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LITERATURE REVIEW



Reliability of kinesiography vs magnetic resonance in internal derangement of TMJ diagnosis: A systematic review of the literature

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ABSTRACT

Objective: The aim of this systematic review was to evaluate the accuracy and the diagnostic reliability of kinesiography and magnetic resonance imaging (MRI) in diagnosis of patients presenting temporomandibular disorders.

Methods: A literature survey carried out through PubMed, SCOPUS, LILACS, and the Cochrane Library from the inception to the last access on August 18 2016 was performed to locate randomized clinical trials, controlled trials, prospective cohort studies, or retrospective studies (with or without a control group), that examined the diagnostic reliability of recording devices of mandibular movements in comparison to MRI.

Results: From the results, it was found that a significant correlation between these electronic devices and MR images could not be detected in case of disc displacement.

Discussion: The scientific evidence does not support the usefulness in clinical practice of the jaw-tracking devices to diagnose temporomandibular disorders because their diagnostic reliability is poor.

Abbreviations: MRI: magnetic resonance imaging; TMJ: temporomandibular joint; TMD: temporomandibular disorder; RCT: randomized clinical trial; CCT: controlled clinical trial; PCS: prospective cohort study; RS: retrospective study

KEYWORDS

Systematic review; kinesiography; magnetic resonance; TMD; reliability; diagnosis; axiography; TMJ

Introduction

In recent years, several studies have questioned the diagnostic reliability of electronic devices (kinesiographic or axiographic) as a diagnostic aid in temporomandibular disorders (TMDs), as they are not fully supported by scientific evidence [1,2]. The only exception so far is for magnetic resonance imaging (MRI), since it can depict temporomandibular joint (TMJ) disc position and the presence of joint effusion [3].

Also, recent investigations using more sophisticated instruments in an experimental setting have brought new insights into the assessment of jaw function and muscle activity, but clinicians may find it difficult to draw clinically useful information from studies using devices designed for research purposes [4].

Often kinesiography, axiography, and MRI have been used for dental diagnosis, particularly regarding the pathological conditions of the TMJ. Neff et al. [5] assessed post-operative functional outcomes regarding loss of vertical

height, disc mobility, relationship of condyle compared with disc and mandibular fossa, protrusive, and translatory movements in patients with condylar head fractures managed by osteosynthesis using MRI and axiography.

The reliability of instruments for making axiographic recordings in the diagnosis of internal derangements of the TMJ remains controversial, and the literature does not suggest that the sensitivity and specificity of jaw-tracking devices are reliable enough to be used for diagnosis and management of intra-articular TMDs [1,6].

For this reason, there is currently not an evident indication for the use of axiographic devices for diagnosis and assessment of temporomandibular dysfunctions. To date, no systematic revision has dealt with the topic of diagnostic reliability of jaw-tracking devices in comparison with MRI. In view of these considerations, the present systematic review was aided in the assessment of the diagnostic accuracy and reliability of kinesiography or axiography, as compared to that from MRI in the diagnosis of internal derangements of the TMJ, to establish whether

such procedures may have a role in the management of intra-articular TMDs.

