International Dental & Medical Journal of Advanced Research (2017), 3, 1–9

SYSTEMATIC REVIEW AND META-ANALYSIS

Effect of computer-aided design/computer-assisted manufacture versus conventional occlusal splints on the management of temporomandibular disorders: A systematic review and meta-analysis

Radhwan Saleh Algabri[1,2], Ahmed Yaseen Alqutaibi[2,3], Hanan Abo-Alrejal[1], Omar Al Adashi[1], Fadag Abdulrahman[2], Amr Elkhadem[1], Ahmed Keshk[1], Eman Maher[4], Amal Fathy Kaddah[1]

[1]Department of Prosthodontics, Faculty of Dentistry, Cairo University, Cairo, Egypt, [2]Department of Prosthodontics, Faculty of Oral and Dental Medicine, Ibb University, Ibb, Yemen, [3]Department of Prosthodontics, Faculty of Dentistry, Ahram Canadian University, Cairo, Egypt, [4]Department of Neurophysiology Unit-Neurology, Faculty of Medicine, Kasr El Einy, Cairo University, Cairo, Egypt

Keywords
Computer-aided design/computer-assisted manufacture, muscle activity, occlusal splint, patient's satisfaction, systematic review, temporomandibular disorders

Correspondence
Dr. Radhwan Saleh Algabri,
6 Abdobadran - Elmanial, Cairo, Egypt.
Email: radalgabri@yahoo.com

Received 17 May 2017;
Accepted 25 Jun 2017

doi: 10.15713/ins.idmjar.72

Abstract

Background: With continuous debate and lack of consensus regarding which are more effective in management of the temporomandibular disorders (TMDs), computer-aided design/computer-assisted manufacture (CAD/CAM) or conventional occlusal splint.
Aim: The aim of this systematic review and meta-analysis was to perform a qualitative and quantitative analysis of the scientific literature regarding the use of CAD/CAM versus conventional occlusal splint in the management of patient with TMDs.
Methodology: Manual and electronic database (PubMed and Cochrane) searches were performed to identify randomized controlled trials (RCTs), without language restriction, comparing CAD/CAM versus conventional occlusal splints. Data were extracted independently by two reviewers. The Cochrane tool was used for assessing the quality of included studies. Meta-analyses were performed for the two included RCTs of similar comparisons reported the same outcome measures.
Results: Eight trials were identified. Out of them two RCTs were included and six trials were excluded. The two included RCTs were considered to be at a low risk of bias. The pooled result revealed that the CAD/CAM occlusal splint has statistically significant less pain in jaw joint, face tension, and time needed for adjustment when compared to conventional occlusal splints.
Conclusion: The meta-analysis revealed that the CAD/CAM occlusal splint has statistically potential in reduction of pain in jaw joint, face tension, and time needed for adjustment when compared to conventional occlusal splints.
Clinical Significance: CAD/CAM occlusal splint may be suggested as an alternative manufacturing modality for TMDs patients who can offer the cost of this treatment modality. This review should be interpreted with caution because of limited number of included studies. Well-designed RCTs should be conducted and the outcome measures evaluation should be standardized between studies to reach potent conclusion.

Introduction

The American Academy of Orofacial pain defined temporomandibular disorders (TMDs) as a number of clinical problems, which involve the masticatory musculature, the temporomandibular joints (TMJs) and associated structures.[1]

TMD prevalence assessment may be a multifaceted problem due to the presence of orofacial pain in addition to the frequent concurrent of different symptoms, such as ear pain, headache, and neuralgia, which may be associated to the TMD or be present as auxiliary findings to be considered in the differential diagnosis procedure.[2]

The prevalence of TMD, according to published literatures, is approximately 10% in patients over 18 years of age, with a considerable proportion being women of reproductive age.[2,3]

Research diagnostic criteria for TMDs (RDC/TMDs) were established and published in 1992.[4] The RDC/TMD details the clinical and historical assessment of TMD patients in an effort to standardize these processes for improved reliability and validity of TMD research.[5]

In a systematic review conducted by Leighann *et al.*,[6] to increase understanding about how pain has been assessed in recent clinical trials. They reported that there are many types of pain assessments available to researchers conducting clinical trials, ranging from simple, single-item visual analog scale (VAS) questions through extensive, multidimensional inventories (including the McGill Pain Questionnaire 40), and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC2). They concluded that the most frequently used assessments were VAS scale and numeric rating scale.

