Suspected trigeminal nerve neuropathy causing persistent idiopathic facial pain: a report of four cases

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Persistent idiopathic facial pain is often a disabling condition for patients. Due to a lack of agreed upon diagnostic criteria and varied symptomatology, the diagnosis of persistent idiopathic facial pain is elusive and remains one of exclusion. It is typically described as a unilateral, deep, poorly localized pain in the territory of the trigeminal nerve, however there are a number of case reports that describe bilateral symptoms. Unlike trigeminal neuralgia, the condition encompasses a wider distribution that does not conform or relate to a specific dermatome. In addition, the pain is typically continuous, with no periods of remission and there are no signs or symptoms suggestive of autonomic involvement. Reports documenting the response to various conservative treatments for persistent idiopathic facial pain have been widely variable likely due to the heterogeneity of the condition. Four cases of persistent idiopathic facial pain

La douleur faciale idiopathique persistante est souvent une condition invalidante pour les patients. En raison de l'absence de critères diagnostiques convenus et d'une symptomatologie variée, le diagnostic de douleur faciale idiopathique persistante est difficile à établir et demeure un diagnostic d'exclusion. On décrit généralement la douleur comme étant unilatérale, profonde et mal localisée dans la région du nerf trijumeau, mais il existe un certain nombre de rapports de cas qui décrivent des symptômes bilatéraux. Contrairement à la névralgie faciale, l'affection englobe une distribution plus large qui n'est pas conforme ou liée à un dermatome précis. De plus, la douleur est généralement continue, sans période de rémission et il n'y a aucun signe ou symptôme suggérant une atteinte du système nerveux autonome. Les rapports documentant la réponse à divers traitements conservateurs utilisés pour la douleur faciale idiopathique persistante ont été très variables, probablement en raison de l'hétérogénéité de l'affection. Quatre cas de douleur faciale idiopathique persistante due à un soupçon de neuropathie du nerf trijumeau et

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due to suspected trigeminal nerve neuropathy and their management are presented. A specific form of targeted, manual, instrument-assisted, intra-oral vibration therapy appeared to provide relief in the four cases described.

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leur prise en charge sont présentés. Dans les quatre cas décrits, une forme spécifique de thérapie par vibration ciblée, intraorale, manuelle, appuyée par des instruments, a semblé apporter un soulagement.

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MOTS CLÉS : nerf trijumeau$_1$, douleur faciale, chiropratique, thérapie par vibration, douleur faciale atypique.

Introduction

Lifetime prevalence of non-specific facial pain is estimated at 26%.[1] The condition presents as a diagnostic challenge for even the most experienced clinicians due to its multifaceted presentation and etiology.

Persistent idiopathic facial pain (PIFP) is typically described as deep, poorly localized pain in the territory of the trigeminal nerve. It is most often unilateral, however approximately one-third of patients develop bilateral symptoms.[2] PIFP often spreads to a wider area, not conforming to a specific dermatome. In addition, the pain is typically continuous with no periods of remission and there are no signs or symptoms of autonomic involvement.[2] Recent evidence supports the notion that PIFP may itself be a neuropathic pain condition.[2, 3-7] Friedman *et al*.[8] demonstrated consistent maxillary alveolar tenderness (MAT) in the distribution of the maxillary nerve on the involved side of the face in patients diagnosed with atypical facial pain. The authors state that this tenderness is often incorrectly attributed to lateral pterygoid hypertonicity or spasm, despite the inaccessibility of this muscle to digital palpation.[8] They found intra-oral tenderness in the maxillary molar periapical area in over 90% of asymptomatic migraine patients, with laterality and degree of tenderness closely related to headache symptoms.[9] Significant ipsilateral tenderness and increased local temperature was found in the maxillary molar periapical area on palpation bilaterally during unilateral migraine, tension type headaches, and facial pain.[10]

Neuropathic pain secondary to trigeminal nerve injury has also been poorly defined in the literature.[11] Benoliel *et al*.[11] has proposed a modified diagnostic criteria for peripheral painful traumatic trigeminal neuropathy (PPTTN) with PPTTN defined as "spontaneous or touch evoked pain predominantly affecting the receptive field of one or more divisions of the trigeminal nerve. The duration ranges widely from episodic (minutes to days) and may also be constant. The pain tends to spread with time and is mostly unilateral without crossing the midline."[11 (pg 50)] They also suggest that the pain develops within three months of an identifiable trauma and lasts for more than 3 months.[11]

The purpose of this article is to familiarize the clinician with the clinical presentation, diagnosis, etiology and management of PIFP secondary to trigeminal nerve neuropathy as currently understood. Four cases are presented to illustrate the features of the disorder.

