Craniomandibular muscles, intraoral orthoses and migraine
Elliot Shevel

Intraoral splints are effective in migraine prevention. In this review, changes in the quality of life of migraineurs treated with a palatal nonoccluding splint were measured. Using the Migraine Specific Quality of Life Instrument (Version 2.1), it was found that the palatal nonoccluding splint significantly improved the quality of life of migraineurs. The role of the craniomandibular muscles in the pathophysiology of migraine is also discussed.

Migraine is a common disorder with a lifetime prevalence of 16% worldwide, and a last-year prevalence of 10% [1,2]. It may significantly diminish quality of life, even between attacks, and impairs quality of life more than diabetes, hypertension and osteoarthritis [3-5]. Although the pathogenesis of migraine headache remains poorly understood, current theories suggest a primary, possibly genetically determined, CNS dysfunction to be involved. There is activation of the trigeminovascular system [6,7], which is comprised of the meningeal vessels, trigeminal nerve and trigeminal nucleus, in particular the trigeminal subnucleus caudalis [8].

Tenderness and dysfunction of the craniomandibular muscles is a common finding in migraine [9-15]. Intraoral interocclusal orthoses, used in the treatment of craniomandibular muscle dysfunction [16-21], are also effective in preventing migraine [22-24]. Their therapeutic muscle-relaxing effect is attributed to the fact that they encourage the mandible to assume the physiologic rest position, thereby altering habitual neuromuscular patterns within the masticatory muscles [21]. When a nonoccluding palatal orthosis is worn, there is increased resting length and relaxation of the craniomandibular muscles [25,26]. This study determined the effect of wearing a nonoccluding palatal orthosis on the quality of life of migraineurs.

Materials & method
Patient selection
In total, 152 patients, 117 female and 35 male, were admitted to the study. The inclusion criteria were:
• Age of onset of migraine before 50 years
• Subjects with all or most of their own teeth, and who did not wear a removable dental prosthesis
• History of migraine of 1 year or more, with at least one attack per week in the previous 3 months
• Headache free between attacks
• A diagnosis of migraine without aura (i.e., group 1.1 in the guidelines laid down by the Headache Classification Committee of the International Headache Society)

To make the diagnosis of migraine without aura, the following criteria must be met [27]:
A. At least five attacks fulfilling criteria B, C and D
B. Headache attacks lasting 4–72 h (untreated or unsuccessfully treated)
C. Headache has at least two of the following characteristics: unilateral location, pulsating quality, moderate or severe intensity (inhibits or prohibits daily activities), aggravated by walking up stairs or similar routine physical activity
D. During the headache at least one of the following: nausea and/or vomiting, photophobia and phonophobia
Factors that could influence the frequency or intensity of migraine, such as pregnancy, the use of prophylactic migraine medication or ergot derivatives, a history of drug or alcohol abuse, or serious illness were exclusion criteria. All participants were fully informed of the nature of the project and their prior consent was obtained.

**Palatal speech-adjusted appliance**

The posture-modifying appliance (PMA) was fabricated using the maxillary cast of the subject. It consisted of a 3 mm thick acrylic resin reinforced with a chrome cobalt strip. The appliance covered the hard palate, with the exception of the anterior part where the tip of the tongue normally touches during speech.

The PMA was adjusted for fit and overall comfort. Patients were told that the PMA should not interfere with the free movement of the tongue during speech. They were asked to speak with the PMA in situ using the words listed in Box 1, which are phonetically balanced and designed to test the whole range of English sounds in various combinations. The PMA was then removed and the part that the tongue had touched during speech indicated by the patient. The offending acrylic was ground away and the process repeated, until the patient was no longer aware of any interference with tongue movement. The final shape and thickness of the PMA was, in most patients, very different to the original.

Subjects were instructed to wear the PMA day and night, but to remove it during tooth brushing, eating and drinking, and when playing contact sports. Subjects were requested to return for adjustment of the PMA if they experienced discomfort or speech difficulty.

**Migraine specific quality of life measurement**

The Migraine Specific Quality of Life Questionnaire (MSQ) Version 2.1 was used to assess the efficacy of the PMA. The MSQ is a 14-item, self-administered questionnaire, which measures three dimensions of headache-related quality of life that are affected by migraine:

- Role function restriction, which measures the percentage of time that the patient can perform normal daily activities
- Role function prevention, which measures the percentage productivity while working
- Emotional function, which measures the percentage of emotional and relationship disability

Patients completed the MSQ before the start of treatment and again 12 months later. Participants were instructed to continue using palliative medication whenever necessary.