The masseter and anterior temporalis muscles are the masticatory muscles that most frequently studied using electromyogram (EMG) given their easy accessibility through surface electrodes.[7] Many studies have obtained recordings and assessed the relationship between these muscles with TMDs.[8,9]

Optical computerized axiography was used to measure condylar movements due to its capacity to record condylar pathways (i.e., TMJ movements) with precision and reliability in the frontal, sagittal, and horizontal planes, rather than interincisal opening.[10,11]

Management of TMD can be either conservative or surgical treatments.[12] The conservative treatments include; analgesia, medications, physical therapy, occlusal adjustment, splint therapy, localized steam application, and external muscle massage.[13]

The stabilization splint is a clinical tool resource applied in dentistry for TMD treatment as well as for the protection of dental structures and for the articular, muscular, and dental system. Furthermore, one of the proposed mechanisms of action is the reduction in proprioception generated by the disocclusion between the upper and lower teeth[14] and the increased TMJ space.[12]

Conventional occlusal appliances are commonly used in the treatment of patients with TMD and have been reported to improve signs and symptoms in these patients.[15,16]

The occlusal splints could be fabricated from hard or soft materials; the hard and soft occlusal splints have similar effects with no significant differences regarding the pain intensity and muscle tenderness reductions.[17]

Conventional methods of splint fabrication are highly technique sensitive and often lead to poor splint fit and require extensive chairside time for adjustments to achieve passive fit and an appropriate occlusal scheme.[18] Moreover, these appliances are more prone to fracture and failure during use.[19]

In contrast to traditional technical processes that has individual human errors, the computer-aided design/computer-assisted manufacture (CAD/CAM) splint eliminate these errors, require less manufacturing time and effort in addition to the high material quality, and possibility of manufacturing duplicate splints.[19,20]

With continuous debate, regarding which are more effective in managements of the TMD, CAD/CAM or conventionally made acrylic stabilization occlusal splint, this systematic review aimed to answer the following question "does the CAD/CAM occlusal splints results in different satisfaction, muscle activities, optical axiography, and time of adjustments when compared with conventional occlusal splints?"

Review Method

This systematic review was conducted and reported in strict accordance with the preferred reporting items for systematic reviews and meta-analyses guidelines.[21]

Eligibility criteria

Included studies

Parallel groups randomized controlled trials (RCTs), in which CAD/CAM occlusal splint was compared with conventional occlusal splint.

Participants

All participants with TMDs-Axis I Group 2 (DDWR) according to RDC/TMD.

Types of interventions

- CAD/CAM occlusal splint
- Conventional occlusal splint.

Outcome measures

- Subjective pain analysis using numeric scale for TMD (TMD/NS)
- Muscle activity using electromyography (EMG)
- Condylar paths using optical axiography in millimeter
- Time needed for adjustment using stopwatch.

Information sources

Electronic databases (PubMed and the Cochrane Library) were searched to identify RCTs without time or language restrictions, reporting on management of patients with DDWR. In addition, a manual search of the following related journals was done; the Journal of Craniomandibular Practice, Journal of Orofacial Pain, Oral Surgery, Oral Medicine, Journal of Oral and Facial Pain and Headache, the Clinical Journal of Pain, and Journal of Oral and Maxillofacial surgery. Moreover, online databases providing information about clinical trials in progress were checked (clinicaltrials.gov; www.centerwatch.com/clinicaltrials;www.clinicalconnection.cm) the last performed search was on the 18 November 2016.

Search strategy

Two reviewers independently performed the search (Algabri and Alqutaibi). Combinations of controlled terms (MeSH)

and keywords were used whenever possible. The search terms used for the search in databases were as follows (conventional stabilization splint) OR conventional occlusal splint) OR traditional stabilization splint) OR traditional occlusal splint) OR conventional stabilization appliance) OR conventional occlusal appliances) OR Michigan occlusal splint) OR Michigan-type splint) OR centric occlusal splints) OR monoplane occlusal stent) OR occlusal stabilization stents) OR occlusal stabilizing appliance) OR anterior positioning appliance) OR anterior repositioning appliance) OR anterior bite plane) OR posterior bite plane)) OR (CAD-CAM splint) OR CAD-CAM occlusal splint) OR CAD CAM) OR digital splint) OR digital occlusal appliances) OR digital occlusal splints) OR computer-aided occlusal splints) OR computer-aided occlusal appliances) OR computer-fabricated occlusal splints) OR computer-fabricated occlusal appliance) OR digital processing splint) OR digital additive splints) OR computer-manufacturing occlusal appliance) OR computer-manufacturing occlusal splints) AND ((TMD) OR TMDs) OR TMDs) OR internal derangement) OR disc displacement) OR myofacial pain) OR TMJ dysfunction syndrome) OR TMJ) OR temporomandibular) OR facial pain) OR bruxism) OR arthralgia).

Selections of the studies

The database search resulted in a total of 521 articles and five records identified from other sources, of which 40 potentially relevant articles were selected after removing duplicates. After the initial screening, two publications were selected for additional evaluation of the full-text version for being directly related with the aim of the present study. Of these, two RCTs fulfilled the inclusion criteria and the two trials were subsequently analysed in this systematic review [Graph 1]. Details of all included studies are summarized in Tables 1 and 2.

Data collection and analyses

Study selection

Two reviewers (Algabri and Alqutaibi) independently shortlisted the searched publications by performing a thorough title and abstract screening. Inclusion of articles for the full-text analyses was performed only after a mutual agreement between the two reviewers. Any disagreements were resolved by discussion; if not a third reviewer (Kaddah A) was consulted.

