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Effects of occlusal splint therapy in patients with migraine or tension-type headache and comorbid temporomandibular disorder
A randomized controlled trial

Felix Joyonto Saha, MD[a], Almut Pulla[a], Thomas Ostermann, PhD[b], Theresa Miller[a], Gustav Dobos, MD[a], Holger Cramer, PhD, MSc[a,*]

Abstract

Background: Migraine and tension-type headache often occur comorbid with temporomandibular disorder; occlusal splint therapy is the most common treatment for temporomandibular disorder. The aim of this study was to assess the effects of occlusal splint therapy on headache symptoms in patients with migraine and/or tension-type headache comorbid with temporomandibular disorder.

Methods: Sixty adult patients with migraine and/or tension-type headache and comorbid temporomandibular disorder were randomly assigned to individualized occlusal splint therapy applied during day- and nighttime plus usual care (n = 30) or usual care alone (n = 30). Primary outcome was the change in current pain intensity on a 100 mm visual analogue scale from week 1 to week 12. Secondary outcomes included changes in headache days and headache hours assessed by headache diaries over a 2-week period, health-related quality of life (SF-36), and adverse events from week 1 to week 12 and (in the occlusal splint plus usual care group only) to week 24.

Results: No group differences in changes in pain intensity from week 1 to week 12 were found. The number needed to treat was 3.8. Physical quality of life reduced stronger in the usual care group than in the occlusal splint plus usual care group. In the occlusal splint plus usual care group, headache intensity significantly decreased and physical quality of life significantly increased from week 1 to week 12 and to week 24 (all $P < .001$). No adverse events were reported.

Conclusions: A day- and night-time occlusal splint therapy in addition to usual care was not superior to usual care alone in patients with chronic headache and comorbid TMD. Four patients need to be treated to induce a minimal clinically relevant improvement in one patient. The small sample size and lack of power limit these findings.

Abbreviations: CONSORT = Consolidated Standards of Reporting Trials, DIR = dynamic intraoral registration, ICD = International Statistical Classification of Diseases and Related Health Problems, SF-36 = 36-health survey questionnaire, SPSS = Statistical Package for Social Sciences, TMD = temporomandibular disorder, VAS = visual analogue scale.

Keywords: migraine, occlusal splint therapy, randomized controlled trial, temporomandibular disorder, tension-type headache

1. Introduction

Migraine and tension-type headache often occur comorbid with temporomandibular disorder (TMD).[1–4] TMD increases the

risk of chronic headache and can worsen existent primary headache.[5] A common central working mechanism of chronic headache and TMD has been proposed, potentially involving central sensitization of neurons due to peripheral nociceptive input.[3,6] Patients comorbid with TMD and headache have been characterized to suffer from a unique symptom complex that is no longer fully representative of isolated headache.[7,8] It thus is recommended to consider comorbid temporomandibular disorders in the treatment of chronic headache.[3] The most common treatment of TMD is occlusal splint therapy. Occlusal splints alter the position of the temporomandibular joint by influencing the occlusal position, thereby changing activity patterns of the jaw muscles during clenching.[9,10] Occlusal splint therapy can reduce TMD-associated pain and muscle tenderness in the short-term.[11] Functional magnetic resonance imaging data indicate, that therapy with a splint can alter the activation of cerebral regions that are linked to anticipation of pain.[12] Effectiveness seems to be increased by day- and nighttime use of the splint compared to overnight use only.[11]

For this randomized controlled trial, it was hypothesized that there would be a stronger decrease in headache pain intensity in patients with migraine and/or tension-type headache comorbid with TMD during 12 weeks of occlusal splint therapy applied

during day- and nighttime plus usual care compared to usual care alone. The aim of this randomized controlled trial was to test this hypothesis. The splint was manufactured on the basis of a reproducible, computerized analysis of the centric position of the mandibular condyles.

