Prospective Case Series

Ultrasound-Guided Trigeminal Nerve Block via the Pterygopalatine Fossa: An Effective Treatment for Trigeminal Neuralgia and Atypical Facial Pain

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Background: Patients presenting with facial pain often have ineffective pain relief with medical therapy. Cases refractory to medical management are frequently treated with surgical or minimally invasive procedures with variable success rates. We report on the use of ultrasound-guided trigeminal nerve block via the pterygopalatine fossa in patients following refractory medical and surgical treatment.

Objective: To present the immediate and long-term efficacy of ultrasound-guided injections of local anesthetic and steroids in the pterygopalatine fossa in patients with unilateral facial pain that failed pharmacological and surgical interventions.

Setting: Academic pain management center.

Design: Prospective case series.

Methods: Fifteen patients were treated with ultrasound-guided trigeminal nerve block with local anesthetic and steroids placed into the pterygopalatine fossa.

Results: All patients achieved complete sensory analgesia to pin prick in the distribution of the V2 branch of the trigeminal nerve and 80% (12 out of 15) achieved complete sensory analgesia in V1, V2, V3 distribution within 15 minutes of the injection. All patients reported pain relief within 5 minutes of the injection. The majority of patients maintained pain relief throughout the 15 month study period. No patients experienced symptoms of local anesthetic toxicity or onset of new neurological sequelae.

Limitations: Prospective case series.

Conclusion: We conclude that the use of ultrasound guidance for injectate delivery in the pterygopalatine fossa is a simple, free of radiation or magnetization, safe, and effective percutaneous procedure that provides sustained pain relief in trigeminal neuralgia or atypical facial pain patients who have failed previous medical interventions.

Key words: Trigeminal nerve, ultrasound-guided, atypical facial pain, trigeminal neuralgia, tic douloureux.

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Trigeminal neuralgia, also known as tic douloureux or suicide disease, is a chronic neuropathic pain syndrome that primarily involves the mandibular branch (V2) of the fifth cranial nerve (1,2). It is the most common form of neuralgia in adults (> 40 years of age) with a prevalence of 5 per 100,000, most frequently occurring in women over the age of 40 (3). The typical clinical presentation of

trigeminal neuralgia is sudden, unilateral electrical shock-like pain dispersed among pain-free intervals along the side of the face (3). Paroxysmal attacks are frequently triggered by chewing, brushing teeth, laughing, talking, and even smiling (4). It is often referred to as the most excruciating pain syndrome known today affecting quality of life (5). In contrast, clinical criteria of atypical facial pain consist of persistent facial pain that does not have the characteristics of cranial neuralgias and cannot be attributed to a different disorder (6).

Twenty-five percent of patients who present with trigeminal neuralgia do not respond to pharmacological treatment and require additional interventions such as injection of local anesthetic, steroids or glycerol injection, radiofrequency treatment, Gamma-Knife radiation, balloon decompression of the Gasserian ganglion, or more open surgical interventions (7,8). Blockade of the branches of the trigeminal nerve (V2 and V3) in the pterygopalatine or infratemporal fossa are traditionally performed using a paresthesia technique by positioning the needle anterior or posterior to the pterygoid plate is an image-guidance approach of either fluoroscopy or computed tomography. The classic approach to reach the Gasserian ganglion is through the foramen ovale which places the needle in a direct line to the Meckel's cave in the middle cranial fossa. X-ray guided techniques rely on bony anatomical landmarks such as the maxilla, lateral pterygoid plate, and foramen ovale, which can be difficult and often a challenge to interpret.