Case presentations

Case 1

A 28-year old female employed as a full-time medical receptionist presented to a chiropractic clinic with a 1.5-year history of bilateral facial pain located over the temporal and temporomandibular joint regions. The onset was attributed having a "nerve struck" while undergoing extensive dental work for caries. Subsequently, a root canal and a dental crown were required. The pain over the temporomandibular region was described as an intermittent dull ache. The temporal headache pain was described as a constant squeezing and pressure sensation occurring weekly. Both painful areas were rated at seven out of 10 on the numerical rating scale (NRS). The major aggravating factor was clenching. The pain was worse in the morning and after work. The patient denied any lancinating, burning or paroxysmal sensations in the face and denied
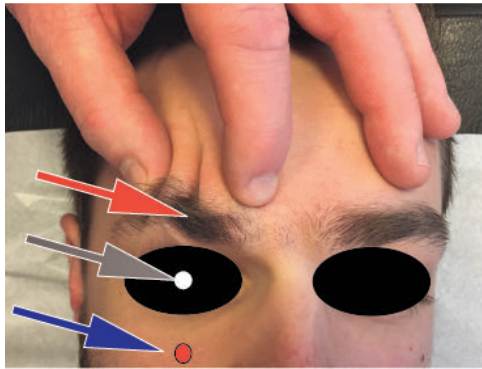
Figure 1.
Location of the infraorbital and supraorbital foramen. The infraorbital foramen is the exit point of the infraorbital nerve from the skull (red dot indicated by the blue arrow). By pinching the skin over the eyebrow directly over the pupillary line (with midline gaze), the supraorbital foramen (or notch) can be easily palpated and subsequently the supraorbital nerve (indicated by the red arrow). The location of the pupil (white dot) is indicated by the grey arrow.

Figure 2.
Proposed trigeminal nerve tension test. Palpating the supraorbital nerve just superior to the supraorbital foramen (or notch) (red arrow) the patient is asked to open their mouth. An increase in tension and/or pain would indicate a positive test.

any associated nausea, vomiting, photophobia, phonophobia and auras. At baseline, her Jaw Functional Limitation Scale score was zero, indicating no limitations. The Jaw Functional Limitation Scale has demonstrated good reliability and construct validity in assessing limitations in mastication, jaw mobility and verbal and emotional expression.[12]

On examination, the patient weighed 54 kg and stood 163 cm tall. Active and passive ranges of motion of the cervical spine were full and pain free. Orthopaedic testing of the cervical spine, inclusive of Spurling's and Jackson's, was unremarkable. The cervical paraspinal musculature was diffusely tender, however no pain referred to the areas of the chief complaint. A rightward C-shaped shift of the mandible was visualized during jaw opening but no obvious clicking was noted. A palpable clunk was noted bilaterally upon closing the mouth. No locking was reported or visualized. Incisal opening, using a Therabite ROM scale[13], measured 53mm, with left lateral mandibular deviation measuring 15mm and right lateral mandibular deviation measuring 10mm. There was a restriction noted during posterior-anterior joint play

of the right temporomandibular joint (TMJ). There was moderate tenderness over the temporalis, masseter and medial pterygoid muscles bilaterally. Palpation over the infraorbital and supraorbital foramen, the exit point from the skull of the infra (See Figure 1) and supraorbital (See Figure 1) nerves, respectively, elicited tenderness, which increased on mouth opening (See Figure 2) recreating a lesser version of her temporal headache pain. Intra-oral palpation along the superior mucobuccal fold in the area of the superior alveolar nerve and inferior mucobuccal fold at the exit and distribution of the mental nerve, the terminal branch of the inferior alveolar nerve, was locally tender bilaterally reproducing her presenting symptoms. Examination of other cranial nerves and peripheral nervous system was within normal limits.

An MRI, ordered by her family medical doctor, of both temporomandibular joints (TM) demonstrated "a normal left TMJ. The right TMJ meniscus was anteriorly subluxed in the resting/neutral position but reduced on opening. There was no abnormality of configuration or signal change within the condylar head or glenoid surface of the TMJ."

Figure 3.
Locating the supratrochlear foramen (red arrow).
By pinching the skin over the eyebrow directly over
the inner canthus, the supratrochlear foramen can be
easily palpated and subsequently the supratrochlear
nerve.

A diagnosis of persistent idiopathic facial pain secondary to trigeminal nerve neuropathy, tension type headaches and temporomandibular disorder (TMD) was made. The plan of management consisted of mobilizations to the TMJ bilaterally, soft-tissue therapy to the affected cervical and orofacial musculature and intra-oral vibration-assisted soft-tissue therapy directed to the affected muscles of mastication and the superior and inferior mucobuccal fold in the area of the superior alveolar and mental nerves (see management section for further description of treatment procedure).

After 10 treatments over a 12-week period, the patient reported significant improvement in their headache and jaw pain. She reported experiencing less than one headache per month at 5-month follow-up. She reported a complete resolution of the pain located over the temporomandibular region. Follow-up at 5 months revealed that her jaw remained symptom free, but she continued to have occasional mild headache pain, as previously described.