2. Methods

2.1. Design

This was an open-label single centered randomized controlled trial conducted at the Department of Internal and Integrative Medicine, Kliniken Essen-Mitte, Faculty of Medicine, University of Duisburg-Essen, Essen, Germany. The study has been approved by the University of Duisburg-Essen ethics committee (approval number: 08-3596) and is reported in accordance with the CONSORT (CONsolidated Standards of Reporting Trials) 2010 guideline.[13]

2.2. Patients

Patients were recruited from the Department of Internal and Integrative Medicine. Male and female patients were included if they were at least 18 years old and were diagnosed with migraine (ICD-10 G43.0/43.1) or chronic or episodic tension-type headache (ICD-10 G44.2) at least 5 years ago and additionally suffered from temporomandibular dysfunction. Patients had to experience at least 5 monthly days of headache and had to be physically and mentally capable to follow the study instructions. Exclusion criteria included a suspected diagnosis of secondary headache and depressive symptoms defined as values ≥8 on the Hospital Anxiety and Depression Scale depression subscale.[14]

Potentially eligible patients received detailed written information describing the study. They were assessed by a study physician, and in case of correspondence to the inclusion/exclusion criteria they were included in the trial, and written informed consent was obtained.

2.3. Randomization

Patients were randomly allocated 1:1 to occlusal splint therapy plus usual care or usual care alone by drawing lots from a bag. The lots were identical in appearance and prepared prior to patient recruitment. Only when a patient was included in the study and informed consent was obtained, a lot was drawn from the bag and the patient was allocated to the respective group.

2.4. Interventions
2.4.1. Occlusal splint therapy plus usual care. Patients in the treatment group consulted a study dentist for functional assessment using the "Dynamic Intraoral Registration" (DIR) concept. Assessment included general and specific functional medical history and manual examination (palpation) followed by instrumental intraoral functional diagnostics. Using an electronic support pin (in line with the Gysi/McGrane method), mandible movements are encoded and recorded under defined chewing power, followed by the positioning of the bite focusing on physiologically ideal (centric) condyle positioning. This assessment was performed by three dentists independently at the same day in order to ensure reliability of the assessment. Based on this instrumental functional diagnostics, an occlusal correction therapy, giving the "ideal", centric condyle position, is imitated

using a DIR bite splint. Patients are advised to wear the splint during day- and night-time and to only remove it for meals and dental care for the following 24 weeks. Additional consultations with the dentist were scheduled after 1, 6, 12, 13, and 18 weeks to check the function of the splint. Additionally at week 12, the dentists' assessment was repeated and the splint was refurbished. Besides occlusal splint therapy, patients were allowed to continue their usual activities and therapies, but not to initiate any new therapeutic regimen for symptom management. Drugs and other therapy use were not limited; their use was not assessed at study entry or during the study period.

2.4.2. Usual care alone. Patients in this group received no specific treatment but were advised to continue their usual activities and therapies. They were asked not to initiate any new therapeutic regimen for symptom management. Drugs and other therapy use were not limited, and their use was not assessed at study entry or during the study period. Patients were specifically asked not to initiate an occlusal splint therapy during this period. At week 12, they were offered the same therapy as the occlusal splint therapy group. This was done to reduce dropout rates in the control groups; it was hypothesized that a longer waiting period would result in frustration in the control group patients.

2.5. Outcome measures

Outcomes were assessed at 12 after randomization. In the occlusal splint plus usual care group, they were additionally assessed at week 24. Outcomes were not measured at week 24 in the control group, because this group had already started occlusal splint therapy at this time point, and could thus no longer serve as an adequate control group. Change in current headache intensity was defined as the primary outcome measure and measured using a 0 to 100 mm visual analogue scale (VAS) from the German Pain Questionnaire with 0 mm indicating 'no pain at all' and 100 mm indicating 'worst pain imaginable'.[15] Predefined secondary outcome measures included headache days and headache hours over a 2-week period. Patients filled in a headache diary during the 14 days before the respective assessment time point where they indicated whether and for how many hours they experienced headache at a given day; and the frequency of headache days and cumulative headache hours over the 14-days period was calculated. Further, health-related quality of life was assessed at each assessment time point using the short form 36-health survey questionnaire (SF-36).[16] This 36-item instrument reliably assesses physical and mental quality of life on 2 sum scores; scores may range from 0 to 100 with higher ratings indicating a better quality of life.

2.6. Safety

All adverse events occurring during the study period were recorded. Patients experiencing such adverse events were asked to see the study physician to assess their import and initiate any necessary response. Patients were asked to indicate any adverse events during the study period regardless of their potential relationship to the study intervention.