Data extraction and management

Data extraction was performed after a mutual agreement on the final list of included publications. Data were extracted independently by the two reviewers (Algabri and Alqutaibi) and were reciprocally blinded to each other's extraction. The following information was extracted: Name of author(s), publication year, country where study done, study design, intervention type, observation period, number of patients, number of occlusal splints placed failed, pain scale, muscle activity, optical axiography, and time needed for adjustment.

Table 1: Characteristics of included studies (demographic data and methodology)

Study ID	Country	Follow-up month	Age (gender)	Problem	Outcomes measured	Number of participants	Interventions	Participants per group	Study design
Pho Duc *et al.*[15] 2016	Germany	9	20-50 years (22 female and 10 male)	TMD	TMD/NS, 10 cm were used to measure headaches, face pain, jaw joint pain, jaw joint noises, mastication pain, neck pain, face tension, limitation of mouth opening, complaints during mastication, and teeth sensitivity - optical axiography	32	CAD/CAM occlusal splint	16	RCT
							Conventional occlusal splint	16	
Algabri *et al.*[25] 2017	Egypt	3	20-45 years (24 female and 6 male)	TMD	TMD/NS, 10 cm were used to measure headaches, face pain, jaw joint pain, jaw joint noises, mastication pain, neck pain, face tension, limitation of mouth opening, complaints during mastication, and teeth sensitivity Muscle activity Time needed for adjustment	30	CAD/CAM occlusal splint	15	RCT
							Conventional occlusal splint	15	

CAD/CAM: Computer-aided design/computer-assisted manufacture, TMD/NS: Temporomandibular disorders/numeric scale, RCT: Randomized controlled trials

Table 2: Characteristics of included studies (outcomes)

Study ID	Interventions	TMD/NS* (Mean±SD†)													Optical axiography (mean±SD) (mm)		Muscle activity (mean±SD)		Time needed for adjustment at time of delivery (mean±SD)
		Headache	Face pain	Pain in the jaw joint	Noise in the jaw joint	Pain during mastication	Neck pain	Face tension	Neck tension	Limitation on mouth opening	Complaints during mastication	Face tension on awakening	Face tension at the end of the day (6 PM)	Teeth sensitivity	Right condyle	Left condyle	Masseter muscle	Temporalis muscle	
Pho Duc *et al*[15] 2016	CAD/CAM occlusal splint	3.1±2.2	1.8±1.8	2.8±2.3	3.3±2.5	2.5±2.1	3.6±2.5	2.8±2.3	4.5±2.4	1.6±1.5	2.2±1.9	2.8±2.0	2.3±1.9	2.6±1.9	9.6±3.8	9.4±4.1	NR3	NR	NR
	Conventional occlusal splint	4.6±3.2	3.2±2.5	3.0±3.1	1.8±2.5	1.6±2.1	4.8±2.5	3.4±2.6	4.9±2.3	1.4±1.8	1.4±2.0	3.0±2.5	3.1±1.9	1.9±2.1	10.5±4.1	11.0±4.6	NR	NR	NR
Algabri *et al.*[25] 2017	CAD/CAM occlusal splint	3.2±2.5	3.4±2.1	4.1±1.9	5.2±2.3	3.1±2.2	2.2±2.4	3.2±2.2	1.9±1.2	2.5±2.2	3.5±2.1	3.0±2.5	2.4±2.3	2.3±2.5	NR	NR	223.5±52.5	279.5±72.7	9.8±1.9
	Conventional occlusal splint	3.7±2.4	3.6±2.3	5.5±1.5	5.4±2.7	5.1±2.7	2.9±2.2	5±2.1	2.1±1.3	3.2±2.5	4.8±2.1	3.8±2.0	2.3±1.0	3.8±2.4	NR	NR	247.6±88.9	283.3±86.5	21.3±3.5

CAD/CAM: Computer-aided design/computer-assisted manufacture, TMD/NS: Temporomandibular disorders/numeric scale, *SD: Standard deviation, †numeric scale, *slandered deviation, not reported

The quality assessment

The risk of bias assessment of the included trials was done by the two reviewers independently using the Cochrane collaboration's tool,[22] six specific domains, namely, sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting, and other bias. An RCT was assigned "low risk of bias" if all domains were at low risk of bias, "unclear risk of bias" if there was unclear risk of bias of at least one domain, and "high risk of bias" if at least one domain was scored as being at a high risk of bias.

Statistical analyses

Measures of treatment effect

For dichotomous outcomes, the estimate of effect of an intervention was expressed as risk differences together with 95% confidence intervals (CIs). For continuous outcomes, mean differences and standard deviations were used to summarize the data for each group with 95% CIs.

Unit of analysis issues

The statistical unit was the patient.

Missing data

If the included articles had any missing relevant information, the corresponding authors were contacted by email. In case of no responses, reminder emails were sent.

Data synthesis

All statistical tests were performed using the REVMAN software release version 5.3[23] by Algabri. Meta-analyses were undertaken where studies of similar comparisons reported the same outcome measures. MD for the patient satisfaction, optical axiography, muscle activity, and time needed for adjustment were calculated and compared between the two studied interventions (CAD/CAM and conventional occlusal splints). CIs were set at 95% (95% CI).