The use of ultrasound guidance to assist with needle placement is becoming increasingly popular due to real-time visualization of soft tissue and surrounding vasculature, as well as the appearance of bony structures. This imaging tool allows for fine adjustment of the needle tip and direct observation of the injectate, thereby confirming local anesthetic spread at the targeted area. The lateral pterygoid plate, the maxillary artery, and the pterygopalatine fossa are easily identifiable by ultrasonography. The placement of the injectate anterior to the lateral pterygoid plate, below the lateral pterygoid muscle, can be visualized in real time. This approach allows access to the pterygopalatine fossa and its contents including the sphenopalatine ganglion and the superficial and deep petrosal nerves. In addition, as previously demonstrated using fluoroscopy, because the volume of the pterygopalatine fossa is small, placing 2 mL of contrast in this space produces a retrograde passage to reach the middle cranial fossa and allows visualization of the trigeminal ganglion (9).

We present a case series of 15 patients who have undergone 43 successful diagnostic and/or therapeutic ultrasound-guided injections of local anesthetic and steroids in the pterygopalatine fossa. We seek to obtain preliminary data on safety, feasibility, and efficacy of this novel technique for the treatment of trigeminal neuralgia and atypical facial pain.

Methods

Following Institutional Review Board approval and written informed consent, 15 consecutive adult patients referred to the Northwestern Pain Medicine Center for the treatment of uncontrolled unilateral facial pain in the distribution of the branches of the trigeminal nerve were identified prospectively and included in the study. Patients were initially diagnosed with trigeminal neuralgia or atypical facial pain by neurosurgeons and had previously failed to achieve sustained pain relief with pharmacological and/or surgical interventions (Table 1). Exclusion criteria was known allergy to local anesthetic or steroids, infection, coagulopathy, and pregnancy. During the initial interview, all patients were asked about when they first experienced pain, whether the pain is continuous or intermittent, the duration of a single episode of pain, the intensity of the pain, location of the pain, and previous pharmacological and surgical interventions (10). All patients underwent injection of local anesthetic with steroid in the pterygoid palatine fossa using ultrasound guidance as previously described (9). The ultrasound-guided technique was standardized in all procedures and performed by resident trainees under the supervision of the lead author.

In brief, patients were placed in the lateral decubitus position in the recovery suite. Standard ASA (American Society of Anesthesiologists) monitors were applied. Following standard sterile preparations, the zygomatic bone, the lateral pterygoid muscle, the lateral pterygoid plate, and the maxillary bone were identified using ultrasonography (LOGIQ P6; GE Healthcare, Waukesha, WI). The 11-L transducer probe covered with a sterile sheath was positioned longitudinally on the side of the face just below the zgyomatic bone, superior to the mandibular notch, and anterior to the mandibular condyle (Fig. 1A). The surrounding vasculature, including the maxillary artery, was visualized by using Color Power Doppler in the pterygopalatine fossa (Fig. 1B). An insulated echogenic needle (Pajunk, Sonoplex 22G 50mm) was inserted in-plane parallel to the transducer probe and advanced from a lateral to

Table 1. *Patient characteristics*.