2.7. Sample size calculation and statistical analysis

With a sample size of 30 patients per group, the study was powered to detect a large group difference on the primary

outcome measure of d = 0.8 with 80% power and a 2-sided α of 0.05 while accounting for a potential loss of power due to up to 10% of patients lost to follow-up.

All analyses were performed using the Statistical Package for Social Sciences software (IBM SPSS Statistics for Windows, release 22.0. Armonk, NY: IBM Group). Single missing values were multiply imputed by Markov chain Monte Carlo method.[17,18] To check for the potential impact of patients stopping the study early, a per-protocol analysis was further performed, including only patients that provided data at the specific time point.

Baseline group differences in sociodemographic and clinical data were analyzed using Student t tests for continuous data and chi-square tests for categorical data. Between-group differences in changes from week 1 to week 12 were analyzed using repeated measures analyses of variance. The clinical relevance of the findings was estimated by calculating the number of patients in each group reaching a minimally clinically relevant improvement of 10 mm on the pain intensity VAS.[19] Based on these numbers, the number needed to treat was calculated. Within group changes in both groups were analyzed using Student t tests for dependent samples. P values ≤.05 were defined as statistical significant.

3. Results

3.1. Patients

A total of 133 patients completed assessment by a study physician and 73 of them were excluded because they did not meet inclusion criteria (Fig. 1). Sixty patients were enrolled after providing informed consent, and were randomized to occlusal splint therapy plus usual care (n = 30) or usual care alone (n = 30). A total of 4 patients in the occlusal splint therapy plus usual care group (13.3%) were lost to follow up because they withdrew consent before initiating the intervention (n = 2) or stopped the intervention early and contact was lost (n = 2). Twelve patients in the control group (40.0%) were lost to follow-up because they withdrew consent (n = 1) or contact was lost (n = 11) (Fig. 1).

There were no group differences in sociodemographic or clinical characteristics (Table 1).

3.2. Outcomes

No group by time effects were found with regard to headache intensity, headache days, headache hours, or physical quality of life form week 1 to week 12 (Table 2). The number needed to treat was 3.8. Mental quality of life slightly decreased in both groups, this decrease was significantly larger in the usual care alone group (P = .022). In the occlusal splint plus usual care group, headache intensity significantly decreased and physical quality of life significantly increased from week 1 to week 12 and to week 24 (all P < .001). Headache days, headache hours and mental quality of life did not change significantly. No within-group changes occurred in the usual care alone group.

Findings of the per-protocol analysis, including only patients that provided data at the specific time point, were comparable.

3.3. Safety

No adverse events were reported.

4. Discussion

This randomized controlled trial found no effects of occlusal splint therapy plus usual care compared to usual care alone in patients with migraine and/or tension-type headache and comorbid TMD. While there was a significant group effect on the secondary outcome mental quality of life, this variable slightly decreased in both groups. The findings are however limited by the small sample size and too low power of the study. The achieved power in the study was 0.38 and thus a sample size of 172 would have been needed to detect a group difference as in the present study with a power of 0.80. Significant within-group effects might be interpreted to warrant further studies in this type of therapy using larger sample sizes with higher power. Especially longer-term studies seem needed.
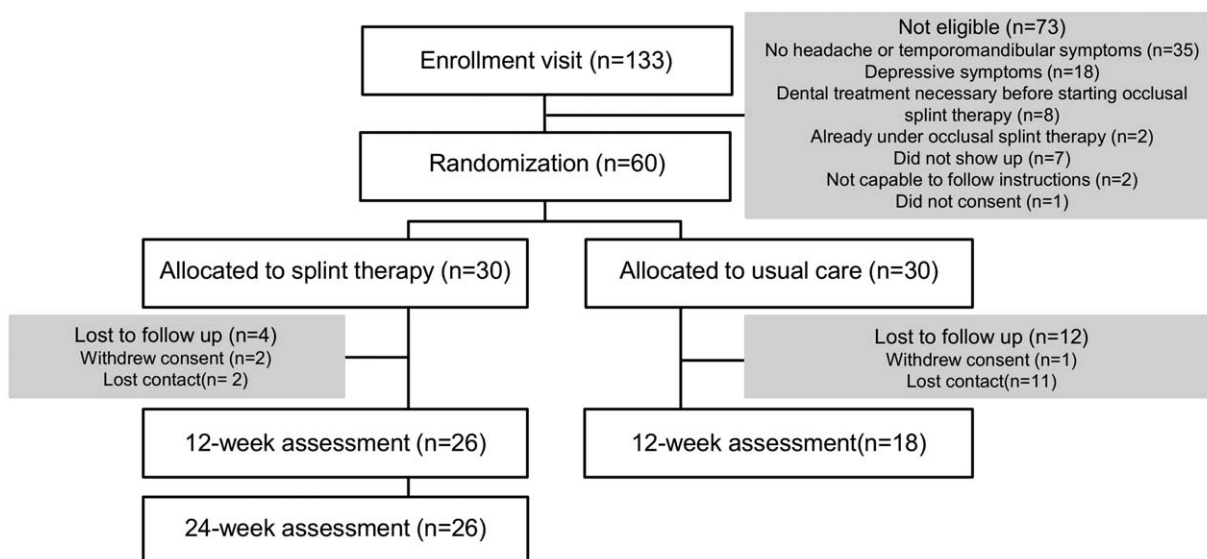

