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Use of a Modified Mandibular Splint to Reduce Nocturnal Symptoms in Persons With Post-traumatic Stress Disorder

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ABSTRACT

Objective: Based on a series of clinical observations that a thicker mandibular splint than that commonly used to treat bruxism and related craniomandibular myofascial pain reduced post-traumatic stress disorder (PTSD) nocturnal symptomatology (sleep disruptions, headaches, and nightmares), this study of 100 PTSD participants was undertaken to systematically establish 'proof of concept' of the therapeutic effectiveness of this modified splinting procedure.

Methods: Following the fabrication of splints thicker than those conventionally used, the effectiveness of this new procedure used by dentists was determined by comparing the self-reported frequency and intensity/severity of PTSD symptomatology during a seven-night pretreatment baseline period without the splint with a second seven-night period in which the modified splint was inserted. The scoring for the three dependent measures (sleep disruptions, headaches, and nightmares) was based on the frequencies on a scale from 0–7 multiplied by the intensity/severity on a scale of 1–10.

Results: Compared with the pre-splint baseline period, the insertion of the thickened splint resulted in a highly significant reduction of sleep disruption, nocturnal headaches, and nightmares. A second seven-night control period without the splint was followed by a second seven-night period with the splint, reproducing the effectiveness of the first splinting period.

Conclusion: The results of this study provide the first systematic, documented proof of concept of the effectiveness of a modified splinting procedure in reducing key nocturnal symptoms in PTSD patients.

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Introduction

Post-traumatic stress disorder (PTSD) is widely diagnosed among individuals with a history of exposure to a traumatic event. It is characterised by intrusion and avoidance symptomatology, negative alterations in cognitions and mood, and aberrant arousal and reactivity.¹ PTSD is linked to a broad

range of nocturnal symptomatology including sleep disruptions, nocturnal headaches, and nightmares.^{2–5}

In general, the responsibility of dentists for treatment of PTSD patients has been limited to routine care of teeth and supporting tissues, much of it provided in military or Veterans Administration hospitals. Although not differing in presentation of periodontal disease, PTSD patients are significantly more distressed by periodontal probing than non-PTSD patients.⁶

Together with the consequences of medication-related xerostomia,^{7,8} the pernicious oral health behaviours (smoking, alcoholism, and drugs) often found in PTSD patients result in poor oral hygiene and related oral disease. Although

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PTSD patients also experience bruxism-related orofacial pain,⁶ overrepresentation of bruxism in PTSD patients has yet to be formally established.

The use of splints by dentists, however, has a long history of success in the prevention and treatment of orofacial and other health-related problems.⁹ While splinting has been considered the treatment of choice for temporomandibular disorder-related myofascial pain,¹⁰ behavioural therapy and psychosocial intervention have been found in recent years to be almost as effective as occlusal splints.^{11,12}

Given this increased role of dentists, the present study was based on a series of clinical dental observations that increasing the thickness of a mandibular splint beyond that commonly used for treating bruxism reduced the nocturnal symptomatology of PTSD patients. Consequently, this study was undertaken to establish 'proof of concept' for the therapeutic effectiveness of a thickened mandibular splint in reducing sleep disruptions, headaches, and nightmares in participants with PTSD.

Methods and materials

Rationale for procedure

In contrast to evaluating splints of 2–3 mm thickness conventionally used for treating bruxism,¹³ the present study was undertaken to demonstrate the effectiveness of increased splint thickness to reduce the noxious nocturnal symptomatology of PTSD. Therefore, the presence of bruxism and/or temporomandibular joint dysfunction (TMJD) was only recorded as comorbidities of PTSD by one of the authors (DRM) without delineation by the current diagnostic criteria.^{14,15}

Participants

In response to a published announcement of a possible new treatment for PTSD at no cost, 104 potential participants initially responded and signed the consent form. Over a period of seven months, during which time the study was completed, four subjects initially dropped out because of unwillingness to comply with the requirements of the study or not meeting the inclusion criteria, leaving 100 participants to complete the four-week study. One of the 100 subjects later dropped out because of a family emergency and was replaced to keep the study at 100 participants, which resulted in an overall dropout rate of 5 out of 105 or 4.8%. The starting time for each participant over the seven-month study depended on the availability of the clinician (DRM), participant, and research assistants responsible for scheduling participant appointments and recording self-reports.