Case	Sex	Age	Preoperative diagnosis	Duration of symptoms prior to injection	Pain distribution of trigeminal branch	Frequency of pain attacks	Previous surgeries/ interventions	Medications
1	F	54	Trigeminal Neuralgia	15 y	V2	Intermittent sharp, Continuous burning	Gamma Knife Fluoroscopy-guided TNB	Baclofen, Duloxetine, Pregabalin,Oxcarbazepine, Synthroid
2	F	56	Acoustic neuroma/ symptomatic trigeminal neuralgia	2 wk	V2,V3	Constant ear pain Intermittent	None	Norco, Oxcarbazepine
3	M	76	Trigeminal Neuralgia	3 y	V3	Intermittent sharp	Fluoroscopy-guided TNB	Baclofen, Carbamazepine, Gabapentin, Methylprednisolone
4	M	56	Atypical facial pain following dental implant	10 y	V2	Continuous burning	Fluoroscopy-guided TNB	Clonidine cream
5	M	39	TN/ON/ACM Atypical facial pain	1 y	V1	Intermittent sharp	None	Norco, Duloxetine
6	M	66	Trigeminal Neuralgia	3 y	V2	Intermittent sharp	Percutaneous balloon decompression, Microvascular decompression	Lamotrigine, Gabapentin, Carbamazepine
7	F	49	Trigeminal Neuralgia	6 m	V2,V3	Intermittent sharp	None	Carbamazepine, Baclofen Ibuprofen, Tylenol, Hydrocodone
8	F	76	Trigeminal Neuralgia	> 10 y	V2,V3	Intermittent sharp	Gamma Knife	Duloxetine, Tramadol, Gabapentin
9	M	44	Trigeminal Neuralgia	1 y	V1,V2	Intermittent sharp	2 x Fluoroscopy-guided TNB	Oxycodone , Gabapentin, Morphine Sulfate
10	M	20	Supraorbital neuralgia Atypical facial pain	4 y	V1	Continuous burning	Peripheral nerve stimulation	Ketamine infusion, Benadryl, Oxymorphine, Scopalmine, Venlafaxine, Ondansetron
11	F	61	Trigeminal Neuralgia	3 y	V2, V3	Intermittent sharp	Microvascular decompression	Ibuprofen, Carbamazepine, Pregabalin
12	F	74	Trigeminal Neuralgia MVA reoccurrence of pain	> 10 y	V2,V3	Intermittent sharp	Percutaneous balloon decompression	Norco, Gabapentin, Methylprednisone
13	F	46	Trigeminal Neuralgia Occipital pain	3 y	V2	Intermittent sharp	None	Ibuprofen, Naproxen, *Acyclovir,* Fluoxetine
14	M	41	Trigeminal Neuralgia Face allodynia	3 y	V2,V3	Intermittent continuous	None	None
15	F	45	Trigeminal Neuralgia	2 y	V2	Intermittent sharp	2 x Gamma Knife Percutaneous balloon compression 2 x Radiofrequency ablation	Methadone, Trileptal, Fentanyl patch, Lyrica, Oxycontin, Hydrocodone

TNB = trigeminal nerve block, MVA =motor vehicle accident, ACM = Arnold-Chiari Malformation