Materials and methods

Search strategy and study selection

This systematic review was based on the guidelines of the *Cochrane Handbook for Systematic Reviews of Interventions* (The Cochrane Collaboration, 2011) and the reporting based on the PRISMA Statement [7]. All the articles that examined the diagnostic reliability of jaw-tracking devices in comparison to MRI were identified through a literature survey carried out through the following databases: (i) PubMed (www.ncbi.nlm.nih.gov/pubmed); (ii) SCOPUS (www.SCOPUS.com); (iii) Latin American and Caribbean Health Sciences (LILACS, www.lilacs.bvsalud.org) and (iv) The Cochrane Library (www.thecochranelibrary.com). The survey covered the period from inception to the last access on August 18 2016, without any limitation dictated by the language of the articles or publishing date [8]. The search algorithms used in each database are reported in Table 1. Finally, a manual search was also performed by scoring the references within the studies examined. The search was made to identify manuscripts meeting the following inclusion criteria: studies that examined the clinical outcomes after recordings with jaw-tracking mechanical devices (i.e. kinesiograph, axiograph) in comparison with MRI. The studies had to be randomized clinical trials (RCTs), prospective and retrospective controlled clinical trials (pCCTs and rCCTs, respectively) and cohort studies or retrospective studies (rSs), regardless of the presence of a control group. Case series, case reports, studies enrolling fewer than 10 subjects, comments, expert opinion, letters to the editor, reviews, and studies that analyzed the same sample of a pre-existing study were excluded. Studies in which patients were investigated before, during, and after a functional treatment with orthodontic appliances (such as Bionator or Twin-Block) to evaluate joint changes were also excluded. In addition, studies that examined patients with systematic diseases affecting joint and/or masticatory muscles, such as fibromyalgia or other rheumatic diseases, were not collected. Full details of inclusion and exclusion criteria are listed in Table 2.

Two researchers (SP and FC) carried out the literature search independently (January 2016), by first analyzing titles and abstracts for relevance and presence of the selection criteria listed above. The full text articles of included and uncertain records were obtained for further eligibility screening by the same two reviewers. In the event of an unsettled disagreement, the opinion of another co-author (GP) was consulted. In case of identification of redundant research in different papers, the paper with the highest

Table 1. Search strategy.

PubMed (www.ncbi.nlm.nih.gov/pubmed)(diagnosis OR accuracy OR sensitivity OR specificity OR correlation OR comparison) AND (Jaw Relation Record [MeSH] OR axiography OR axiographic OR axiographia OR kinesiograph*) AND (Magnetic Resonance Imaging [MeSH] OR MRI) AND (tmj OR (temporomandibular and (disorder* OR dysfunction*)) OR internal derangement)
SCOPUS (www.scopus.com)((Axiography) OR (Jaw Relation Record)) AND ((Magnetic Resonance Imaging) OR (MRI)) AND ((temporomandibular disorder) OR (temporomandibular dysfunction) OR (internal derangement))
LILACS (www.lilacs.bvsalud.org)((Axiography) OR (Jaw Relation Record)) AND ((Magnetic Resonance Imaging) OR (MRI)) AND ((temporomandibular disorder) OR (temporomandibular dysfunction) OR (internal derangement))
Cochrane Library (Registered Controlled trials) (www.thecochranelibrary.com) ((Axiography) OR (Jaw Relation Record)) AND ((Magnetic Resonance Imaging) OR (MRI))

Note: * is the wildcard in the boolean research. If used after the root of a word, it will get results that contain variations of that root in the title or description.

Table 2. Details of inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> Randomized clinical trials (RCTs); prospective and retrospective controlled clinical trials (pCCTs and rCCTs, respectively); and cohort studies or retrospective studies (rSs), with or without a control group; All of the studies that examined the clinical outcomes after recordings with jaw-tracking mechanical devices (i.e. kinesiograph and axiograph) in comparison with MRI. 	<ul style="list-style-type: none"> Case reports, case series, study enrolling fewer than 10 subjects, comments, expert opinion, letters to the Editor, reviews, studies that analyzed the same sample of a pre-existing study; Studies that are not reported in form of full text (only abstract available); Studies in which patients were investigated before, during and after a functional treatment with orthodontic appliances (such as Bionator or Twin-Block) to evaluate joint changes; Studies that examined patients with systematic diseases affecting joint and/or masticatory muscles, such as fibromyalgia or other rheumatic diseases; All of the studies that examined the clinical outcomes after recordings with jaw-tracking mechanical devices (i.e. Kinesiograph, Axiograph) without a comparison with MRI; Studies limited to the investigation of patients with other techniques (i.e. Ultrasound, Arthroscopy, Arthrography).

follow-up was included. References of all papers included were searched to identify any further relevant studies.