Figure 1. Participant flow diagram.

Baseline sociodemographic and clinical characteristics. Values are expressed as means±standard deviations if not otherwise denoted.

	Occlusal splint therapy plus usual care (n=26)	Usual care alone (n=18)	*P* value
Sociodemographic characteristics			
Age, years	43.96±10,0	47.33±8,9	.258
Gender, female n (%)	24 (92.3%)	16 (89.0%)	.698
Clinical characteristics			
Main diagnosis n (%)			.545
Migraine	24 (92.3%)	16 (88.9%)	
Chronic tension-type headache	2 (7.7%)	2 (11.1%)	
Additional diagnosis n (%)			.545
Chronic tension-type headache	6 (20.0%)	0 (0.0%)	
Episodic tension-type headache	2 (6.7%)	3 (10.0%)	
Headache intensity (visual analog scale)	41.3±28.2	43.2±25.1	.819
Headache days	9.6±3.1	10.0±3.9	.742
Headache hours	118.6±80.2	110.7±80.1	.749
Health-related quality of life (SF-36)			
Physical component summary	39.2±10.4	41.1±9.1	.417
Mental component summary	50.0±8.4	52.5±7.9	.410

Effects of occlusal splint therapy plus usual care and usual care alone. Values are expressed as mean±standard deviation.

	Occlusal splint therapy plus usual care (n=26)			Usual care alone (n=18)		Group difference (95% confidence interval) Week 12	*P* value	% missing data
	Week 1	Week 12	Week 24	Week1	Week 12			
Headache intensity	41.3±28.2	37.7±30.3	31.0±23.0	43.2±25.1	49.8±25.5	−12.2 (−29.1, 4.8)	.283	4.5%
Headache days	9.6±3.1	7.6±5.1	6.8±5.2	10.0±3.9	7.1±5.4	0.5 (−2.7, 3.7)	.757	9.1%
Headache hours	118.6±80.2	92.7±88.4	79.0±91.0	110.7±80.1	78.0±91.0	14.7 (−41.0, 70.5)	.558	9.1%
SF-36								
Physical component summary	39.2±10.4	44.3±10.5	44.3±13.1	41.1±9.1	40.5±8.8	3.8 (−2.1, 9.7)	.057	9.1%
Mental component summary	50.0±8.4	48.7±10.5	48.7±11.4	52.5±7.9	43.5±15.2	5.3 (−2.5, 13.0)	.022	9.1%

SF-36 = 36-health survey questionnaire.