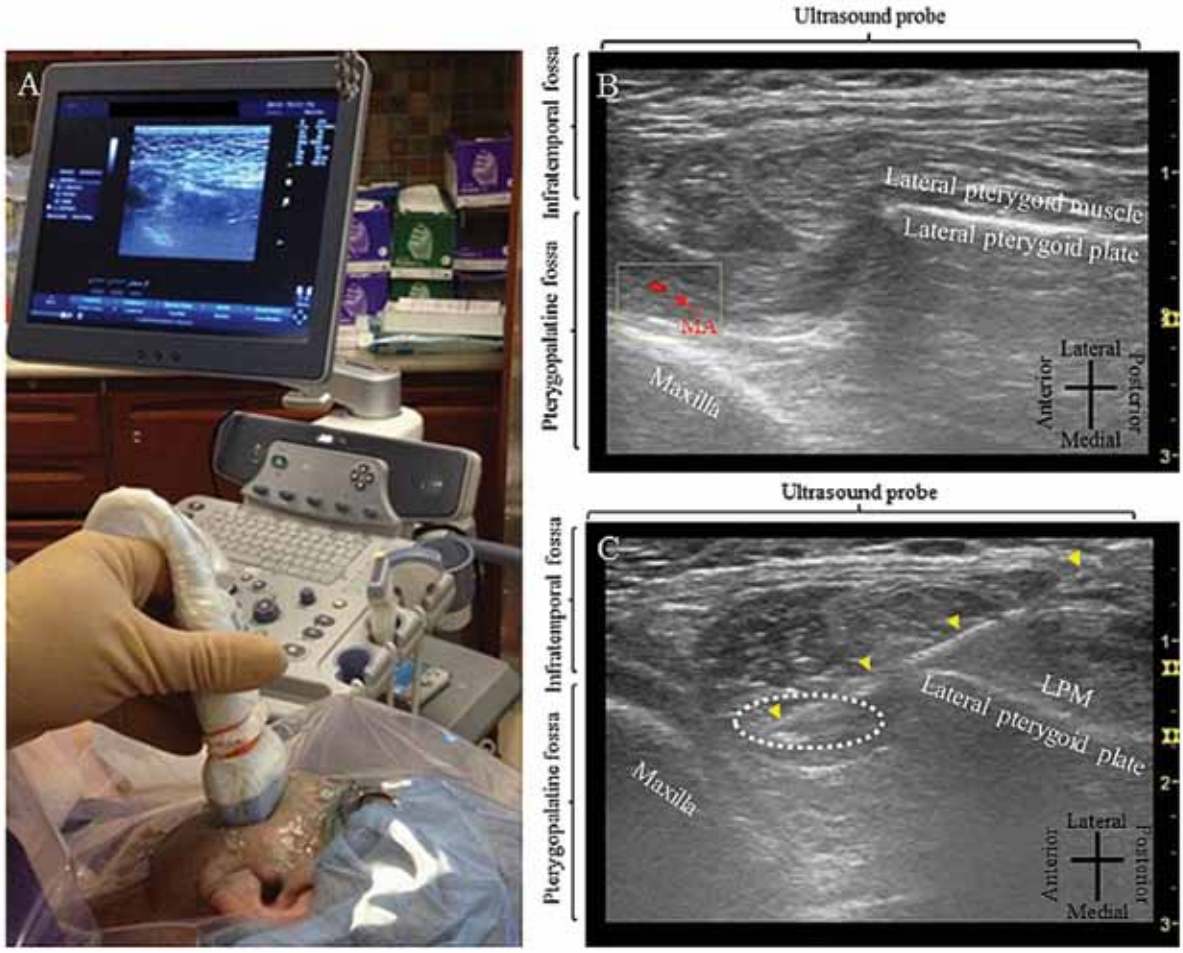

Fig. 1. A. The ultrasound probe is positioned below the zygomatic bone and above the condylar notch on the lateral part of the face. B. The ultrasound image represents a sagittal view with the top of the image displaying the transducer. The bottom of the image, beyond the lateral pterygoid plate, is medial in orientation. The infratemporal fossa, which is the entrance into the pterygoid palatine fossa, is seen on the left of the image labeled anterior. The maxillary artery appears as a deep structure. C. The ultrasound beam travels from lateral to medial through the infratemporal fossa. LPM = lateral pterygoid muscle, arrows = needle trajectory, dashed circle = target area, MA = maxillary artery (color flow Doppler).

medial and posterior to anterior direction toward the pterygopalatine fossa (Fig. 1C). In order to optimize the "angle of insonation" (needle to probe angle), the transducer probe was placed closer (just anterior) to the mandibular condyle. To avoid the acoustic shadow of the coronoid process, the subject's mouth was slightly opened and the transducer probe was slightly directed in a superior direction (Fig. 2). Following negative aspiration, the injectate was deposited deep to the lateral pterygoid muscle and plate.

A total of 4 mL of bupivacaine 0.25%, and one mL of steroids were injected. Patients received an initial injection of 4 mg of dexamethasone and bupivacaine with the subsequent injections consisted of 40 mg of triamcinolone and bupivaccine. Following needle withdrawal, sensory assessments to pin prick were performed using a Neurotips examination pin in the V1, V2, and V3 trigeminal nerve distributions. Pain relief and sensory analgesia in the distribution of the trigeminal nerve were assessed by an observer not involved in the clinical care of the patient. All patients were observed for a minimum of 30 minutes in the recovery suite prior to discharge. Patients were asked to rate their 24-hour global pain experience including severity, duration, frequency of the episodes, and to report it as a percentage of global pain relief during follow-up visits. Pain

relief was classified as "excellent" when the pain was completely resolved or had decreased by 75% or more, "good" for a decrease of 50% to 74%, "fair" for a decrease of 25% to 49%, or "poor" for a decrease of less