Data items

Two reviewers extracted all data simultaneously but independently, using a standardized outline. The following data items were collected: study design; sample size; age and sex distribution of the sample; type of internal derangements of the TMJ; techniques of investigation; correlation between axiographic/kinesiographic parameters for MRI findings; accuracy of axiographic/kinesiographic

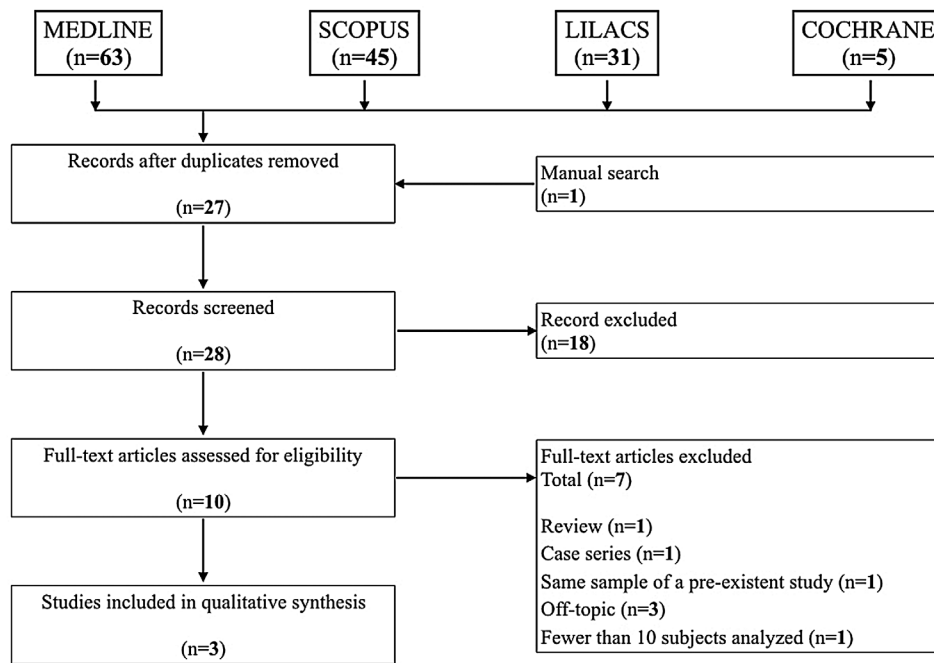


Figure 1. Flow diagram of the search strategy.

parameters for MRI findings; specificity of axiographic/kinesiographic parameters and MRI; sensitivity of axiographic/kinesiographic parameters for MRI findings; and clinical implications according to authors' conclusions about the diagnostic reliability of the methods based on the results obtained.

Assessment of risk of bias in individual studies

Evaluation of the methodological quality of published studies is very important because it gives an indication of the strength of scientific evidence provided by these studies. However, no single approach in assessing methodological soundness may be appropriate for all systematic reviews to evaluate the quality [9]. Therefore, contextual, pragmatic, and methodological considerations are followed when assessing study quality (Center for Reviews and Dissemination. Systematic Reviews, 2009). Herein, a custom risk of bias analysis has been used as follows: enrollment (prospective/retrospective), control group (yes/no), sample size calculation (yes/no), method error (yes/no), adequacy of statistical analysis (yes/no), and expert rates (yes/no). According to the retrieved information related to the single items, the overall risk of bias of the selected studies was defined as either Low or High.

Results

The results of the automatic and manual searches are shown in Figure 1. From the automatic search through

Table 3. Full-text articles exclusion details.

Reason for exclusion	Number of studies	Study author
Review	1	Badel et al. [17]
Same sample of a pre-existent study	1	Beer et al. [18]
Off topic	3	Ettlin et al. [19] Hasegawa et al. [20] Neff et al. [5]
Case series	1	Dhanda et al. [21]
Fewer than 10 subjects analyzed	1	Braun and Hicken [22]

the main scientific databases, a total of 144 articles were found. Furthermore, a manual search was performed, and one article was added for the analysis. After having removed all double entries and applying the inclusion/exclusion criteria, 10 studies were selected and analyzed in full-text. From the resulting 10 full-text articles assessed for eligibility, 7 studies were excluded for the reasons detailed in Table 3.