According to prior study results, occlusal splints can effectively reduce pain and other symptoms in patients with TMD,[11] however, their effects on symptoms of chronic headache have only sparsely been investigated. Small pilot trials suggest limited effectiveness of occlusal splint therapy in isolated migraine or tension-type headache without comorbid TMD[20] while sustained effects were found in patients with tension-type headache and comorbid TMD.[21] In a prior 4-arm randomized trial on patients comorbid with migraine and TMD, only a combined treatment with propranolol and occlusal splint therapy induced reduction in migraine symptoms while drug therapy or splint therapy alone were ineffective.[6]

For TMD alone, a recent meta-analysis identified a total 33 randomized controlled trials of stabilization splints.[11] This meta-analysis found significant short-term reductions but no group differences in the longer term. Further short-term effects were found on muscle tenderness and maximum mouth opening but not for TMJ lateral and posterior tenderness reduction and depression.[11] Interestingly, in individual studies, the majority included no significant group differences, hinting at a potential lack of power in each individual study. Likewise, although significant within-group changes occurred in the occlusal splint plus usual care group in the current study, the study most likely was not powered to detect significant group differences. Thus, larger studies with adequate power are needed to conclusively judge the potential of this type of occlusal splint therapy in patients with migraine and/or tension-type headache and comorbid TMD.

Occlusal splint therapy is thought to be effective in TMD because this dysfunction's symptoms are considered to mainly arise from the strain of dealing with improper occlusal. Occlusal splints are then thought to establish ideal maxillomandibular relationships and thus relieve pain and restore the function.[22]

4.1. Limitations

There are a number of limitations in this study. The study sample was rather small and the study thus underpowered. Moreover, drop-out rates were high and not well balanced between groups. This resulted in far more patients completing the study in the treatment group than in the control group. Future studies should focus on motivating patients especially in the control group to remain in the study. However, the comparable findings in per-protocol and intention-to-treat analyses hinted at a minor impact of study drop-out. The use of placebo splints might increase adherence to the study.[6] Treatments before and during the study period were not assessed or compared between treatment groups. Outcomes at week 24 were assessed in the occlusal splint therapy group only in order to reduce waiting time in the control group. It was hoped to reduce dropout rate in the control group by these means; this however was not the case. Moreover, given that pain intensity further improved in the occlusal splint therapy group between weeks 12 and 24, it is likely that a potentially significant and relevant long-term effect of the intervention was not detected in this study.

4.2. Implications for further research

In order to increase power for between-group differences, future studies might investigate the effects of occlusal splint therapy in larger samples of patients with TMD and chronic headache. Strategies to maintain patients in the studies should be implemented in future trials. Given that prefabricated splints have shown to effectively reduce pain in patients with myofascial pain,[23] it should be investigated whether this finding can also be applied to patients with chronic headache. Given that the splints used in this trial were fabricated individually after instrumental intraoral functional diagnostics by specially trained dentists, a comparison of these individual splints with prefabricated ones would have important economic implications. Beyond that, comparisons with placebo splints[6] as well as dose-finding studies investigating the most effective length of use are needed. Most importantly, longer-term group comparisons are needed to verify a potential effect of the occlusal splint therapy after 6 months or longer treatment.

4.3. Implications for clinical practice

In conclusion, this study found only few effects of a 24-week day- and night-time occlusal splint therapy might reduce headache intensity in patients with chronic headache and comorbid TMD. Although significant within-group changes were found, occlusal splints cannot currently be recommended as a treatment option for patients with migraine and/or tension-type headache who additionally suffer from TMD. Based on the number needed to treat, 4 patients need to be treated to achieve a minimally clinical relevant difference in one patient. Given that these findings are limited by lack of power and short follow-up periods, no clear implications for clinical practice can be drawn.

Author contributions

Conceptualization: Felix Joyonto Saha, Thomas Ostermann, Gustav Dobos.
Data curation: Almut Pulla, Thomas Ostermann, Theresa Miller.
Formal analysis: Thomas Ostermann, Holger Cramer.
Funding acquisition: Felix Joyonto Saha, Gustav Dobos.
Investigation: Felix Joyonto Saha, Almut Pulla, Theresa Miller.
Methodology: Felix Joyonto Saha, Almut Pulla, Thomas Ostermann, Theresa Miller, Gustav Dobos, Holger Cramer.
Software: Thomas Ostermann.
Supervision: Felix Joyonto Saha, Thomas Ostermann, Gustav Dobos, Holger Cramer.
Validation: Thomas Ostermann, Holger Cramer.
Visualization: Holger Cramer.
Writing – original draft: Holger Cramer.
Writing – review & editing: Felix Joyonto Saha, Almut Pulla, Thomas Ostermann, Theresa Miller, Gustav Dobos.