Table 2. *Summary of patient information.*

Case	Immediate post block distribution of sensory analgesia in V1, V2, V3 trigeminal branches	Duration and pain relief 1st injection	Duration of pain relief 2nd injection	Duration of pain relief 3rd injection	Duration of pain relief 4th injection	Total # of ultrasound injections	Distribution of residual pain (V1, V2, V3) and quality of pain relief
1	complete	2 wk (80)	11 m sustained (80)			2	V2 Excellent
2	complete	8 wk sustained (Acoustic N.)				1	None Excellent
3	complete	2 wk (80)	2 wk (80)	2 wk (80)	10 m sustained (80)	4	V3 Excellent
4	complete	3 d (100) 1 wk (50)	5 d (80)	10 m sustained (80)		3	V2 Excellent
5	complete	2 m sustained (50) (ACM)				1	V1 Good
6	complete	8 m sustained (100)				1	V2 Excellent
7	partial	1 wk (50)	2 wk (60)	7 m sustained (60)		3	V2, V3 Good
8	complete	2 wk (80)	3 wk (80)	1 wk (80)	1 wk (80)	5*	V3 Fair
9	complete	4 m (100)	4 m (100)	9 m sustained (100)		3	None Excellent
10	complete	2 wk (20)	2 wk (20)	4m sustained (20)		3	V1 Poor
11	complete	1 wk (80)	1 wk (80)	2 wk (80)	13 m Sustained (90)	4	None Excellent
12	partial	3 wk V2 (100) V3 (50)	2 wk V2 (100) V3 (50) (VD 2m later)			2	V3 Good
13	complete	2 wk (60)	1 wk (80)	1 wk (80)	1 wk (100)	6*	None Excellent
14	partial	2 wk V2 (100) V3 (50)	2 wk V2 (100) V3 (50)	2 m sustained V2 (100) V3 (50)		3	V3 Good
15	complete	1 wk (80)	1 m sustained (80)			2	None Excellent
Total	Complete 12 (80) Partial 3 (20)	41 ± 63	47 ± 90	74 ± 100	158 ± 180	3 (2-4)	Excellent 9 (60) Good 4 (27) Fair 1 (6.5) Poor 1 (6.5)

Data presented as n (%) and median (interquartile range). ACM = Arnold-Chiari Malformation. Complete = complete sensory analgesia to pin prick in V1, V2, and V3 distributions of the TN. Partial = incomplete sensory analgesia to pin prick in V1 or V2 or V3 distributions of the TN. Case 8 received a total of 5 injections with the fifth injection (1 wk, 100%) (4 m). Case 13 received a total of 6 injections with the fifth injection (10 wk, 100%) and sixth injection (5 m sustained). Sustained pain relief = patients achieved pain relief not requiring any further intervention. TN = trigeminal neuralgia. VD=vascular decompression.