Three studies were judged to be relevant to the present study according to the inclusion/exclusion criteria [4,10,11]. The full details of the studies included in the review are summarized in Table 4.

Study design

The three selected studies comprised one cohort study [11] and one retrospective study (rS) [4]. The article by Lochmiller et al. [10] did not report any information about the study design.

Table 4. Summarized data of the three studies included in the review.

Study	Sample size	Sex and age	TMJ disorders	Techniques of investigation used	Correlation AX/KG parameters and MRI (n [%])	Accuracy of AX/KG parameters for MRI findings (n [%])	Specificity of AX/KG parameters and MRI (n [%])	Sensitivity of AX/KG parameters for MRI findings (n [%])	Clinical implications
Neff et al. [11]; Cohort	57	M: 26; F: 31 26.9 years	Healthy TMJ, No TMJ disorder	Axiography, S-MRI, CINE-MR, Arthrosonography	Pr: 91% (v = 0.038) with CINE-MR; AIC: 94% with CINE-MR (v = 0.00336)	NA	CINE-MRI: 56/57 (98%); S-MRI: 54/57 (97%) AXIOGRAPHY: NA CINE-MRI: 25/33 (76%); S-MRI: 28/33 (85%); AXIOGRAPHY: NA	NA	CINE-MRI and S-MRI are superior to axiography
Lochmiller et al. [10]	24	NA	Clinically manifest dysfunctions, so far conservatively treated Slight or moderate dysfunctions; 21: unilateral condylar fractures, surgically treated; 6: bilateral fractures, surgically treated Bilateral or unilateral reciprocal articular disorders	Axiography, MRI, Compression tests and Translation tests Kinesiography and MRI	88%	49%	NA	NA	Axiography does not add any important finding MRI is superior to kinesiography
Manfredini et al. [4]	31	M: 13%; F: 87% 43.1 years	Unilateral disorders (DDR: 35.5–54.8%; DDNR: 6.5%; Eff: 19.4–29%)		NS	KG parameters: Def: 38.7–54.8% Dev: 42–54.8% Inc: 9.6–71%	KG parameters: Def: 40–55.1% Dev: 30–50% Inc: 3.4–10%	KG parameters: Def: 38.1–50% Dev: 47.6–100% Inc: 100%	

Notes: AIC: angle of condylar inclination; Pr: protrusion; v: variance; NS: not significant; NA: not available; S-MRI: static MRI; CINE-MRI: cinematic MRI; KG: kinesiographic; AX: axiographic; rS: retrospective study; Def: deflection at the end of jaw movement; Inc: incisures; Dev: deviation during mandibular opening; DDR: disc displacement with reduction; DDNR: disc displacement without reduction; Eff: effusion.

Study population

The sample size of patients who were examined through the two methods of investigations (axiography or kinesiography and MRI) ranged from a minimum of 24 subjects [10] to a maximum of 90 subjects [11]. The mean subjects' age was reported in two of the three studies, and it was included between 26.9 years [11] and 43.1 years [4]. In two studies, both sexes were monitored [4,11]. Only the study by Lochmiller et al. [10] did not provide any information as regards both age and sex. Only one study considered a real control group [11]. In contrast, the study by Manfredini et al. [4] considered a sample of patients with internal derangements of the TMJ in which the subjects served as cases and controls. In all of the studies, the subjects were systemically healthy.