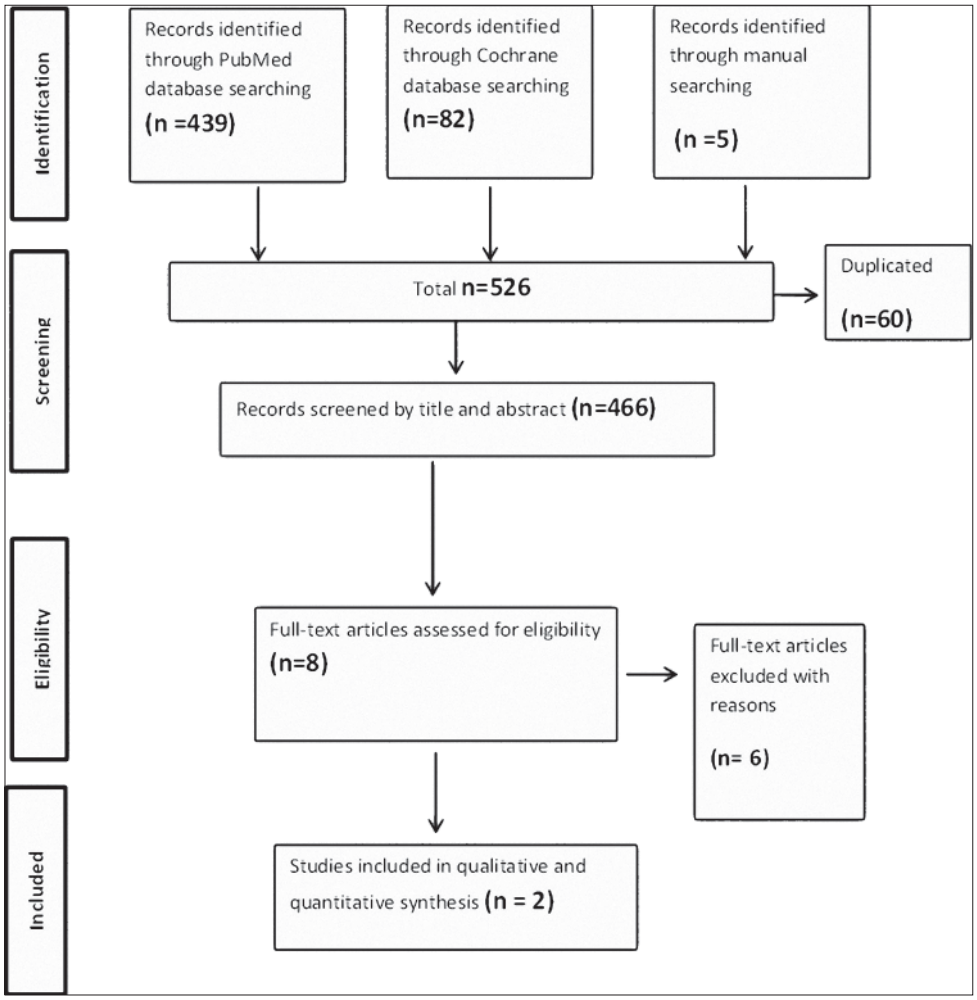
Weighted means across the studies were calculated using a fixed-effects model. Where statistically significant ($P < 0.1$) heterogeneity was detected and a random-effects model was used to assess the significance of treatment effects.

Assessment of heterogeneity

The significance of any variations in the estimates of the treatment effects from the different trials was to be assessed by means of Cochran's test for heterogeneity and heterogeneity would have been considered statistically significant if $P < 0.1$. Heterogeneity between the studies was assessed using the I-squared statistic (I^2-statistic), which describes the variation percentage due to heterogeneity rather than chance.[24] I^2 over 50% was considered as moderate-to-high heterogeneity.

RESULTS

The electronic search yielded a total of 345 articles (PubMed = 439; The Cochrane Library = 82). Five more



Graph 1: Preferred reporting items for systematic reviews and meta-analyses 2009 flow diagram

relevant articles were identified from the reference cross-checks. Of the eight potentially eligible RCTs,[15,19,25-29] two[15,25] were included and six[19,26-29] were excluded. Reasons of exclusion were as follow: The six trials[19,26-29] were non-randomized clinical trials.

Characteristics of included studies

All included trials compared the effect of CAD/CAM versus conventional occlusal splints in management of TMD. One trial[15] conducted in Germany and one[25] in Egypt. All trials conducted in university dental clinics.

The trial conducted by Pho Duc *et al.*[15] comprised 32 patient (22 female and 10 male) diagnosed as TMDs (disc displacement with reduction, disc displacement without reduction, muscle disorders, and arthralgia) using RDC/TMD with follow-up 9 months.