**Results**

As there was no significant statistical difference between the results for males and females, they were combined, and the average pretreatment and post-treatment scores for each parameter were calculated. Analysis of the data using the Student's t-test showed statistically significant improvement in all three parameters. Role function restriction improved from 54.6 to 91% (p < 0.0001), role function prevention improved from 45.4 to 84.8% (p < 0.0001) and emotional function improved from 45.4 to 91.2% (p < 0.0001).

**Discussion**

Migraine is considered to be a neurovascular syndrome, with abnormal neuronal excitability in the cerebral cortex, peripheral sensitization of the trigeminovascular system and pain due to dilation of intracranial blood vessels. The triptans were developed as cranial vasoconstrictors to mimic the desirable effects of serotonin, while avoiding its side effects. An important hindrance to the more widespread use of the triptans is the unsubstantiated perception that they have harmful vasoconstrictor effects.

Nociceptive input to the CNS is increased due to sensitization of peripheral sensory afferents, and the resultant barrage of nociceptive impulses results in sensitization of second- and third-order neurons in the CNS. In this way, sensitization may play a role in the initiation and maintenance of migraine. Consequently, current research has focussed upon prejunctional and presynaptic targets on nociceptive trigeminovascular neurons in an attempt to develop drugs that inhibit trigeminal nociceptive traffic and central sensitization without vasoconstrictor effects.

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Peripheral chemoreceptors, cells in the trigeminal nucleus caudalis that are normally nociceptive-specific begin to respond to low-threshold, primary afferent non-nociceptive mechano-receptors [50]. Repeated stimulation of a dorsal root produces, in some neurons, a prolonged heterosynaptic facilitation with an augmentation of the response to the conditioning root (homosynaptic potentiation) as well as to adjacent test roots (heterosynaptic potentiation) [51].

Restoring a patient's ability to function normally is now recognized as the primary treatment goal, rather than merely relieving pain [52]. The results of this study show that relaxation of the craniomandibular muscles by means of a PMA improves the quality of life of migraineurs. By reducing sensory input from the craniomandibular muscles, central sensitization is reduced. The probable mechanism is that intraoral splints may have therapeutic effects apart from those commonly attributed to the occlusal component [53]. This may be attributed to the fact that an intraoral appliance may encourage the mandible to assume the physiologic rest position, thereby altering habitual neuromuscular patterns within the masticatory muscles [54]. Further research has shown that when a nonoccluding palatal appliance is worn there is an increase in the interocclusal distance and, consequently, in the resting length of the masticatory muscles [55,56].

A limitation of this study is the lack of a placebo control group. There is, unfortunately, no remedy for this when testing a physical intervention such as an intraoral appliance, given the sensitivity of the intraoral structures. The possible placebo effect of the PMA cannot therefore be measured, and its importance must remain the subject of speculation. According to Occam's Razor, in science the simplest theory that fits the facts of a problem is the one that should be selected. This is interpreted to mean that the simplest of two competing theories is preferable. If Occam's Razor is applied, then the most likely conclusion is that the PMA does have a beneficial nonplacebo effect. The possibility of natural regression of the migraine in this group of patients is minimal, given that all the subjects had been suffering for a long time frame without improvement until the PMA was fitted.

Further corroborating evidence that the craniomandibular muscles play a role in the cascade of events in migraine pathogenesis is described below.

Anatomy

- The middle meningeal artery, dura of the middle and anterior cranial fossae, and craniomandibular muscles, all receive sensory afferents from the mandibular division of the trigeminal nerve. They all send sensory afferent input to the subnucleus caudalis, possibly enhancing central sensitization. The middle meningeal artery and dura of the middle and anterior cranial fossae via its recurrent meningeal branch, and the muscles via their individual branches [57,58].

Box 1. Phonetically balanced word list designed to test the whole range of English sounds in various combinations [28].

- Iceberg
- Armchair
- Sunset
- Mousetrap
- Playground
- Inkwell
- Whitewash
- Pancake
- Cowboy
- Woodwork

- Volumetric analysis of the masseter and medial pterygoid muscles showed that the volume of masticatory muscles in migraineurs is nearly 70% greater than in nonmigraineurs (p < 0.0001) [59].

Neural pathways

- Sensory afferents from the craniomandibular muscles project to the trigeminal sensory nuclei, and in particular to the subnucleus caudalis. Subnucleus caudalis neurons, including low-threshold mechanoreceptive, wide-dynamic range and nociceptive-specific neurons, are excited by the stimulation of craniomandibular muscle sensory afferents [42,60–66].

The subnucleus caudalis also acts as a critical interneuronal relay site in craniofacial nociceptive reflex activity involving the craniofacial muscles [67–70].