Temporomandibular disorders

The study by Lochmiller et al. [10] analyzed subjects with bilateral or unilateral reciprocal articular disorders, but the type of intra-articular TMD was not specified. The article by Neff et al. [11] investigated 57 healthy subjects who did not present any internal derangement of the TMJ, and a group of 33 patients as control. This last group comprised 6 patients with clinically manifest dysfunctions, which were so far conservatively treated, and 27 patients with condylar fractures that were previously surgically treated (21 unilateral fractures, 6 bilateral fractures, at least 12 months after the end of the treatment, with slight or moderate dysfunctions). The article by Manfredini et al. [4] considered a group of patients in the attempt to get deeper into the assessment of TMJ symptoms and/or differentiate them from other muscle disorders, and at the end of the investigation, found only unilateral disorders. In particular, the frequency of diagnosis was: (i) disc displacement with reduction (DDR): 35.5% (right) and 54.8% (left); (ii) disc displacement without reduction (DDNR): 3.2% for both the articulations; (iii) effusion (Eff): 29% (right) and 19.4% (left).

Techniques of investigations

The methods of investigation used for the analysis were well described in each article. Axiography or kinesiography and MRI were adopted in all studies. One study used both conventional static MRI and dynamic MRI (CINE-MRI) and arthrosonography, a further procedure to examine the TMJ [11]. Only one study carried out a "manual investigation" that included dynamic compression and translation, in addition to electronic axiography and MRI (computer-assisted methods), for a differential diagnosis of joint sounds [10]. Manfredini et al. [4] performed MRI

and kinesiographic recordings to detect internal derangements of the TMJ.

Correlation between kinesiographic or axiographic recordings and magnetic resonance imaging

Two of the three studies reported a statistically significant correlation between MRI findings and kinesiographic/axiographic parameters [10,11]. In the article by Neff et al. [11], axiography and MRI (specifically CINE-MRI) showed a correlation equal to 91% in the jaw movement of protrusion and about the angle of condylar inclination measured during protrusion's movement (94%, with a variance of 0.036). Lochmiller et al. [10] found a correlation equal to 88% between electronic axiography and MRI findings; the remaining 12% was because clinically relevant joint sounds were not attributable to the dislocation of the articular disc, and therefore, they were not represented in the axiographic tracings. Only in the study by Manfredini et al. [4] the correlation between MRI findings and kinesiographic parameters was defined as not significant because there was not more than one kinesiographic variable that showed a p -value below $p = 0.10$ with any MRI finding. In detail, DDR showed p -values ranging from 0.62 to 0.999; DDNR p -values ranging from 0.063 to 0.999, and MRI-depicted joint effusion showed p -values from 0.09 to 0.999.

Clinical outcomes

In only one study, the value of accuracy of axiographic/kinesiographic parameters for MRI findings was reported [10]. In the study by Manfredini et al. [4], because of the poor revealed relationship between kinesiographic and MRI findings, the accuracy of the various kinesiographic findings to predict the presence of any specific MRI sign at the patient level was poor. In particular, the accuracy value of kinesiographic deflection for diagnosing signs detected on MRI ranged from 38.7 to 54.8%, that of kinesiographic deviation spanned from 42 to 54.8%, and that of kinesiographic incisures from 9.6 to 71%. In the study by Lochmiller et al. [10], the accuracy of the registered axiographic tracings with the use of dynamic tests of compression and translation in relation with results of MRI corresponded to 49%. This means that half of all the axiographic tracings coincided with MRI findings. The article by Neff et al. [11] did not determine the level of accuracy of electronic axiography for MRI results. The value of specificity of the different kinesiographic parameters for MRI findings was considered only in the study by Manfredini et al. [4]. Specifically, kinesiographic deflection's values ranged from 40 to 55%, that of kinesiographic deviation from 30 to 50%, and that of kinesiographic incisures from

3.4 to 10%. The study by Neff et al. [11] considered only the specificity of CINE-MRI and static MRI in the group with TMJ dysfunctions (33 of 90 total subjects) and in the group of subjects with healthy TMJs (57 of 90 total subjects). The specificity values were very different between the two considered groups of patients. The specificity in the first group coincided with 76% (25/33) for CINE-MRI and with 85% (28/33) for static MRI; for the healthy group, the percentages were changed: 98% (56/57) for CINE-MRI and 97% (54/57) for static MRI. Only in the article by Manfredini et al. [4], the percentages of sensitivity of various kinesiographic parameters for MRI findings were provided (deflection: 38.1–50.0%; deviation: 47.6–100%; incisure: 100%). The other two articles did not provide any information about the sensitivity of the techniques [10,11]. All of the clinical outcomes of the three included studies are summarized in Table 4.