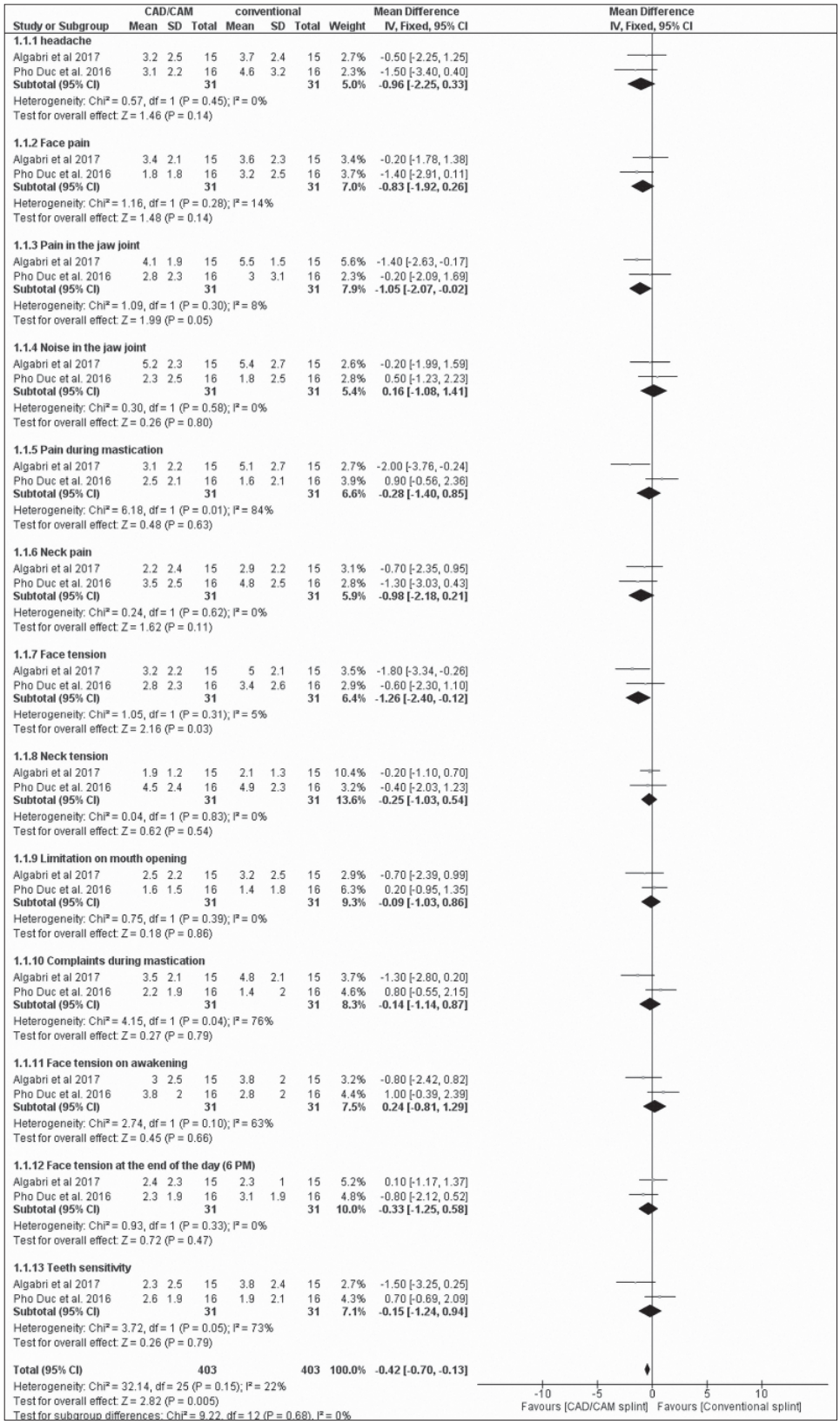
The trial conducted by Algabri *et al.*[25] comprised 30 patient (24 female and 6 male) diagnosed as TMD (disc displacement with reduction) using RDC/TMD with follow-up 3 months.

The outcomes were reported as follows:

- Patient's satisfaction: Two RCTs[15,25] reported this outcome using TMD/NS, 10 cm to measure the following; headaches, face pain, jaw joint pain, jaw joint noises, mastication pain, neck pain, face tension, limitation of mouth opening, complaints during mastication, and teeth sensitivity.
- Optical axiography: Moss and Garrett[15] reported outcome using electronic optical axiography system in a RCT to measure the right and left condyle movements or condylar pathways (in mm).
- Muscle activity: Algabri *et al.*[25] reported using EMG to measure muscle activity of masseter and temporalis muscles in a RCT.
- Time needed for adjustment: It was reported in one RCT by Algabri *et al.*[25] using stopwatch in minutes.

Risk of bias assessment

The final risk of bias assessment of the included trials is summarized in Table 3. For each trial, we assessed whether it was at low, unclear, or high risk of bias. All two included RCTs were judged to be at low risk of bias [Table 3].



Graph 2: Forest plot of computer-aided design/computer-assisted manufacture versus conventional occlusal splint (patient's satisfaction)

Meta-analysis

A meta-analysis was performed for studies with similar comparisons that reported the same outcome measures.