Case 2
A 24-year old female employed as a part-time cashier and full-time student presented to a chiropractic clinic with a seven-year history of bilateral orofacial pain and a three-year history of recurrent neck pain. The patient reported the onset of pain overlying the TMJ began when she was 17-years old after her orthodontic braces were removed. The pain persisted and was made worse during a standard dental procedure. The pain was rated at a constant four out of 10 throughout the day. The pain was described as a dull ache with consistent referral of pain to the temporal, frontal and supraorbital regions of the head. Eating large pieces of food, requiring her to open her mouth wide, aggravated the pain. In addition, chewing gum and the use of a store bought mouth guard also exacerbated her symptoms. The patient received treatment intermittently directed to the TMJ for her jaw and headache symptoms from a chiropractor over a period of several years. These treatments consisted of cervical spinal manipulative therapy, soft-tissue therapy to the cervical and facial musculature and intra-oral vibration-assisted therapy directed at the muscles of mastication. She reported the treatments provided temporary relief of the headache pain but had improved opening and closing of her jaw considerably.

The patient felt her neck pain was due to poor postures while attending school. The pain was located bilaterally at the base of the neck extending to the postero-lateral shoulders bilaterally. The pain was described as a dull ache and rated at an average of 4 out 10. The pain was made worse by prolonged studying at a desk. The patient denied any upper extremity pain referral or paraesthesia.

On examination, the patient weighed 62 kg and stood 155 cm tall. Active and passive ranges of motion of the cervical spine were full and pain free. Spurling's and Jackson's tests were unremarkable. The cervical posterior paraspinal musculature was tender, however there was no pain referred to the areas of the TM complaint. A right-sided deviation on opening of the mouth was visualized. No jaw locking was seen on examination or reported by the patient. Incisal opening, using a Therabite ROM scale, measured 37mm. Palpation intraorally along the superior mucobuccal fold in the area of the superior alveolar nerve and inferior mucobuccal fold at the exit and distribution of the mental nerve was locally tender as were the muscles of mastication bilaterally. There was tenderness over the supraorbital (Figure 1) and supratrochlear (Figure 3) foramina, bilaterally and increased with mouth opening (See Figure 2). At baseline her Jaw Functional Limitation

Scale score was 17. Cranial nerves and peripheral nervous system examination was otherwise within normal limits.

A diagnosis of persistent idiopathic facial pain secondary to trigeminal nerve neuropathy and TMD was made on the basis of the clinical assessment. The plan of management consisted of mobilizations to the TMJ bilaterally, soft-tissue therapy to the affected cervical and orofacial musculature and intra-oral vibration-assisted soft-tissue therapy directed to the affected muscles of mastication and the superior and inferior mucobuccal fold in the area of the superior alveolar and mental nerves (refer to management section for further description of treatment procedure).

The patient reported a complete resolution of her orofacial pain after seven treatments over a seven-week period. Follow-up at three-months revealed that she had remained symptom free.

Case 3

A 25-year old female full-time student presented to a chiropractic clinic with a five-year history of bilateral jaw pain and headaches. The jaw pain and headaches reportedly began shortly after prolonged dental work. The headaches were described as a daily dull ache located over the temporal regions. The patient denied any nausea, vomiting, photophobia, phonophobia, or auras. Prolonged studying, sitting and/or driving aggravated the headache pain. Self-directed, extra-oral massage of the TMJ muscles reportedly decreased the intensity of the headaches. The jaw pain was described as dull and achy and rated three to four out of 10 on an NRS. Teeth grinding and not wearing her night-time mouth guard, prescribed by her dentist, increased the TMJ pain. The patient described a non-painful clicking on opening and closing the jaw. The patient denied any lancinating or paroxysmal pain. At baseline her Jaw Functional Limitation Scale score was 25. The patient reported receiving ongoing treatments at intermittent frequency directed to the TMJ for her jaw and headache symptoms from a chiropractor for a period of several years. Her treatments consisted of cervical and facial soft-tissue therapy and intra-oral vibration-assisted therapy directed at the muscles of mastication. She reported the treatments provided only temporary relief of the headache pain but had improved her jaw function considerably.

On examination, the patient weighed 70 kg and stood 155 cm tall. Active and passive ranges of motion of the cervical spine were full and pain free. Spurling's and Jackson's test were unremarkable. The posterior cervical paraspinal musculature was tender, however there was no referred pain to the areas of the TM complaint. Opening and closing the mouth revealed a non-painful audible clicking in the bilateral TMJ. Incisal opening, using the Therabite ROM scale, measured 38mm, with left lateral mandibular deviation measuring 10mm and right lateral mandibular deviation measuring 11mm. Maximal opening caused pain along the left TMJ. Restriction during anterior-posterior joint play of bilateral TMJ was noted. Palpation intraorally of the muscles of mastication and along the superior mucobuccal fold in the area of the superior alveolar nerve elicited tenderess bilaterally. Palpation over the supraorbital foramen (or notch) (Figure 1), was tender bilaterally, increasing with mouth opening (See Figure 2). Examination of the cranial nerves and peripheral nervous system was within normal limits.

