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Modern techniques for TMJ evaluation - Modjaw versus Cadiax - a systematic review

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ABSTRACT

The temporomandibular joint (TMJ) plays a crucial role in various functions of the jaw, including chewing, speaking, and swallowing. Disorders of the TMJ can significantly impact a patient's quality of life, causing pain, dysfunction, and other systemic issues. Comprehensive TMJ evaluation is essential for accurately diagnosing and effectively treating these disorders. Two modern techniques for TMJ evaluation, Modjaw and Cadiax, offer advanced tools for detailed assessment. This comparison explores the capabilities, methodologies, and benefits of each system based on the current published studies. The aim is to highlight the novel nature of using digitalized tools for diagnosis and treatment planning, ass well as assessing the reliability of two systems.

Keywords: Modjaw, Cadiax, TMJ, articles

INTRODUCTION

TMJ evaluation is essential for diagnosing and managing disorders, alleviating pain, assessing jaw function, and ensuring comprehensive oral health care. It plays a vital role in customizing dental treatments, addressing associated conditions, improving quality of life, and preventing long-term damage. Mandibular movement analysis is a critical step in recreeating the functional occlusal morphology and improving the diagnosis and treatment of temporomandibular joint disorders (TMDs). Ulrich and Walker were the first ones to record condylar movement in 1896, they generated graphic curves from marking stylus fixed to a mandibular face-bow onto plates attached to a cranial bow [1]. Several techniques have been developed over the years to accurately capture and analyze these movements: Electromyography (EMG), Kinesiography, Ultrasonography, Magnetic Resonance Imaging (MRI), Cone Beam Computed Tomography (CBCT), Mechanical and Electronic Axiography, Optical Motion Capture Systems, etc.

Practicing modern dentistry comes with a myriad of challenges, reflecting both advancements in the field and evolving patient expectationsVirtual planning has revolutionized the field of dentistry by integrating advanced technology to improve accuracy, efficiency, and outcomes in dental treatments [2].

Recently, certain systems, which involve computerized data collection and analysis, have been found to be easy to use and noninvasive, in terms of tracking the motion of the jaw. These include the French company Modjaw launched in 2019 having a 4D dentistry concept, using true jaw motion and dynamic occlusion, in addition to 3D modelling [3] and Cadiax introduced by Gamma GmbH, Klosterneuburg, Austria in 1999 as a computerized axiography for electronic registration of mandibular movements [4]. The purpose of this review is to synthesize the results obtained in the current published

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studies regarding the use of the two digital devices and their reliability.

MATERIALS AND METHODS

A literature search was conducted to identify published articles that describe the use of Modjaw and Cadiax systems for measurment of TMJ kinematics. Articles were identified through a systematic search of the Pubmed database using the following keywords: "modjaw", "cadiax system", "jaw motion analysis", "jaw tracking system". Only studies published within the last 10 years were taken into consideresion to ensure current and relevant data. The results obtained from the search were analyzed. The set of criteria used to select the articles connected with the theme of the present study is presented in Table 1.

TABLE 1. The inclusion and exclusion criteria for the selected articles

Inclusion criteria	Exclusion criteria
1. Articles that studies the posibility of tracking the jaw movements using either Cadiax or Modjaw systems	1. Articles that studies the posibility of tracking the jaw movements without using Cadiax or Modjaw systems
2. Use of either Cadiax or Modjaw device for TMJ evaluation, SCI, BA or bite registration	2. Registration of SCI, BA, bite or TMJ evaluation without using either Cadiax or Modjaw device
3. Studies that report on quantitative outcomes such as accuracy, reliability, ease of use, patient outcomes, cost-effectiveness, and clinical relevance of the measurements provided by both systems	3. Studies lacking clear outcome measures related to the performance and efficacy of Modjaw or Cadiax systems
4. Articles written in English, abstract and free full text in the period 2014-2024	4. Studies published more than 10 years ago unless they are seminal works with a significant impact on the field

RESULTS

A total of 586 articles were found in the PubMed database search by using the specified keywords. 18 of these publications were relevant to the subject of the study. After a thorough review, only 8 articles were selected as eligible for the present research. The study workflow is presented in Figure 1. Out of the 18 articles analyzed for eligibility 10 of them described dental thechniques and workflows using either Cadiax [5-7] or the Modjaw device [8-14] without giving any precize informations on the accuracy of the measurements provided by the two systems.

