studies were included irrespective of the method used to investigate body postural imbalances. However, the number of retrieved studies is still limited, as this aspect has been investigated poorly. Moreover, the heterogeneous designs and recordings of the included studies did not allow any meta-analysis, while direct comparisons of the results obtained are not fully applicable.

Only 11 out of 1,056 screened studies were included according to the inclusion and exclusion criteria. The main reasons for exclusion were that studies were out of topic or investigated correlations between the stomatognathic system and the head and neck reagion which cannot be considered as whole body posture. [2] For this reasons, results from previous reviews [1,7] not clealry discriminating between head and neck and whole body posture should be carefully evaluated, especially when considering the asymmetries in the stomatognathic system. Moreover, the existence of TMDs may consitute a further confounding factor. Therefore, considering that previous investigations did not account for confounding factors (see Results and previous reviews [2,4]), herein only studies on subjects without TMDs (according to the Authors' procedures) were included. Similalry, studies in which asymmetry in the stomatognathic system was induced termporarly were not considered because of their lack of proper follow-up (Table 4). Indeed, an immediate re-evaluation after having induced an imbalance in the occlusion, is not able to uncover late and potentially stable body posture imbalances, or it may be misleading by the identification of immediate but transient effects. For these reasons, the present results apply to non-induced asymmetries of the stomatognathic system and in subjects without TMDs.

Study design and risk of bias

In spite, previous reviews [2,7] have reported the necessity of high-quality studies investigating on the potential correlations between the stomatognathic system and body posture, the overall risk of bias remains generally high. Indeed, only 1 RCT [20] has been retrieved with a follow-up of 1.1 years. All the other included studies were observational [14,15,17-19,21-23] or CCTs without follow-up. [13,16] Moreover, both of the CCTs [13,16] were classified as such only because of the use of cotton rolls during recording. Therefore, to date, only one study [20] evaluated the potential effects on body posture by orthodontic treatment for asymmetry in the stomatognathic system. Moreover, the cross-sectional or longitudinal without follow-up designs of the other included studies render not feasible any investigation on the causal relationship between asymmetry in the stomatognathic system and body posture impairments.

Table 5. *Summarized data of the 11 studies included in the review*

(CCT, controlled clinical trial; RCT, randomized clinical trial; P, Prospective; R, Retrospective; M, males; F, females; NA, not available; --, not applicable)