Main reported results and clinical outcomes

In their conclusions, Lochmiller et al. [10] reported that the electronic jaw-tracking devices are essential for diagnosis position in patients with intra-articular dysfunctions, and the study revealed a good correlation between MRI and axiography; but axiographic recordings do not give any additional diagnostically relevant findings that go beyond the manual examination. Neff et al. [11] concluded that concerning metric sensitivity, both MRI techniques (CINE-MRI and Static-MRI) are sufficiently able to match axiography; in particular, Static-MRI can be considered the method of choice, due to the better representation of morphological details. In the last study, Manfredini et al. [4] affirmed that MRI is superior to kinesiographic devices, and kinesiography cannot be used in dental practices as a method of diagnosis and management of internal derangements of the TMJ.

Risk of bias in individual studies

The results of the quality analysis of the included studies are summarized in Table 5. The overall risk of bias was judged to be high in all three studies [4,10,11]. The enrollment of the patients was prospective for the study by Neff et al. [11], retrospective for the study by Manfredini et al. [4], while in the last study [10], this information was not available. A real control group was considered only in the study by Neff et al. [11] (33 subjects with temporomandibular dysfunctions). In the study by Manfredini et al. [4], the same sample of patients (31 subjects) was considered as case group and control group. None of the three included studies used an estimation of the sample size [4,10,11]. Method error was not evaluated in any of the included studies for either recording procedure

Table 5. Analysis of the risk of bias for the 3 included studies.

Study	Enrollment	Control group	Sample size calculation	Method error	Adequacy of statistics	Expert rates	Overall risk of bias
Neff et al. [11]	Prospective	Yes	No	No	Yes	Yes	High
Lochmiller et al. [10]	NA	No	No	No	Yes	NA	High
Manfredini et al. [4]	Retrospective	Yes	No	No	Yes	Yes	High

Note: NA: not available.

[4,10,11]. To avoid interpretation bias related to the different radiologists or clinicians assessing the images, the evaluations were made by expert clinicians with expertise in the interpretation of MRI images and axiographic tracings [4]. The expert rates were reported in two of the three studies [4,11]. In the study by Lochmiller et al. [10], the evaluation of the outcomes of MRI and axiography by expert clinicians was not mentioned. The modalities of statistical analysis were appropriate in all three studies included in the review [4,10,11].

Discussion

The present systematic revision was conducted with the aim to evaluate diagnostic reliability and accuracy of kinesiography and axiography as compared with MRI in diagnosis of patients presenting internal derangements of the TMJ. There is a great controversy about the use of a jaw-tracking device in the diagnosis of intra-articular TMDs because the external validity of commercially available devices has not yet been assessed. In contrast, despite a cautionary statement by the research community [12], the use of kinesiographic and axiographic instruments have been accepted by several clinical practitioners, without appraising their validity, based only on claims and opinions of the users of these instruments [4,13]. From the analysis of the articles, it is possible to observe that the three studies [4,10,11] present a high risk of bias, due to the persons who collected data and the persons who interpreted images and tracings not being blinded (Table 5). It should be emphasized that the scientific data available in the literature are very poor, and this fact represents a limit for the research of a diagnostic value of these instruments in a clinical setting. From the 144 articles obtained by the first automatic search in the literature, at the end of the selection's procedure, only three studies that satisfied all the inclusion and exclusion criteria were selected for the analysis. The majority of the articles did not deal with the theme of the accuracy of axiography in comparison with MRI but either considered the value of two methods independently or used them for monitoring functional and clinical outcomes in patients treated for intra-articular TMDs without explaining if a technique of investigation was superior to another. It should be considered that, in the field of TMJ dysfunctions, MRI, the