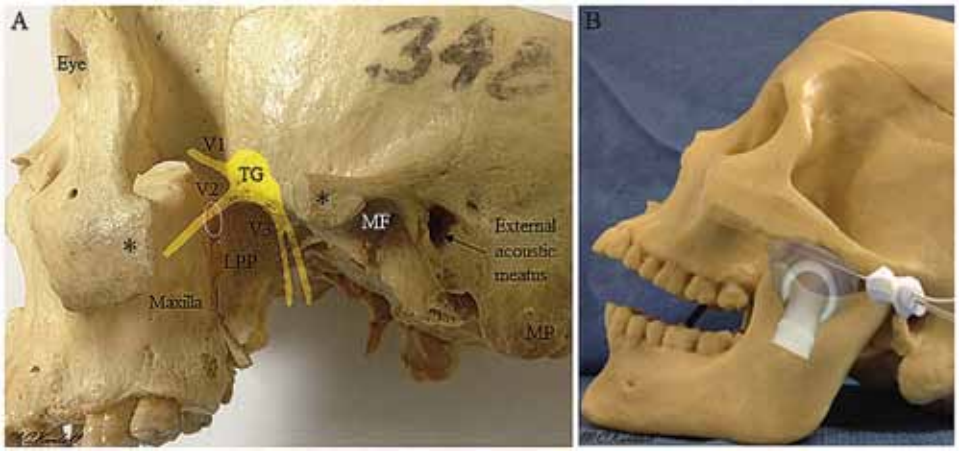

Fig. 2. *(A) Anatomical drawing showing the trigeminal ganglion (Gasserian ganglion) and its corresponding branches V1 ophthalmic, V2 maxillary, and V3 mandibular divisions. The pterygopalatine fossa is bound posteriorly by the palatine plates, medially and anteromedially by the palatine bone, and anteriorly by the maxillary bone. The pterygopalatine fossa is a very compact space and an injection into the space places it close to the foramen rotundum allowing the injectate to reach all branches of the trigeminal nerve. (B) A skull model showing the ultrasound probe positioned longitudinally just below the zgyomatic bone, superior to the mandibular notch, and anterior to the mandibular condyle. Using the in-plane approach, the needle is advanced from a lateral to medial and posterior to anterior direction toward the pterygopalatine fossa. * = zygomatic process (removed), TG = trigeminal ganglion, LPP = lateral pterygoid plate, MF = mandibular fossa, MP = mastoid process, dashed circle = target area.*

than 25% or an increase in pain (Table 2). Patients were instructed to return to the pain clinic when they were experiencing less than good pain relief at a minimum of one week following the initial injection and 2 weeks for additional injections. After the second injection, if the pain relief was not sustained for a minimum of one week, patients were instructed to return to the pain clinic for evaluation and possible injection.

Results

Patient characteristics are presented in Table 1. All of the nerve blocks were performed in less than 5 minutes from needle insertion to needle withdrawal. All patients achieved complete sensory analgesia to pin prick in the distribution of the V2 branch of the trigeminal nerve and 80% (12 out 15) achieved complete sensory analgesia in V1, V2, and V3 distribution within 15 minutes of the injection. All patients reported pain relief within 5 minutes of the injection. In 10 out of 15 patients, good or excellent pain relief was sustained for the duration of the study. An additional 3 patients reported excellent pain relief until scheduled surgery within the next 3 months. One patient reported only 20% sustained pain relief and one patient reported 100% pain relief in the V2 and 50% pain relief in V3 distribution (Table 2).

One patient reported complete sustained pain relief following the first injection and did not require any further intervention, while 14 out of 15 patients required additional injections to achieve sustained pain relief (Fig. 3). No patients experienced symptoms of local anesthetic toxicity or onset of new neurological sequelae.

Discussion

This case series has demonstrated that ultrasound-guided placement of a total of 5 mL of 0.25% bupivacaine and steroid solution below the lateral pterygoid muscle in the pterygoid palatine fossa results in immediate sensory analgesia in the distribution of the branches of the trigeminal nerve and sustained pain relief in a majority of patients. In 3 cases, the procedure was successfully performed to decrease the facial pain symptoms while the patients are waiting for their scheduled surgical procedures (acoustic neuroma resection, Arnold-Chiari malformation, pre-scheduled balloon decompression). Two of our cases were initially admitted to the hospital ward due to intractable pain and the procedure was performed as inpatient in the recovery room. These 2 cases were discharged on postoperative day one with minimal discomfort and received further interventions in an outpatient setting of the pain clinic.