Article	Design, enrollement	Sample size and gender distribution	Mean age in yrs (range or SD)	Type of asymmetry	Stomatognathic system examination and/or conditions	Follow-up	Posturgraphic recordings	Main results	Clinical implications
Ferrario et al.[13]	CCT	10 F	21 (19–23)	Asymmetrical occlusion; no orthodontic history	Different mandibular positions with or without clenching and cotton rolls, eyes open	–	Asymmetry index and sway area assessed by static vertical force platform	Asymmetrical occlusion did not correlate with body sway in any of the mandibular positions	Not reported
		10 F	21 (19–21)	Normal occlusion					
Ben-Bassat et al.[14]	Cross-sectional	17 M; 79 F	13.9 (6.2-25.3)	Several occlusal features dealing asymmetry with idiopathic scoliosis	NA	--	Idiopathic scoliosis clinically examined by a spine surgeon; dental relationship performed by orthodontists	Asymmetrical canine relationship, upper and lower midline deviation, anterior/ posterior crossbite presented a higher frequency in scoliosis group	Early detection and treatment of asymmetrical malocclusion can sound and alarm a possible underlying orthopedic problem
		705	NA	Several occlusal features without idiopathic scoliosis					
Michelotti et al.[15]	CCT; P	14 M; 12 F	13.7 (1.2)	Unilateral posterior crossbite	Mandibular intercuspidal position and gentle clenching with cotton rolls, eyes open	--	Index of asymmetry of weight distribution and sway velocity assessed by static vertical force platform	Mandibular lateral slide does not influence the stabilometric measurement	The treatment of unilateral posterior crossbite to prevent or to treat postural disorders is not justify
		52 subjects matched for gender and age		No posterior crossbite					
Michelotti et al.[16]	Cross-sectional; P	633 M; 526 F	12.3 (10.1–16.1)	Unilateral posterior crossbite with or without leg length discrepancy (n=142)	Standing position	--	Leg length inequality assessed by physical examination	Unilateral posterior crossbite was not associated with leg length discrepancy at multivariate level	Unilateral posterior crossbite is not a risk factor for leg length inequality
				No posterior crossbite with or without leg length discrepancy (n=1017)					
Perillo et al.[17]	Cross-sectional; P	344 M; 359 F (divided in 4 groups)	12.2 (0.65)	Posterior crossbite with trunk asymmetry (n=90)	Standing position	--	Trunk posture assessed by photographic method	No clinical associations between body posture and dental occlusion	Claims of association between body posture and occlusion in growing subjects should be discarded
				Posterior crossbite without trunk asymmetry (n=14)					
				No posterior crossbite and trunk asymmetry (n=541)					
				No posterior crossbite with trunk asymmetry (n=58)					
Ohlendorf et al.[18]	Case control; P	15 M; 17 F	14 (3.28)	Crossbite	Different head positions; eyes open/closed	--	Force distribution assessed by vertical force platform	No significant differences between the groups	Crossbite does not appear to influence postural stability
		13 M; 20 F	13.1 (2.14)	No crossbite					
Perinetti et al.[19]	Cohort; P	86 M; 36 F	13.1 (1.6)	Variable occlusal condition including posterior crossbite (n=14), anterior crossbite (n=6), dental midline deviation (n=11), scissorbite (n=0). No previous orthodontic treatment	Mandibular rest positions and intercuspidal position, eyes open	--	Sway area and velocity, antero-posterior and right-left load differences assessed by a static vertical force platform	No significant correlations at the multivariate level for any trait of asymmetric occlusion	Low relevance for static sway recording in the monitoring of potential body postural effects triggered by occlusal asymmetries
Lippold et al.[20]	RCT	13 M; 18 F	7.3 (2.1)	Unilateral posterior cross bite; functional mandibular asymmetry	No treatment	1.1 years	Kyphotic and lordotic angle, lateral deviation, vertebral rotation, pelvic tilt and torsion assessed by rasterstereography	No clinically relevant differences between the groups at either time point, or between time points wihtin the groups	Treatmet for unilateral posterior crossbite does not affect postural parameters
		17 M; 18 F	7.3 (2.1)		Slow maxillary expansion followed by U-Bow activator teraphy				
Pachì et al.[21]	Case control	4 M; 8 F	7,5	Posterior unilateral crossbite with mandibular deviation	Standing positon, eyes open/closed	--	Asymmetry index, velocity and length sway assessed by static vertical force platform	Differences in terms of the length and velocity of sway between the groups	Posterior unilateral crossbite seems to influence postural stability
		5 M; 7 F	9,5	No orthodontic problems in trasveral plane or mandibular deviation					
Lopatienè et al.[22]	Cross-sectional	35 M; 41 F	12-14 (12.79)	Variable occlusal condition including posterior crossbite (n=14).	Standing position	--	Orthodontic analysis assessed by study model and cephalometric analysis; body posture examined	No relationship between the presence of posterior crossbite and transversal orthopedic parameters	Not reported
				No orthopedic disorders or orthodontic treatment			from the front, the side, and the back		
Zhou et al.[23]	Cross-sectional	10 (NA)	25 (3.6)	Neutral occlusion; no orthodontic hystory	Standing position	--	Scoliotic degree of cervical of thoracolumbar and cervical vertebrae, and imbalance angle of shoulder and trunk method assessed by antero-posterior X-ray film of the full-length spine	Significatly greater scoliosis and trunk imbalance were seen in combination with mandibular deviation	Scoliosis and trunk imbalance should be clinically evalueted in the management of mandibular deviation
		19 M; 16 F	23.5 (4.8)	Skeletal mandibular deviation with variable occlusal features					

Even though the blinding of the personnel providing the treatment (not possible in orthodontics) was not considered as a source of bias, herein, the risk of bias within studies was high for several included studies. This was also the case of the RCT [20], with reasons behind such judgment residing mainly in the selection bias, significant dropout and lack of method error analysis (Table 6). Similarly, the risk of bias of all the other studies was generally high or medium (Table 7) limiting the reliability of the results.

Main findings and clinical implications

Among the eight studies [13,15-20,22] that reported no relevant correlations are the RCT [20] and the five investigations judged of medium quality. [13,15-17,19] Moreover, the three studies [14,21,23] reporting significant correlations between the asymmetry in the stomatognathic system and body posture impairments were also judged to have a high risk of bias, with 1 of them [23] having the lowest scores according to the modified Downs and Black tool (Table 7). These investigations were focused on monolateral crossbite [14,21] and spine coronal morphology and trunk balance [23], and were all cross-sectional studies. Of interest, both the crossbite and mandibular shift were shown to be not associated with signs or symptoms of TMDs in an epidemiologic investigation. [24] Hence, the potential impact of these two conditions on body posture remains to be investigated.

According to the present evidence, the treatment of the asymmetry in the stomatognathic system would not have an impact on the body posture. Therefore, the improvement of body posture imbalances may not be considered at present as an indication for the treatment of asymmetries in the stomatognathic system. However, the present evidence lacks substantial strength being most of the studies based on observational designs and suffering the noteworthy risk of bias. Indications for the treatment of asymmetry in the stomatognathic to treat postural imbalances reported by some [14,23] of the included cross-sectional studies may not be drawn from such study design. Future studies will have to include proper control groups with longitudinal designs. Moreover, body posture will need to be recorded after having carefully evaluated the method error of the followed procedures/parameters and results, with corresponding statistically significant correlations, will have to be judged accordingly.