CAD/CAM versus conventional occlusal splint (patient's satisfaction)

The meta-analyses of two trials,[15,25] regarding headaches, face pain, jaw joint noises, mastication pain, neck pain, limitation of mouth opening, complaints during mastication, and teeth sensitivity, there were no statistically significant differences between the two interventions. In regard to jaw joint pain, the pooled data revealed statistically significant reduction in pain in CAD/CAM occlusal splints when compared to conventional splint (I^2 = 8%, P = 0.05; RD: −1.05, 95% CI: −2.07, −0.02). In similar way face tension, there was statistically significant reduction in face tension in CAD/CAM occlusal splints when compared to conventional splint (I^2 = 5%, P = 0.03; RD: −1.26, 95% CI: −2.4, −0.12) [Graph 2].

CAD/CAM versus conventional occlusal splint (optical axiography)

The meta-analyses of one trial[15] regarding optical axiography comparing CAD/CAM versus conventional occlusal splint showed no differences between CAD/CAM versus conventional occlusal splint [Graph 3].

CAD/CAM versus conventional occlusal splint (muscle activity)

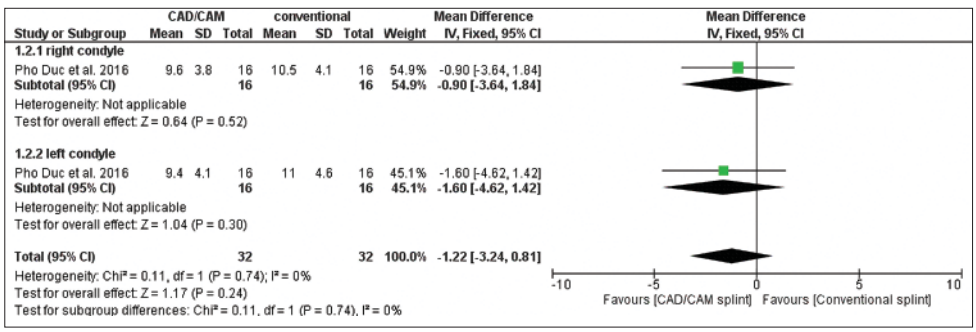
The meta-analyses of one trial[25] regarding improvement of muscle activity comparing CAD/CAM versus conventional occlusal splint showed no differences between CAD/CAM versus conventional occlusal splint [Graph 4].

CAD/CAM versus conventional occlusal splint (time needed for adjustment)

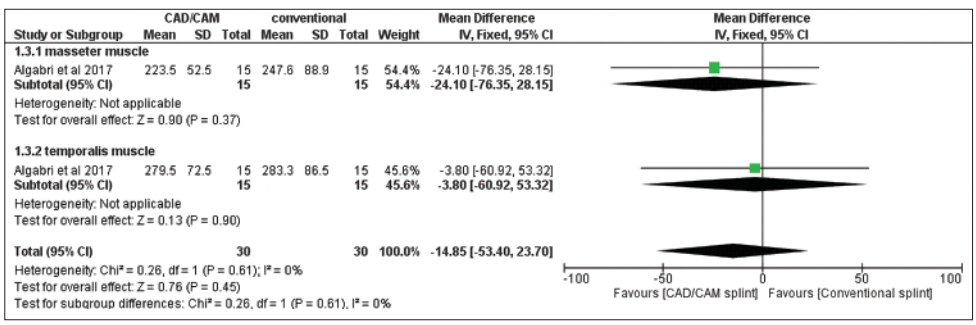
The meta-analyses of one trial[25] regarding the time needed for adjustment comparing CAD/CAM versus conventional occlusal splint showed statistically significant less time needed for adjustment in the CAD/CAM occlusal splint when compared to conventional occlusal splint (P = 0.00001; MD: −11.5, 95%, CI: −13.52, −9.48) [Graph 5].

Discussion

This review delivered meta-analyses of the RCTs that considered as the highest level of confirmatory scientific evidence today.[30] In



Graph 3: Forest plot of computer-aided design/computer-assisted manufacture versus conventional occlusal splint (optical axiography)

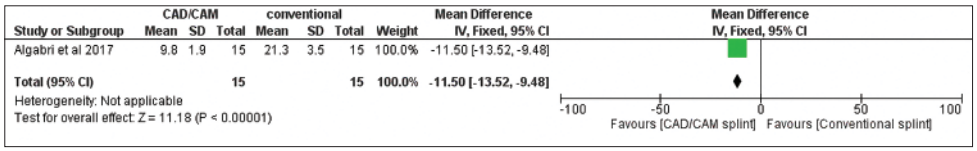


Graph 4: Forest plot of computer-aided design/computer-assisted manufacture versus conventional occlusal splint (muscle activity)

Table 3: Risk of bias assessment of the included RCTs

Study ID	Random sequence	Allocation concealment	blinding	Incomplete outcome data	Selective reporting	Others
Pho Duc *et al.*[15] 2016	Low risk	Unclear	Low risk	Unclear	Low risk	Low risk
Algabri *et al.*[25] 2017	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk

RCT: Randomized controlled trials



Graph 5: Forest plot of computer-aided design/computer-assisted manufacture versus conventional occlusal splint (time needed for adjustment)

terms of internal validity, RCTs represent the most scientifically rigorous study design, when properly executed, as they are best able to control bias and serve as a gold standard of study designs for evaluating treatment efficacy and widely considered as highest level of confirmatory scientific evidence.[31]

This meta-analysis of two RCTs[15,25] including 62 patients (62 occlusal splints placed) revealed that there are significant differences between the MD of the two investigated interventions (CAD/CAM and conventional occlusal splints) regarding the reduction of pain in jaw joint, face tension, and time needed for adjustment. However, there are no significant differences between the MD of the two investigated interventions (CAD/CAM and conventional occlusal splints) regarding headaches, face pain, jaw joint noises, mastication pain, neck pain, limitation of mouth opening, complaints during mastication, and teeth sensitivity, in addition to optical axiography and muscle of adjustment.