A diagnosis of persistent idiopathic facial pain secondary to trigeminal nerve neuropathy and TMD was made. The plan of management consisted of mobilizations to the TMJ bilaterally, soft-tissue therapy to the affected cervical and orofacial musculature and intra-oral vibration-assisted soft-tissue therapy directed to the affected muscles of mastication and the superior and inferior mucobuccal fold in the area of the superior alveolar and mental nerves.

The patient reported a significant improvement in her headache and jaw pain. After 20 treatments over a nine-week period the patient reported having less than one headache per month and intermittent, two out of 10 jaw pain intensity. Follow-up at eight-months revealed that the improvement had been maintained. The patient is currently receiving ongoing symptomatic care for her intermittent low-grade jaw pain and headaches.

Case 4

A 63-year old female retired florist presented to a chiropractic office with a three-month history of left jaw pain. No headaches were reported. The jaw pain reportedly began shortly after a dental crown procedure. The patient described the pain as a constant dull ache; however, she noted that up to three times per week she experienced sharp, shooting pain along the left mandible from the angle of the mandible toward the mental foramen. The jaw pain was rated at a daily four to five out of 10 on an NRS with episodes of sharp, shooting pain reaching eight out of 10.

Aggravating factors for the jaw pain included eating large mouthfuls of hard foods, such as apples, and talking and moving her tongue in side-to-side movements. At baseline her Jaw Functional Limitation Scale score was zero.

On examination, the patient weighed 79.4 kg and stood 152.4 cm tall. Active and passive ranges of motion of the cervical spine were within normal limits. Spurling's and Jackson's were unremarkable. The cervical paraspinal musculature was tender, however there was no pain referred to the areas of the TM complaint. No audible click or deviation was noted during maximal jaw opening. Incisal opening, utilizing the three finger test, was full (three fingers) and pain free. Palpation intraorally along the superior mucobuccal fold in the area of the superior alveolar nerve and inferior mucobuccal fold at the exit and distribution of the mental nerve revealed local tenderness on the left side more so than the right. Palpation of the inferior mucobuccal fold in the area of the exit and distribution of the mental nerve reproduced the chief complaint. Palpation over the supraorbital (See Figure 1) and supratrochlear (See Figure 3) foramina was unremarkable bilaterally. Palpation of the temporalis muscle was nontender, however, palpation intra and extra-orally of all other accessible muscles of mastication were focally tender. Examination of the cranial nerves and peripheral nervous system was within normal limits.

A diagnosis of persistent idiopathic facial pain secondary to trigeminal nerve neuropathy and trigeminal neuralgia was made. The plan of management consisted of facial acupuncture, low level laser therapy (LLLT) to the TM joint, soft-tissue therapy to the affected cervical and orofacial musculature, and intra-oral vibration-assisted soft-tissue therapy directed to the affected muscles of mastication and the superior and inferior mucobuccal fold in the area of the superior alveolar and mental nerves bilaterally. The patient had had success with both LLLT and acupuncture for previous cervical and upper thoracic musculoskeletal complaints so it was included in the plan of management.

The patient reported a significant improvement in her jaw pain after her first treatment. After six treatments over a six-week period the patient reported having a minimal amount of pain and very few episodes of shooting pain. The patient also received a custom-made mouthguard from her dentist three weeks into treatment, which she felt also helped her jaw pain. Follow-up at three-months revealed no pain since her last visit. The patient continued to receive ongoing supportive care as above.

Discussion

The applicability of understanding this complex anatomy for clinicians who utilize intra-oral digital palpation as part of their assessments cannot be overstated. Under normal circumstances, tissues overlying peripheral nerves are painless to gentle palpation, however, when neural tissue is inflamed even gentle palpation can cause focal and referred pain.[14, 15]

Given the complexity of trigeminal nerve neuroanatomy and its' numerous connections, dysfunction and/or injury can result in a myriad of symptoms, some of which will be discussed below. (See Appendix 1 for a more thorough discussion of the anatomy of the trigeminal nerve).