other method adopted for the comparison with kinesiography and axiography, for several years was considered the gold standard in diagnosis of internal derangements of the TMJ. Moreover, over the years, the indications for the routine use of this technique in TMJ diseases are losing for the high costs and the evidence of the benign natural course of most TMJ disc displacements; but in the new DC/TMD, MRI is returned as an indication [14]. In this respect, Manfredini et al. [4] suggested that a thorough clinical assessment is often enough for managing the majority of patients' intra-articular TMDs, and so, the use of electronic devices for analyzing patients with internal derangements of the TMJ should stand comparison with less expensive diagnostic approaches. In line with this opinion, Lochmiller et al. [10] found that the recorded condylar movements give no additional, diagnostically relevant insights that go beyond the manual examination. In the systematic review, mandibular movements during the axiographic recordings were examined independently, without always considering the single types of internal derangement dysfunction or influencing factors of jaw motions. Among these, muscle disorders could have an important role on the accuracy of jaw-tracking devices, and they could change the findings. If permanent disc displacements are present, it should be pointed out that if this disturbance persists for longer, it does not need to show limited tracks anymore. In the course of time, the initial short tracks become long and regular, and they cannot be distinguished from normal [15]. Furthermore, there is a large variety of systems used to record mandibular movements. As supported by Lueckerath et al. [16], their recordings could not be offhand with each other. For this reason, there are currently no generally accepted guidelines for the interpretation of the recording's devices. Only the study by Neff et al. [11] involves a cohort/case-control study, and they investigated separately the healthy patients and the subjects with intra-articular TMD. In the study by Manfredini et al. [4], a convenience sample of patients with internal derangement of the TMJ was considered, in which subjects and joints with or without specific signs in MRI images served as cases and controls. The last study [10] investigated a small sample of patients without a control group. It is necessary to consider a larger sample size and to examine two different large pure control and case groups. It is important to observe that the evaluations

were made by expert clinicians with expertise in the interpretation of MRI images and axiographic tracings in two studies analyzed in full-text [11,12], but the lack of blindness of these experts and the persons who performed the techniques results in a low studies' quality. Moreover, a strong limit for a methodological study is the lack of the analysis of the repeatability. This aspect could provide a further stimulus for future research on a larger sample of patients with an effective follow-up.

The results demonstrate that axiographic or kinesiographic instruments cannot represent useful jaw-tracking devices to detect intraarticular disorders in the clinical setting, although limited available data should be considered. Neff et al. [11], in their study, concluded that both MRI techniques (static MRI and CINE-MRI) are superior to electronic axiography, mainly for the diagnosis process, documentation, and therapeutic decisions. They considered static MRI to be the method of choice, due to a superior representation of morphological details, but the study presents a high risk of bias. Manfredini et al. [4] reported that the correlation between kinesiographic parameters and MRI findings was not significant because none of the chosen parameters were correlated with any of the MRI findings. These authors also reported that the accuracy of kinesiographic findings to predict MRI diagnoses was not acceptable and too low to support the use of kinesiography in the clinical setting. In the last study [10], a high correlation between axiography and MRI (88%) was reported; furthermore, the authors showed that the remaining 12% was due to disc dislocations. The accuracy reported in this study was of 49%; approximately half of all axiographic interpretations corresponded to MRI results. According to the authors' opinion, this high percentage derives from the techniques of manual examinations, which have enhanced the accuracy of electronic jaw-tracking devices, with regard to the visualization of internal derangement. According to this evidence, instrumental analysis does not add any more important, further information, as compared to manual investigation.

Conclusion

A significant correlation between jaw-tracking systems and MR images in cases of TMJ disc displacement could not be detected. The scientific evidence does not support the usefulness of jaw-tracking devices in clinical practice to diagnose internal derangements of the TMJ, because those instruments' accuracy and reliability to diagnose TMJ disease is poor. It is necessary to perform further studies on this topic, less subjected to risk of bias, in particular, having larger samples and a control group to better elucidate the role of these TMJ recording's instruments.

Disclosure statement

No potential conflict of interest was reported by the authors.

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