CONCLUSIONS

According to the present review the following conclusions may be drawn:

- The quality of the existing study reports is low and further investigations with qualitatively better study designs are necessary.
- Using current methodology, asymmetry in the stomatognathic system (in the absence of TMDs) do not appear to be correlated to body posture impairments at a clinically relevant level.
- According to the limited available evidence, prevention or treatment of the body posture imbalance may not be included at present among the indications for the treatment of the asymmetry in the stomatognathic system.

Figure 1. *Flow diagram of the search strategy.*

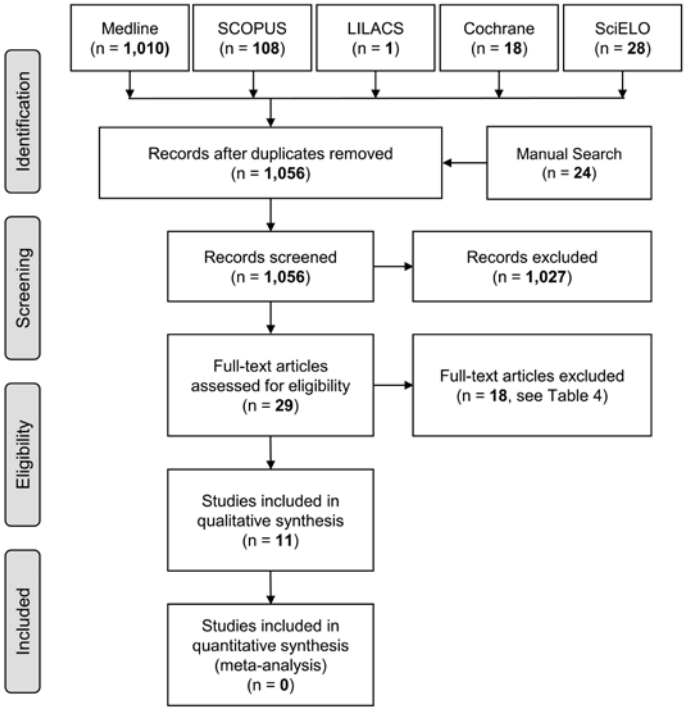

Table 6. *The risk of bias for the randomized clinical trial according to the Cochrane tool*

Study	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias	Overall risk of bias
Lippold et al.[20]	No	Unclear	No, a	Unclear, b	No	No	Unclear, c	High

a, Even if not feasible for personnel providing treatment, the risk of bias for non-blinded personnel performing the treatment was not judged as a significant risk of bias; b, including any type of outcome assessment and data treatment; c, mean ages of the examined groups is not reported while a significant drop-out was seen after randomization. Moreover, an analysis of the method error of the recorded outcome is not described.

Table 7. *The risk of bias for the controlled clinical trials according to the modified Downs and Black tool (--, Not applicable)*

Item	Ferrari et al.13	Ben-Bassat et al.14	Michelotti et al.15	Michelotti et al.16	Perillo et al.17	Ohlendorf et al.18	Perinetti et al.19	Pachì et al.21	Lopatienè et al.22	Zhou et al. 23
1	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)
2	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)
3	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	No
4	Yes (2)	Yes (2)	Yes (2)	Yes (2)	Yes (2)	No	Yes (2)	Yes (2)	Yes (2)	No
5	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)
6	Yes (1)	No	Yes (1)	Yes (1)	Yes (1)	No	Yes (1)	Yes (1)	Yes (1)	Yes (1)
7	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	No	Yes (1)	Yes (1)	Yes (1)	Yes (1)
8	Yes (1)	Unclear	Yes (1)	Yes (1)	Yes (1)	Unclear	Yes (1)	Yes (1)	Unclear	Unclear
9	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Unclear	Yes (1)	Yes (1)	Yes (1)	Unclear
10	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)
11	Yes (1)	No	Yes (1)	Yes* (1)	Yes (1)	Unclear	No*	Yes (1)	Yes (1)	Unclear
12	No	No	No	No	No	No	No	No	No	No
13	No	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Yes (1)	Unclear	Unclear	No
14	Yes (1)	Unclear	Yes (1)	Yes (1)	Yes (1)	Unclear	Yes (1)	Unclear	Unclear	Unclear
15	No	No	No	No	No	Yes (1)	No	No	No	No
16	No	No	No	No	No	No	No	No	No	No
17	Yes (1)	No	No	No	No	No	--	No	--	No
18	Yes (1)	Unclear	Yes* (1)	Yes* (1)	Yes (1)	Unclear	--	Unclear	--	Unclear
19	No	No	No	No	No	No	Yes (1)	No	No	No
20	No	Unclear	Yes (1)	Yes (1)	Yes (1)	Unclear	No*	Unclear	Unclear	Unclear
Total	**15**	**11**	**16**	**16**	**16**	**7**	**14**	**12**	**11**	**6**
Overall risk of bias	**Medium**	**High**	**Medium**	**Medium**	**Medium**	**High**	**Medium**	**High**	**High**	**High**

** information provided by the authors*

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