Pho Duc *et al.*[15] evaluated the efficacy of CAD/CAM and conventional occlusal splints in the management of TMD. 32 patients with TMD were diagnosed and were randomly assigned into two groups of 16 patients each. Group 1: Participants were given CAD/CAM occlusal splint and Group 2: Conventional occlusal splint for 9 months. Pain analysis using TMD/NS was performed at baseline and then monthly for 9 months and optical axiography was performed at baseline, 3 months and 6 months. The results showed that there is no statistical significant between the two groups regarding TMD/NS and optical axiography. They added that pain symptoms (headaches, face pain, jaw joint pain, mastication pain, and neck pain) and TMJ-related symptoms (jaw joint noises, limitation in mouth opening, and mastication complaints) improved after 3 months in the conventional splint group, whereas in the CAD/CAM group improvement was seen only after 4 months. Similarly, improvement in tension-related variables (i.e. face tension, neck tension, face tension on awakening or at the end of the day in the last month, and teeth sensitivity) was observed in Group 2 after 2 months while in Group 1 the lowest measurement was observed only after 7 months. Both splints were effective and reached similar measurement levels at the last time point (9-month follow-up). Finally, there was no relapse in either group during the 9-month test period in any TMD/NS variable.

Algabri *et al.*[25] compared the effectiveness of CAD/CAM versus conventional occlusal splint regarding patient's satisfaction, muscle activity, and time needed for adjustment in the management of TMD. 30 patients were randomly assigned to CAD/CAM and conventional occlusal splints. The TMD/NS, muscle activity of masseter and temporalis muscles, and time needed for adjustment were used as outcome measures during a 3-month follow-up (baseline, 1 month, and 3 months). There was statistically significant improvement in TMD/NS of CAD/CAM splint group when compared to conventional splint after one and three months and highly statistical significant less time required for adjustment for the CAD/CAM occlusal splints when compared to the conventional occlusal splints. Regarding muscle activity of masseter and temporalis muscles, there was no statistically significant differences at all follow-up periods between CAD/CAM and conventional occlusal splints. They concluded that the CAD/CAM occlusal splint improves the patient's satisfaction of TMDs patient greater than that of conventional occlusal splint. Moreover, both CAD/CAM and conventional occlusal splint improves the masseter and temporalis muscle activities. In addition that the CAD/CAM occlusal splint decreases to a large extent, the time needed for splint adjustment compared to conventional occlusal splint.

Several studies[13,32-34] revealed that most symptoms of TMD if not all disappear after 3 months of occlusal splint therapy in accordance with their finding, the meta-analysis of the two included studies of this systematic review conducted after 3 months of occlusal splint therapy.

Conclusion

The meta-analysis revealed that the CAD/CAM occlusal splint has statistically significant potential in reduction of pain in jaw joint, face tension, and time needed for adjustment when compared to conventional occlusal splints. However, this should be interpreted with caution because limited numbers of studies were included.

Recommendation

Well-designed RCTs, comparing CAD/CAM and conventional occlusal splints and reporting on patient-related outcomes, are highly recommended to evaluate the effectiveness of the occlusal splint type.

References

1. de Leeuw R, editor. Orofacial Pain. Guidelines for Assessment, Diagnosis, and Management. 4th ed. Chicago, IL: The American Academy of Orofacial Pain, Quintessence Publishing Co, Inc.; 2008.
2. LeResche L. Epidemiology of temporomandibular disorders: Implications for the investigation of etiologic factors. Crit Rev