Pathophysiology of nerve injury

Peripheral neuropathy is a blanket term used to describe disorders affecting the function of one or more peripheral nerves due to numerous causes including trauma, disease or dysfunction.[16] Within the nerve sheath, the blood nerve barrier is vital to ensure homeostasis. Breakdown of the barrier can occur with a nerve injury, including compression and tension injuries.[17] Secondary to breakdown of the barrier, is a loss of homeostasis within the endoneural environment.[17] This results in the accumulation of various proteins as well as infiltration by lymphocytes, fibroblasts, and macrophages as a reaction to previously protected antigens contained within the perineurial space.[18, 19] There is thus the potential for a mini-compartment syndrome within the fascicles due to the build up of fluid.[18] The tortuous arrangement of the fascicles in the peripheral nerves embedded in its fibrous matrix is predisposed to the mechanical propagation of this neurogenically induced local compartment syndrome.[18] The neurogenically induced inflammation provides a cytokine-based mechanism for a cycle of inflammation without frank demyelination. This helps to explain the inconclusive and often normal findings found on electrophysiological studies or other imaging modalities in disorders where patients report paraesthesia, such as in carpal tunnel syndrome, thoracic outlet syndrome and atypical facial pain.[18]

Relatively recent diagnostic ultrasound work has demonstrated that affected nerves show a significantly increased cross-sectional area compared to the asymptomatic

side.[20] Kara *et al*.[20] showed an increase in the sciatic nerve in those patients with low back pain and unilateral sciatica. Cartwright *et al*.[19] reported similar findings in the median nerve in unilateral carpal tunnel syndrome, as did Cho *et al*.[21] in unilateral occipital neuralgia with the greater occipital nerve. It would stand to reason that an inflamed nerve would be predisposed to a greater number of entrapment sites along its route due to an increase in cross-sectional area and thus a greater proximity to surrounding soft tissue.

Support for the hypothesis that an inflamed nerve is more predisposed to compression has come from the results of decompression procedures.[22] Direct observation of the scalene triangle during such procedures has demonstrated fibrous bands and persistent adhesions that can be visualized to limit normal movement of the brachial plexus.[22] Small perineural adhesions are said to be responsible for the continued symptom formation and, as noted, are difficult to visualize with current imaging techniques. Resection of the perineural adhesions normalizes blood flow and results in the resolution of distal vasospasms as confirmed thermographically.[22] Ellis[17] reported that more than 100 surgical decompressive cases utilizing intraoperative thermography documenting the presence of both directly mechanical (fibrous bands and fibrotically transformed muscles) and neurogenic (small perineural adhesions) mechanisms for neural constriction, inflammation and distal vasospasm. Evidence of similar pathophysiology has been documented for ulnar and median nerve entrapments. Rosenbaum *et al*., concluded that the presence of endoneural fibrosis was the most damaging due to the direct effect on nerves and blood vessels.[23]

Upton and McComas[24] introduced the concept of the double crush phenomenon in the early 1970's. They stated that a proximal nerve injury might predispose distal sites to compression and that the opposite, reverse double crush, was also a possibility. Upton and McComas[24] noted that compression along the nerve alters axoplasmic flow, which subsequently leads to pathology and symptomatology. These changes have been demonstrated in animal models.[24] Although most authors agree it is more of a "multiple crush" presentation[25], this is an important concept clinically as the failure to recognize and treat the multiple points of injury will likely result in an unsuccessful outcome.

Sauer *et al*.[26] showed that the nervi nervorum provide innervation to the nerve sheath in peripheral nerves and are nociceptive in nature. The nervi nervorum may be the cause of both nerve trunk pain and dysesthetic pain which may be caused by persistent inflammation in the nerve.[27] Bove states, "symptoms can appear as local tenderness of the nerve (nerve trunk pain), or a 'doorbell' type of response, where palpation leads to dysesthetic symptoms in a more distal region."[27] Cranial nerves are known to be richly innervated by nervi nervorum.[28]

The neurogenic inflammation, causing an irritation within the nerve sheath, leads to the cascade of swelling, cellular recruitment and spread of perineural and endoneural fibrosis, and provides a possible explanation for the enigmatic clinical presentation of persistent idiopathic facial pain. This mechanism helps explain the finding of pain on palpation of the various branches of the trigeminal nerve in the presented cases and also the lack of sensory findings (numbness or tingling) or motor deficits (weakness or atrophy).

Diagnosis

Atypical facial pain or more commonly referred to as, persistent idiopathic facial pain (PIFP) is typically described as deep, poorly localized pain in the territory of the trigeminal nerve. It is most often unilateral, however approximately one-third of patients develop bilateral symptoms.[2] Unlike trigeminal neuralgia, PIFP often spreads to a wider area, not conforming to a specific dermatome. In addition, the pain is typically continuous with no periods of remission and there are no signs or symptoms of autonomic involvement. Apart from sensitivity to palpation and tension along the course of the nerve, as demonstrated in our four cases, the condition shows no other abnormal findings in clinical examination or additional investigations and as a result, the diagnosis of PIFP is one of exclusion.[2]

Currently there is a lack of diagnostic criteria and validated diagnostic procedures. However, the International Headache Society (IHS) describes PIFP as persistent facial and/or oral pain, with varying presentations but recurring daily for more than two hours per day over more than three months, in the absence of clinical neurological deficits.[28] In addition, IHS suggests the following diagnostic criteria:

- facial and/or oral pain that is recurring daily for greater than two hours per day for greater than three months;
- the pain is characterized as being poorly local-

ized, not following the distribution of a peripheral nerve;

– the character of pain is either dull, aching, or nagging.