The final sample, consisting of 73 males (mean age 43.38 ± 11.18 years) and 27 females (mean age 40.67 ± 10.43 years) was recruited from a catchment area including a large retired and active military population in the region of Fort Benning US Army Base in Columbus, Georgia, USA. At the time of their participation, all participants met the following inclusion criteria: (i) being between age 21 and 65; (ii) with six

periodontally sound and stable mandibular teeth in each arch; (iii) a previously established diagnosis of PTSD of at least three years duration made or confirmed by a psychiatrist or clinical psychologist; (iv) with no changes in medications or other therapeutic interventions during the month prior to or during this study. Although not required for participation, ninety-eight percent of these participants were under active psychiatric care at the time of the study.

Procedure

Following IRB protocol approval by a civilian Institutional Review Board (Fox Commercial IRB, Springfield, IL) and obtaining informed consent, thicker-than-conventional splints were fabricated by one of the authors (DRM) to increase their vertical thickness and subsequent vertical dimension and mouth opening.

Beginning with an alginate impression of the mandibular arch reproduced as a study model in dental plaster, the modified removable intra-oral soft mandibular vacuum-thermo-plastic vinyl splints were initially produced. Using soft vinyl rather than acrylic facilitated the correction of occlusal discrepancies in order to optimise maxillary and mandibular dental contact.

Following initial insertion of the splint, participants were allowed to rest in a reclining dental chair for 30 minutes to make necessary adjustments to ensure appliance fit and participant comfort with respect to the muscles of mastication and dentition. Side effects included transient gagging and/or sialorrhea. When a participant expressed no further complaints or concerns about muscle tenderness or pain during the 30-minute adjustment period, the final splint configuration was adopted, to begin the first of four evaluation periods.

The initial determination of splint thickness was based on the participant's height in relation to mouth size,¹⁶ ranging from 3 to 7 mm for females and 5 to 14 mm for males, based on the following schemata.

Participant height were grouped into nine categories:

Height	Splint thickness
152–157 cm	2–3 mm
158–162 cm	4–5 mm
163–167 cm	5–6 mm
168–170 cm	6–7 mm
171–173 cm	7–8 mm
174–178 cm	8–10 mm
179–182 cm	10–12 mm
183–190 cm	12–14 mm
>190 cm	14 mm (maximum)

Experimental design

Independent variable

The independent variable was the presence or absence of the splint over four sequential seven-night periods: beginning with an initial baseline period without the splint ('OUT 1') followed by the initial insertion of the treatment splint ('IN 1'), then a return to the control period ('OUT 2'), and second and final insertion of the splint ('IN 2').

Dependent variables

The dependent variables were the self-reported responses to three noxious nocturnal symptoms of PTSD: sleep disruptions, nocturnal headaches, and nightmares. These self-reported responses obtained at the end of each of the four seven-night periods assessed the frequency of occurrence from 0 to 7 and the average intensity/severity from 1 to 10 for each of the three symptom classes: (i) sleep disruption, using the Iowa Sleep Disturbances Inventory¹⁷; (ii) nocturnal headaches, by means of the Brief Pain Inventory¹⁸; and (iii) nightmares, using the Disturbing Dreams and Nightmares Severity Inventory.¹⁹

To determine the total scores for each of the dependent variables across the four conditions, the frequency from 0 to 7 was multiplied by the average intensity/severity scores from 1 to 10, resulting in scores ranging from 0 to 70 for each of the participants' self-reported responses across the four dependent conditions, as reported in the Table.