Oral Biol Med 1997;8:291-305.
3. Turp JC. Temporomandibular Pain: Clinical Presentation and Impact. Chicago, IL: Quintessence Publishing; 2000.
4. Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders: Review, criteria, examinations and specifications, critique. J Craniomandib Disord 1992;6:301-55.
5. Hunter A, Kalathingal S. Diagnostic imaging for temporomandibular disorders and orofacial pain. Dent Clin North Am 2013;57:405-18.
6. Litcher-Kelly L, Martino SA, Broderick JE, Stone AA. A systematic review of measures used to assess chronic musculoskeletal pain in clinical and randomized controlled clinical trials. J Pain 2007;8:906-13.
7. Pita MS, Ribeiro AB, Garcia AR, Pedrazzi V, Zuim PR. Effect of occlusal splint thickness on electrical masticatory muscle activity during rest and clenching. Braz Oral Res 2011;25:506-11.
8. Dawson PE. Evidence-based versus experience-based views on occlusion and TMD. Am J Orthod Dentofacial Orthop 2005;128:150-1.
9. Yabushita T, Zeredo JL, Toda K, Soma K. Role of occlusal vertical dimension in spindle function. J Dent Res 2005;84:245-9.
10. Piancino MG, Roberi L, Frongia G, Reverdito M, Slavicek R, Bracco P. Computerized axiography in TMD patients before and after therapy with "function generating bites". J Oral Rehabil 2008;35:88-94.
11. Han BJ, Kang H, Liu LK, Yi XZ, Li XQ. Comparisons of condylar movements with the functional occlusal clutch and tray clutch recording methods in CADIAX® system. Int J Oral Sci 2010;2:208-14.
12. Seifeldin SA, Elhayes KA. Soft versus hard occlusal splint therapy in the management of temporomandibular disorders (TMDs). Saudi Dent J 2015;27:208-14.
13. Alqutaibi AY, Aboalrejal AN. Types of occlusal splint in management of temporomandibular disorders (TMD). J Arthritis 2015;2015:176.
14. Pho Duc JM, Hüning SV, Grossi ML. Parallel randomized controlled clinical trial in patients with temporomandibular disorders treated with a CAD/CAM versus a conventional stabilization splint. Int J Prosthodont 2016;29:340-50.
15. Moss RA, Garrett JC. Temporomandibular joint disfunction syndrome and myofascial pain dysfunction syndrome: A critical review. J Oral Rehabil 1984;11:3-28.
16. Dahlström L. Conservative treatment methods in craniomandibular disorder. Swed Dent J 1992;16:217-30.
17. Algabri RS, Alqutaibi AY, Keshk AM, Alsourori A, Swedan M, El Khadem AH, *et al*. Effect of hard versus soft occlusal splint on the management of myofascial pain: Systematic review and meta-analysis. Indian J Sci Technol 2017;10:10-16.
18. Dunn DB, Lewis MB. CAD/CAM occlusal splints: A new paradigm. Aust Dent Pract 2011;22:131.
19. Hogan J. DentaBite: A precision engineering solution to a traditional problem. Aust Dent Pract 2011;8:164-8.
20. Dedem P, Türp JC. Digital Michigan splint - From intraoral scanning to plasterless manufacturing. Int J Comput Dent 2016;19:63-76.
21. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. Ann Intern Med 2009;151:264-9.
22. Higgins JP, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, *et al.* the cochrane collaboration's tool for assessing risk of bias in randomised trials. BMJ 2011;343:d5928.
23. Collaboration C. Review Manager (RevMan). Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration; 2011.
24. Harris R, Bradburn M, Deeks J, Harbord R, Altman D, Sterne J. Metan: Fixed-and random-effects meta-analysis. Stata J 2008;8:3.
25. Algabri RS, Elkhadem AH, Maher EA, Kaddah AF. Patient's satisfaction and muscles activity after management of TMD patients using CAD/CAM versus conventional occlusal splints (randomized clinical trial). Int Dent Med J Adv Res 2017;2:1-8.
26. Salmi M, Paloheimo KS, Tuomi J, Ingman T, Mäkitie A. A digital process for additive manufacturing of occlusal splints: A clinical pilot study. J R Soc Interface 2013;10:20130203.
27. Lyzscxw C. A novel method in the design and fabrication of dental splints based on 3D simulation and rapid prototyping technology. Int J Adv Manuf Technol 2006;28:919-22.
28. Solow RA. Customized anterior guidance for occlusal devices: Classification and rationale. J Prosthet Dent 2013;110:259-63.
29. Strub JR, Rekow ED, Witkowski S. Computer-aided design and fabrication of dental restorations: Current systems and future possibilities. J Am Dent Assoc 2006;137:1289-96.
30. Glenny AM, Nieri M, Worthington H, Espostio M. The importance of the study design: From the case report to the randomised controlled clinical trial. Eur J Oral Implantol 2008;1:317-21.
31. Friedman LM, DeMets DL. Fundamentals of Clinical Trials. New York: Springer; 2010.
32. Suvinen T, Reade P. Prognostic features of value in the management of temporomandibular joint pain-dysfunction syndrome by occlusal splint therapy. J Prosthet Dent 1989;61:355-61.
33. Raphael KG, Marbach JJ, Klausner JJ, Teaford MF, Fischoff DK. Is bruxism severity a predictor of oral splint efficacy in patients with myofascial face pain? J Oral Rehabil 2003;30:17-29.
34. Hamata MM, Zuim PR, Garcia AR. Comparative evaluation of the efficacy of occlusal splints fabricated in centric relation or maximum intercuspation in temporomandibular disorders patients. J Appl Oral Sci 2009;17:32-8.

How to cite this article: Algabri RS, Alqutaibi AY, Abo-Alrejal H, Al Adashi O, Abdulrahman F, Elkhadem A, Keshk A, Maher E, Kaddah AF. Effect of computer-aided design/computer-assisted manufacture versus conventional occlusal splints on the management of temporomandibular disorders: A systematic review and meta-analysis. Int Dent Med J Adv Res 2017;3:1-9.