– In addition, the clinical neurological examination is normal and the pain cannot be attributed to any known or understood pathological process.[28]

Recent evidence supports the notion that PIFP may itself be a neuropathic pain condition.[2,3-7] Friedman *et al*.[8] demonstrated consistent maxillary alveolar tenderness (MAT) in the distribution of the maxillary nerve on the involved side of the face in patients diagnosed with atypical facial pain. The authors state that this tenderness is often incorrectly attributed to lateral pterygoid hypertonicity or spasm, despite being inaccessible to digital palpation.[8] Preliminary data of intra-oral tenderness in the maxillary molar periapical area was noted in over 90% of asymptomatic migraine patients, with laterality and degree of tenderness closely related to headache symptoms.[9] On palpation bilaterally during unilateral migraine, tension type headaches, and facial pain, the maxillary molar periapical area displayed significant ipsilateral tenderness and increased local temperature.[10] As previously stated, local neural inflammation can result in symptom provocation to normally non-noxious palpation.[15] In this example, tissues surrounding the jaw supplied by terminal branches of the maxillary nerve are sensitized secondary to neural inflammation.

In order to improve the accuracy of detecting subclinical cranial neuropathies, sensitive neurophysiological recording and quantitative sensory testing (QST) have been recommended. Jääskeläinen *et al*.[5] examined whether electrophysiological testing of trigemino-facial system could aid in the diagnosis of atypical facial pain. They found that atypical facial pain patients could be divided into three groups based on their electrophysiological findings:

1. major trigeminal neuropathy, representing the patients that had both clinical and electrophysiological signs of trigeminal neuropathy despite normal brain magnetic resonance imaging (MRI);

2. minor trigeminal neuropathy, where the patients displayed increased excitability during electrophysiological testing signifying trigeminal nerve dysfunction despite normal MRI; and

3. idiopathic, where despite the clinical symptoms there were no abnormalities with electrophysiological or QST testing.[5]

Forssell *et al*.[2] sought to elucidate the pathophysiology of atypical facial pain and test the idea that the disorder represents a clinically undiagnosed neuropathic pain condition through the use of clinical, neurophysiologic and thermal QST. They examined atypical facial pain patients and patients with diagnosed trigeminal neuropathic pain. The majority (75%) of atypical facial pain patients showed abnormalities in electrophysiological or thermal QST recordings or both. It would appear that PIFP is a heterogeneous entity, which is better understood as a disorder that forms a spectrum of neuropathic involvement due to the amount of inflammation present.

Due to the relative lack of a gold standard in diagnosing trigeminal neuropathic pain, the suspected diagnosis of PIFP secondary to trigeminal neuropathy may best be facilitated with palpation and proposed nerve tensioning (i.e. mouth opening). Ellis[17] states that the inflammation, if not identified and treated appropriately, can spread both perineurally (within the nerve) and endoneurally causing activation of the CNS. A study done by Younger *et al*.[29] showed changes in the gray matter in several areas of the brain in patients with TMD versus controls on MRI. The authors reported these changes were likely associated with dysregulation of the trigeminal and limbic systems as well as somatotopic reorganization in the putamen, thalamus and somatosensory cortex[29]. The mechanism outlined by Ellis can then cause the subsequent inflammation of other adjacent/connected nerves, and can lead to mirror symptoms in the opposite limb.[17] With respect to the four cases outlined above, this could be the mechanism involved in the tenderness of several branches of the trigeminal nerve accessible to palpation including the supratrochlear, supraorbital, infraorbital, the muscular branches to the muscles of mastication and the superior alveolar and mental nerves that may occur bilaterally even with a unilateral complaint.

Therefore, tenderness of the nerves branches would suggest inflammation along the route of the trigeminal nerve with an element of central sensitization. It can be difficult to be confident that the nerve is being palpated especially when other structures in the area could be the source of pain. Increasing pain with palpation of the nerve under tension especially with no other soft tissue structure crossing the tensioned structure would reinforce that the

palpated tissue is in fact the nerve. In cases 1, 2 and 3 there was tenderness over the supraorbital nerve branch that increased under the tension position of mouth opening. This position would theoretically create tension in the trigeminal nerve due to a stretch of the inferior alveolar branch, in particular the mental nerve, with opening. To our knowledge, this proposed trigeminal nerve tension test has not previously been described in the literature.