Clinical findings

The following clinical findings have been determined:

- Pericranial muscle pain and tenderness are prominent features in migraine [71–73]
- There is increased pericranial muscle electromyographic activity in migraine [74,75]
- Physical therapy can precipitate migraine attacks [76]

Treatment modalities

Treatment modalities that reduce craniomandibular muscle tension are effective in the treatment of migraine and include:

- Intraoral splints which reduce migraine intensity and frequency [77–82].
- Biofeedback to induce muscle relaxation is widely used in migraine prophylaxis. The positive treatment response to biofeedback/relaxation in migraine headache is not related to presence of changes in blood flow velocity [83].
- Intramuscular trigger point injections are effective in the treatment of acute migraine pain [84–86].
Resection of the corrugator supercilii muscles in patients who respond positively to botulinum toxin A injection results in prolonged and effective migraine prophylaxis [87–89].

**Drug therapy**

Preliminary studies indicate that drugs such as botulinum toxin A, baclofen and tizanidine, which reduce skeletal muscle spasm and tone, may be useful in migraine prophylaxis [90].

Sumatriptan was developed as a cerebral vasoconstrictor, but it has also been shown to act on skeletal muscle [91–93]. It cannot be excluded, therefore, that the triptans may be effective in migraine due to altered muscle metabolism.

**Expert opinion**

Current theories suggest that a primary, probably genetically determined, CNS dysfunction is involved in the initiation of the migraine headache, with activation of the trigeminovascular system and sensitization of neurons in the CNS [6]. Clinical findings suggest a relationship between migraine headaches on the one hand and dysfunction of the craniomandibular muscles on the other. In this study, the quality of life of migraineurs was significantly enhanced by the use of an intraoral palatal nonoccluding appliance. This and other evidence, including anatomical evidence, the projection of sensory afferents from the craniomandibular muscles to the trigeminal subnucleus caudalis, clinical findings, treatment modalities designed to reduce muscle tension which also successfully treat migraine, and drug trials, provide a compelling argument that central sensitization in migraineurs is enhanced by sensory input originating from the craniomandibular muscles. Therefore, the best current treatment regimen must include assessment and treatment of the pericranial muscles.

**Five-year view**

It is unlikely that this treatment regimen will gain much favor. The reason being that medicine is divided into different disciplines, each with its own sphere of interest. While the general public may believe that these disciplines share information at the highest level, in reality they rarely communicate with each other. The excellent results achieved with the use of intraoral splints in migraineurs have been on record for many years. In spite of this, intraoral splints are rarely mentioned in the headache literature - there is not a single article on the subject in *Headache* or *Cephalalgia* in at least the last 3 years. Unfortunately, despite the excellent clinical results, splint therapy for migraine is still regarded with scepticism. In the words of Max Planck (Nobel Prize Physicist, 1918), “A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it”. It is improbable, therefore, that, despite the proven efficacy of intraoral splints, their use will be widely adopted within the next 5 years. In the next 50 years... perhaps?

**Acknowledgements**

The author would like to express sincere thanks to Daniel Shevel for his invaluable input in the writing of this review.

**Key issues**

- Migraine is a common disorder.
- It is characterized by moderate-to-severe pain, with associated symptoms such as nausea, vomiting, photophobia and phonophobia.
- Migraine is associated with changes in the trigeminovascular system.
- Tenderness and dysfunction of the craniomandibular muscles is a common finding in migraine.
- Intraoral orthoses are used to relax the craniomandibular muscles and restore them to normal function.
- This review studies the effect on migraineurs of wearing a nonoccluding palatal orthosis.
- Placebo-controlled studies are not feasible when intraoral orthoses are used.
- The effect was therefore measured by comparing pretreatment with post-treatment quality of life.
- Statistical analysis of the results showed a significant improvement in quality of life when the orthosis was worn.
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References

Papers of special note have been highlighted as:
• of interest
** of considerable interest


• Raises the possibility that pericranial muscle tenderness is present early in migraine without aura, and thus may contribute to the etiology.


• As early as 1988, Laper suggested that “further research into occlusal splint therapy as an adjunct to relieving or aborting the painful sequelae of migraine headaches is necessary”.


• First suggestion in the literature that a palatal appliance could bring about improvement of myofacial pain dysfunction syndrome.


• Shows that cumulative evidence for the migraine-specific quality of life instrument meets established criteria for validity, consistency and reproducibility. It confirmed that quality of life testing is a valid tool for measuring treatment efficacy in migraine.


• Elucidated the concept that nociceptive input to the CNS may be increased due to activation or sensitization of peripheral sensory afferents.


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The volume of masticatory muscles in migraineurs is nearly 70% greater than in nonmigraineurs (p < 0.0001).


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