Results

Data analysis and presentation

Given that the three key dependent measures met criteria for normality of distribution, parametric inferential statistics were used to compare the scores of the three sets of dependent variables for without splint (OUT 1 and OUT 2) with splint (IN 1 and IN 2) during each of the four evaluation periods as shown in the Table.

A one-way ANOVA model was performed for each dependent measure, with a single independent variable of splint in or no splinting condition (as described below), followed by planned post hoc comparisons using t-tests, with P values corrected for multiple comparisons by the use of Bonferroni procedures.

Using SAS software (SAS Inc., Cary, NC) for analysis, each comparison is indicated by arrows for the resulting t-test (displayed in the Table as ' $\leftarrow t \rightarrow$ ') for each of the comparisons of the three dependent variables: sleep disruptions, headaches, and nightmares, together with the relative percent changes in effectiveness across the three symptom classes.

The self-reported responses, summarised in the Table, reveal a highly statistically significant difference between OUT and IN conditions, thereby demonstrating the effectiveness of increased thickness of removable mandibular splints in reducing distressing nocturnal symptomatology, compared with the return of nocturnal symptomatology without the splint. PTSD participants exhibited a decrease in symptoms for each of the dependent measures from the OUT to the IN condition for both the first and second trials followed by a return of increased symptom severity upon withdrawal of the splint (OUT 2) and subsequent reduction in symptoms with return of the splint (IN 2).

Relative to the determination of splint size, there were no significant age or gender differences in self-reported responses.

Additional clinical observations

An unexpected phenomenon observed by DRM upon placement of the final adjusted splint was that approximately 40 percent of participants experienced rapid sleep onset in the dental chair after insertion of the adjusted splint, despite the presence of extraneous distracting stimuli, such as bright light and ambient noise.

Reliability

Consistency or reliability of responses was demonstrated by the highly significant correlations between OUT 1 and OUT 2 for the three dependent variables: sleep disruptions $r = 0.67$,

Table – Comparison of nocturnal self-report scores with splint (IN) and without splint (OUT).

t Value (99 df) for each comparison (indicated by $\leftarrow t \rightarrow$)				
	OUT 1 (Baseline) Mean ± SD	IN 1 (1st Treatment) Mean ± SD	OUT 2 (Control) Mean ± SD	IN 2 (2nd treatment) Mean ± SD
Sleep disruptions	50.5 ± 17.15	17.8 ± 14.98	42.7 ± 16.17	16.5 ± 15.33
		$\leftarrow t = 13.0 \rightarrow$ 64.8%	$\leftarrow t = 11.1 \rightarrow$	$\leftarrow t = 10.6 \rightarrow$ 61.4%
Headaches	29.4 ± 18.55	14.3 ± 13.93	29.6 ± 18.06	13.2 ± 13.16
		$\leftarrow t = 9.5 \rightarrow$ 51.4%	$\leftarrow t = 8.8 \rightarrow$	$\leftarrow t = 8.8 \rightarrow$ 55.4%
Nightmares	32.3 ± 19.53	13.3 ± 20.44	29.0 ± 18.55	11.6 ± 12.04
		$\leftarrow t = 8.7 \rightarrow$ 58.8%	$\leftarrow t = 8.8 \rightarrow$	$\leftarrow t = 7.5 \rightarrow$ 60.0%

All comparisons: $P < .001$.

headaches $r=0.72$, and nightmares $r=0.71$; and similarly between IN 1 and IN 2 for the same dependent variables: sleep disruptions $r=0.83$, headaches $r=0.80$, and nightmares $r=0.82$ (all P values < 0.001).

Further evidence of reliability was provided by the reproducibility of percent change in the relative order of effectiveness in relieving symptomatology of PTSD: sleep disruptions $>$ nightmares $>$ headache pain.