DISCUSSION

Regarding the use of the Cadiax system, only 2 [15,16] Pubmed articles have been published in the last 10 years, which follow and compare the accuracy of measurements obtained by using the Cadiax system with other clinical recording methods. In nov 2014 Kianoosh Torabi et al. conducted a clinical comparative study of Cadiax Compact II and intraoral records using wax and addition silicone [15]. The results they obtained show that there are significant diffrences for all measurements between Cadiax and intraoral records and that Cadiax measurements had a stronger correlation with silicone records [15]. In a studie published on april 2020 researchers evaluated the sagittal condylar guidance angles (SCGAs) determined by the use of pantographic tracing (recorded using Cadiax® Compact system), protrusive records (using polyvinyl siloxane bite registration material, transferred to a semiadjustable articulator using facebow transfer and CR records, to determine SCGAs), and radiographic (CBCT) techniques [16]. By comparing the results they found strong correlations between SCGAs obtained using PT, PR, and. CBCT techniques [16]. In the other studies published in this time frame Cadiax it's used rather as a reference tool [5-7,17,18] which proved reliability over the years in the medical world [19-22].

In an article published in nov 2021 Bapelle, M. et al. investigated the use of Modjaw® device with the objetive to find the repetability and kinematic data of Modjaw recordings in a group of 22 asymptomatic patients. The results found in this study indicate a good to excellent repeatability. They conclude by saying that "The Modjaw® device reliably records the patient's real hinge axis kinematics during functional mandibular movements" [23]. In January and March 2023 Marta Revilla-León et al conducted two studies with the purpose of assesing the accuracy of the maxillomandibular relationship recorded at CR

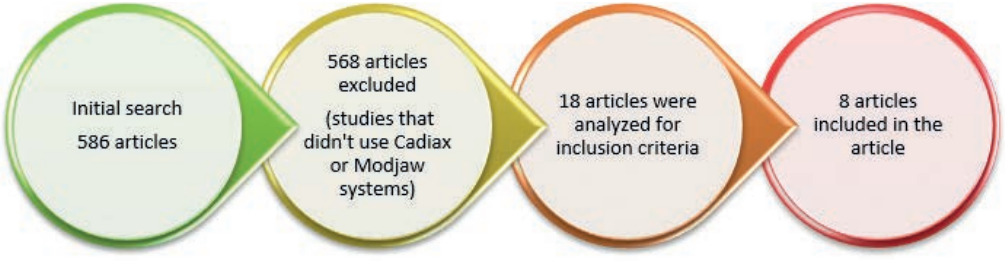

FIGURE 1. The workflow of the studies selection

position using different intraoral scanners with or without jaw tracking systems and compared it to the gold standard conventional method (polyvinyl siloxane impressions, dental stone, facebow registration, semi-adjustable articulator) as a reference [24,25]. The findings in these studies were that the trueness and precision of the maxillomandibular relationship recorded at the CR position were influenced by the different digital techniques tested [24,25]. Following up in nov 2023 Zsolt Nagy et al. published an in vitro studie, comparing the Modjaw accuracy to the one of an industrial-grade 3 D scanner [26]. The results in this studie has shown that Modjaw could be described as an optical scanner similar to industrial scanners as the Modjaw trueness was inferior only by 2 μm compared to the precision and was less than 11 μm [26]. Moreover differences were shown between IMR at 1mm group and IMR at 4 mm group, which helped the autors to drawn the conclusion that the Modjaw device can detect subtle changes in mandibular kinematics that could be significant in diagnosing and treating dental disorders [26]. When comparing to the previous studies [24,25] trueness of the Modjaw indicated values approximately 40 times higher than the pure Modjaw trueness obtaind in the in vitro studie of Zsolt Nagy et al., indicating the magnitude of the IOS uncertainty [26]. In 2023 and a year later in 2024 two different groups of researchers compared the values of condylar inclination obtianed by measuring it using Cadiax Compact 2 and Modjaw device [17,18]. Both groups measured the values of SCI and BA at 3 and 5 mm of condylar displacement. The results were similar for the both groups of researchers, concluding that the SCI and BA values for MODJAW measurements were higher than those acquired with Cadiax [17,18].

CONCLUSION

Based on the on the findings of this literature review, the following conclusions were drawn:

1. Both systems can detect subtle changes in mandibular kinematics and are useful in orthodontic diagnosis
2. The Cadiax device is a reliable device, with high repeatability of the recordings and low mean error proved over the time.
3. In the recent years the Cadiax system is used as a reference between the researchers.
4. Modjaw is a promising tool that can provide usefull information, but further studies are needed to confirm it's accuracy.

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All authors have read and agreed to the published version of the manuscript.

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