References

[1] Goncalves DA, Bigal ME, Jales LC, Camparis CM, Speciali JG. Headache and symptoms of temporomandibular disorder: an epidemiological study. Headache 2010;50:231–41.

[2] Goncalves DA, Speciali JG, Jales LC, Camparis CM, Bigal ME. Temporomandibular symptoms, migraine, and chronic daily headaches in the population. Neurology 2009;73:645–6.

[3] van der Meer HA, Speksnijder CM, Engelbert R, Lobbezoo F, Nijhuis-van der Sanden MW, Visscher CM. The association between headaches and temporomandibular disorders is confounded by bruxism and somatic complaints. Clin J Pain 2017;33:835–43.

[4] Stuginski-Barbosa J, Macedo HR, Bigal ME, Speciali JG. Signs of temporomandibular disorders in migraine patients: a prospective, controlled study. Clin J Pain 2010;26:418–21.

[5] Bevilaqua Grossi D, Lipton RB, Bigal ME. Temporomandibular disorders and migraine chronification. Curr Pain Headache Rep 2009;13:314–8.

[6] Goncalves DA, Camparis CM, Speciali JG, et al. Treatment of comorbid migraine and temporomandibular disorders: a factorial, double-blind, randomized, placebo-controlled study. J Orofac Pain 2013;27:325–35.

[7] Goncalves DA, Camparis CM, Franco AL, Fernandes G, Speciali JG, Bigal ME. How to investigate and treat: migraine in patients with temporomandibular disorders. Curr Pain Headache Rep 2012;16:359–64.

[8] DeRossi SS E, Sollecito T. Temporomandibular disorders and migraine headache: comorbid conditions? Intern J Dental Sci 2004;2.

[9] Lobbezoo F, van der Glas HW, van Kampen FM, et al. The effect of an occlusal stabilization splint and the mode of visual feedback on the activity balance between jaw-elevator muscles during isometric contraction. J Dent Res 1993;72:876–82.

[10] Chandu A, Suvinen TI, Reade PC, Borromeo GL. The effect of an interocclusal appliance on bite force and masseter electromyography in asymptomatic subjects and patients with temporomandibular pain and dysfunction. J Oral Rehabil 2004;31:530–7.

[11] Kuzmanovic Pficer J, Dodic S, Lazic V, et al. Occlusal stabilization splint for patients with temporomandibular disorders: Meta-analysis of short and long term effects. PLoS One 2017;12:e0171296.

[12] Lickteig R, Lotze M, Kordass B. Successful therapy for temporomandibular pain alters anterior insula and cerebellar representations of occlusion. Cephalalgia 2013;33:1248–57.

[13] Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. BMJ 2010;340:c332.

[14] Zigmond AS, Snaith RP. The hospital anxiety and depression scale. Acta Psychiatr Scand 1983;67:361–70.

[15] Pfingsten MN, B Emrich O, Seemann H, Lindena G. Deutscher Schmerz-Fragebogen. 2012.

[16] Bullinger MIK. SF-36 - Fragebogen zum Gesundheitszustand (PSY-NDEX Tests Review). 1998.

[17] Toutenburg H, Rubin DB. Multiple imputation for nonresponse in surveys. H Statistical Papers 1987.

[18] Schafer JL. Analysis of incomplete multivariate data. Champman & Hall/CRC. 1997.

[19] Dworkin RH, Turk DC, Wyrwich KW, et al. Interpreting the clinical importance of treatment outcomes in chronic pain clinical trials: IMMPACT recommendations. J Pain 2008;9:105–21.

[20] Quayle AA, Gray RJ, Metcalfe RJ, Guthrie E, Wastell D. Soft occlusal splint therapy in the treatment of migraine and other headaches. J Dent 1990;18:123–9.

[21] Ekberg E, Vallon D, Nilner M. Treatment outcome of headache after occlusal appliance therapy in a randomised controlled trial among patients with temporomandibular disorders of mainly arthrogenous origin. Swed Dent J 2002;26:115–24.

[22] Klasser GD, Greene CS. Oral appliances in the management of temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;107:212–23.

[23] Nilner M, Ekberg E, Doepel M, Andersson J, Selovuo K, Le Bell Y. Short-term effectiveness of a prefabricated occlusal appliance in patients with myofascial pain. J Orofac Pain 2008;22:209–18.