Discussion

The present study of 100 participants was undertaken to systematically test whether increasing the thickness of a splint and height of the subsequent mouth opening resulted in decreasing the severity of nocturnal symptomatology of PTSD participants. The results described herein confirmed the findings of a previous series of clinical observations by one of the authors (DRM).^{20,21}

In relation to other relevant studies, Wolowski et al.²² recently provided additional support for the present results by finding an inverse relationship ($r = -0.48$, $P < 0.01$) between increases in splint thickness related to mouth opening and self-reported reduction of 'painful craniomandibular dysfunction'²² among PTSD patients. While providing useful clinical information, this investigation was limited by its lack of assessment of PTSD symptomatology and psychiatric comorbidity. Moreover, the 55% patient dropout rate carries a risk of potential selection bias.^{23,24}

To offset the possibility that the therapeutic effectiveness of increased mandibular splint thickness might be a short-term placebo effect, 25 of the 60 participants still available from the original 100 were recalled two years later to find that the initially observed therapeutic effectiveness was maintained long term. No statistically significant difference was found using matched pair t -tests ($df=24$) between the self-reported symptomatic relief in the original fourth splint condition (IN 2) and the same self-reports two years later.

We note the possibility that a learning effect could be responsible in part for the maintenance of therapeutic effectiveness, which might be determined by starting with an additional follow-up of participants who no longer used the splint yet retained a similar level of reduced symptomatology of PTSD.

While there may be some concern about the appropriateness of the control procedure in this study (i.e. removal of the splint, OUT 1 and OUT 2, vs. splint in place, IN 1 and IN 2), others have pointed out the practical and ethical problems associated with providing a sham splint for this purpose.²⁵ Therefore, the use of a sham control was not considered in the present study. Rather, the responses of the three dependent variables to the independent variable were simply the presence of the splint compared with its absence as a control.

Neuromuscular feedback from wearing an occlusal splint may conceivably interact with brain function, for example, the reticular activating system as it relates to sleep as well as other higher-order central nervous system functions.²⁶ In recent years, a literature has emerged that delineates

alterations in brain function as a function of splinting. For example, a functional magnetic resonance imaging (fMRI) study of bruxism and TMJD by Ernst et al.²⁷ reported that splinting was associated with a decrease in brain activation magnitude within the somatosensory cortex and insular cortex. Further, left hemispheric anterior insula and the cerebellar fMRI activation decrease were associated with decrease in pain over time. Additionally, a meta-analysis of fMRI studies of occlusal function delineated activation of the sensorimotor cortex, the thalamus, and the cerebellum.²⁸ Combined, these findings indicate the presence of circumscribed regions of brain activation associated with bruxism.

Beyond acknowledging the limitation in the present study of having evaluated only one final splint thickness per participant, the authors suggest further studies be directed toward systematically determining the physical configuration for this new therapeutic modality for treating PTSD. Such studies should also include independent psychophysiological and neurophysiological correlates of self-reported PTSD symptomatology; for example, the magnitude of the forces of mastication (e.g., piezoelectric sensing), electrodermal activity, electromyography, electroencephalography, and fMRI. The relationship of the relative order of the effectiveness of this method in reducing the distressing symptomatology in the present study (sleep disruptions $>$ nightmares $>$ headache pain) to other studies of relative therapeutic effectiveness should also be considered for further investigation.

Nevertheless, the present study, even with recognised shortcomings, does establish successful 'proof of concept' of the therapeutic effectiveness of a thickened mandibular splint in reducing PTSD nocturnal symptomatology, which was maintained in a follow-up study for at least two years beyond the formal evaluation period. Moreover, this demonstrated effectiveness of a dental procedure provides yet another opportunity for the profession to become more involved with overall health care.

Conclusion

The results of this study demonstrate the effectiveness of a thicker-than-conventional removable soft mandibular splint in attenuating the nocturnal symptomatology of PTSD: sleep disruptions, nocturnal headaches, and nightmares. Given the limited efficacy of pharmacologic interventions for PTSD, use of the procedure described here should be considered as an adjunctive or alternative option for treating PTSD.

Public access

The data used in analyses for this publication are archived for public access.

Conflict of interest

The authors declare no conflicts of interest.

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