Management

Secondary to the concept of increased tenderness and temperature being signs of inflammation, Friedman *et al*.[9] examined the efficacy of intra-oral chilling for the relief of headache pain. A randomized controlled study design was used to evaluate the effectiveness of maxillary intra-oral chilling (MIC) in 35 symptomatic episodic migraine patients compared to oral sumatriptan and sham (tongue) chilling. Pain and nausea was recorded at baseline, one, two, four and 24 hours after the treatment. Both MIC (p= 0.001) and sumatriptan (p= 0.024) significantly reduced the pain scores compared to control group. No significant differences between MIC and sumatriptan were noted.[9] Of interest, the sumatriptan caused mild side effects, including dizziness, paraesthesia, and somnolence, in seven of 12 subjects. Only one in 12 subjects for the MIC group reported a minor side effect, which included dizziness and post-treatment gingival tenderness.

Friedman *et al*.[30] also investigated the effectiveness and tolerability of topical nonsteroidal anti-inflammatory drugs (NSAID) to treat headache patients. Topical medication was applied to the periapical area of the maxillary molars on the symptomatic side(s) in 20 chronic headache patients. Patients recorded the frequency, severity, duration, and type of headache for 60 days. After 30 days the patients were instructed on how to apply the medication and told to apply the medication once daily for 30 days. The patient reported headache burden was examined, which was defined as the average headache intensity (0 to 10 scale), multiplied by its duration in hours. The authors noted that the average headache burden score decreased from 454.8 (baseline 30 days) to 86.5 (during the 30 day treatment phase).[30] The reported side effects were minor and included one incident of gastrointestinal intolerance, one incident of burning gingiva, and one incident of cheek irritation. They concluded that NSAID applied to the periapical area of the maxillary molars on

Figure 4.
Depiction of palpation and treatment of the left mental nerve using targeted vibration therapy. Acupuncture points are targeting (from left to right to midline) Gallbladder 1, the right supraorbital foramen (exit of the supraorbital nerve), Urinary Bladder 2 – right supratrochlear foramen (exit of supratrochlear nerve), and Extra 3 (Yintang).

the symptomatic side(s) was significant (p<0.001) in reducing headaches with minimal side effects.[30]

In addition to the conservative treatments outlined above, a targeted manual instrumented assisted intra-oral vibration therapy has demonstrated effectiveness (See Figures 4 and 5)[31]. Targeted vibration therapy is hypothesised to aid in the breakdown of scar tissue and mobilize the surrounding soft-tissues[32], increase local blood flow[33] and reportedly, to decrease pain.[34, 35] Kerschan-Schindl *et al*.[33] demonstrated a significant increase in blood volume and mean blood flow after three-minutes of vibration exercise in the quadriceps and gastrocnemius muscles. The suggested mechanism of action of vibration therapy is to reduce blood viscosity and improve blood flow velocity.[33] Intra-oral vibration therapy theoretically disrupts the proposed dynamic ischemia occurring within the trigeminal nerve in patients with PIFP via mobilizing the nerve itself and surrounding soft-tissues, as well as promoting improved local circulation.

It is important to note, however, that a lack of a clear pathophysiological basis makes it difficult to establish a validated/evidence-based treatment protocol. Given the

Figure 5.
Depiction of palpation of the left superior mucobuccal fold in the area adjacent to the left superior alveolar nerve.

psychosocial comorbidities that accompany chronic pain conditions and the lack of randomized controlled trials for the putative diagnosis, a pragmatic multidisciplinary approach is recommended. Since the application of vibratory stimulation has been shown to increase local blood flow[33] and decrease pain[34, 35], it may be reasonable to assume that targeted vibration therapy may be an effective intervention in the treatment of the suggested dynamic ischemia in the terminal branches of the trigeminal nerve.

Summary

Four cases of PIFP due to suspected trigeminal nerve neuropathy and their conservative management are described. Studies have postulated that in patients with PIFP there is local pathology (inflammation) of the distal branches of the trigeminal nerve, which results in the range of symptoms described. Empirically, the use of specific manual release techniques (soft tissue therapy), and the use of a hand held apparatus that transmits vibrations might be useful. At this time, PIFP thought to be due to trigeminal nerve neuropathy remains a diagnosis of exclusion. Awareness of other sinister conditions that may mimic PIFP such as, giant cell arteritis, septic arthritis/infection of the TMJ, tumors and pseudo-tumours of the TMJ as well as common etiological conditions with accepted standard treatments is imperative for the prac-titioner managing persistent facial pain. If suspected, appropriate referral and investigations should be pursued prior to the commencement of the treatments proposed above or if the clinical picture fails to resolve in a reasonable amount of time.

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Appendix 1.
Anatomy review of the trigeminal nerve

The trigeminal nerve is the second largest cranial nerve in the body.[36,37] The nerve is enveloped by a connective tissue called the mesoneurium, which is critical to allow gliding during movement.[36,37] The mesoneurium is continuous with the external epineurium, which defines and surrounds the nerve trunk. The nerve trunk is composed of myelinated and unmyelinated nerve fibres bound together within fascicles, which are surrounded by the perineurium.[36] In between the fascicles is the internal epineurium. Finally, the connective tissue within the matrix of the fascicle is termed the endoneurium.[36]

The trigeminal nerve supplies both general somatic afferent and special visceral efferent to derivatives of the first pharyngeal arch.[36,37] It is comprised of four nuclei, three sensory and one motor.

The composition of the sensory root is predominantly pseudounipolar neurons that make up the trigeminal ganglion. The trigeminal ganglion, housed within a dural recess lateral to the cavernous sinus, receives afferent and efferent information from the peripheral ganglionic neurons forming the three nerve divisions: ophthalmic (CN V1), maxillary (CN V2), and mandibular (CN V3).[36, 38]

CN V1 exits the cranium via the superior orbital fissure and provides the afferent supply to the skin, mucosa membranes and conjunctiva of the front of the head and nose as well as the anterior and supratentorial dura mater.[36, 38] The first branch from the ophthalmic division is the small recurrent meningeal branch, which supplies the sensory innervation to the dura mater. The ophthalmic division divides into three branches the names of which indicate the structures innervated: lacrimal nerve, frontal nerve and nasociliary nerve.[38] The frontal nerve further branches into the supratrochlear and supraorbital nerves that exit the skull from their similarly named foramina. Fallucco *et al*. report that only 26.7% of the cadavers in their study had a supraorbital foramen while 83.3% had a notch.[39] In 10% of the cadavers there was both a foramen and a notch.[39] In 86.0% of their cases with a notch, the neurovascular bundle passing through was encased by fibrous bands suggesting a potential compression site.[39] The supratrochlear nerve supplies sensation to the skin and soft tissue of the glabella, lower medial portions of the forehead, upper eyelid and conjunctiva.[40] The supra-

orbital nerve further branches into a superficial and deep branch. The deep branch runs deep to the frontalis muscle in a superior direction supplying sensation to the frontoparietal scalp. The superficial branch further divides with some divisions either penetrating or passing over the frontalis muscle as it travels superiorly to supply sensation to the forehead and anterior scalp.[41]

CN V2 exits the cranium via the foramen rotundum and enters the pterygopalatine fossa and divides into the zygomatic nerve, ganglionic branches to the pterygopalatine ganglion and infraorbital nerve.[36, 38] CN V2 supplies sensation to the skin of the face over the maxilla, including the upper lip, maxillary teeth, mucosa of the nose, maxillary sinuses, and palate, as well as the dura matter of the anterior part of the middle cranial fossa.[36, 38]

The infraorbital nerve passes through the inferior orbital fissure to enter the infraorbital canal and exits onto the face via the infraorbital foramen (See Figure 1).[42] Its fine terminal branches supply the skin between the lower eyelid and upper lip. The anterior superior alveolar branches, middle superior alveolar branches and posterior superior alveolar branches are the other terminal branches and form the superior dental plexus, which supplies sensory innervation to the maxillary teeth.[38] These three branches are often the targets for nerve blocks during dental procedures.[42] Since there are numerous overlying structures in this area, including medial and lateral pterygoid muscles, a structurally accurate diagnosis cannot be made through palpation alone. However, sensitivity in this area suggests local inflammation, which may be inclusive of the posterior superior alveolar nerve.[43, 44]

Unlike the other two branches, CN V3 has both general sensory and branchial motor components. The mixed afferent-efferent mandibular division exits the cranium through the foramen ovale and enters the infratemporal fossa on the external aspect of the base of the skull.[36, 38] It gives off a meningeal branch, which re-enters the middle cranial fossa to supply sensory innervation to the dura.[36, 38] The mandibular division has four main sensory branches: auriculotemporal nerve, lingual nerve, inferior alveolar nerve, and buccal nerve. The branches of the auriculotemporal nerve supply the temporomandibular joint, the temporal skin, external auditory canal, and the tym-

panic membrane. The lingual nerve supplies the sensory fibers to the anterior two-thirds of the tongue. The afferent fibers of the inferior alveolar nerve pass through the mandibular foramen into the mandibular canal and branches into the inferior dental plexus, which supply the mandibular teeth. The mental nerve, a terminal branch of the inferior alveolar nerve, supplies the skin of the chin, lower lip and body of the mandible. The buccal nerve pierces the buccinators muscle and supplies sensation to the mucous membrane of the cheek.[36, 38]

The efferent fibers of the inferior alveolar nerve supply the mylohyoid and the anterior belly of the digastric muscles. The pure motor branches of the CN V3 leave the main trunk distal to the origin of the meningeal branch and supply the masseter muscle (masseteric nerve), temporalis muscle (deep temporal nerve), pterygoid muscle (pterygoid nerve), tensor tympani muscle (nerve of the tensor tympani muscle) and tensor veli palatini muscle (nerve of the tensor veli palatini muscle).[36, 38]