The current treatment for trigeminal neuralgia is pharmacological therapy with carbamazepine desig-

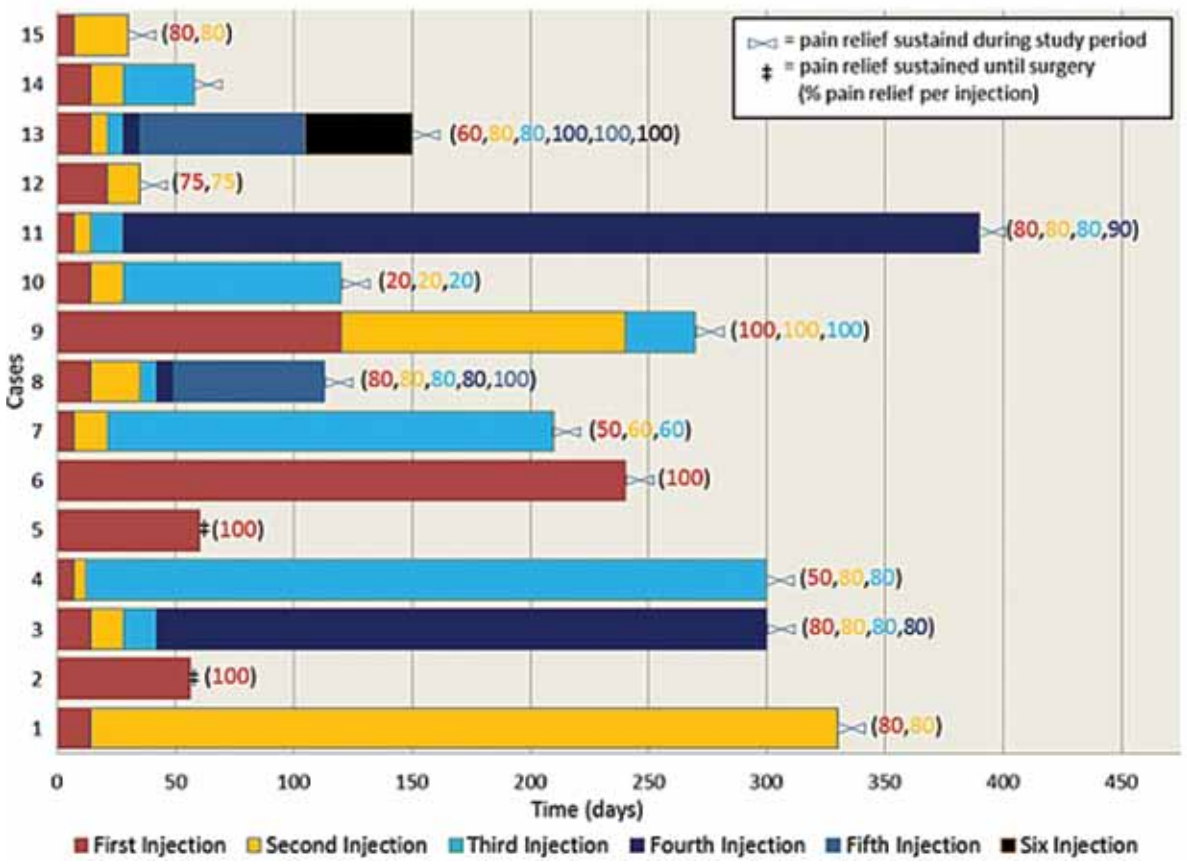

Fig. 3. *A bar graph shows the frequency of injections and duration of pain relief for 15 patients. The color coding percentages corresponds to the percentage of pain relief reported by the patient at the follow-up intervals.*

nated as the first choice of treatment (11). Secondary pharmacological treatments, either as single or combination therapy, include baclofen, gabapentin, oxcarbazepine, and lamotrigine (12). Twenty-five percent of patients who present with symptoms of trigeminal neuralgia can be refractory to medical treatment and up to 8% of these patients can become drug intolerant (13). Patients with atypical facial pain have benefited from pharmacological therapy, however, medical treatment still remains challenging.

Although x-ray based guidance is still considered the "gold standard" in diagnostics and interventional procedures for head and neck blocks, the use of ultrasonography allows the visualization of soft tissues and surrounding vasculature within the pterygopalatine fossa with real-time needle placement. Despite being more costly and less readily available, computed tomography imaging does provide good guidance, although subjecting the patient to radiation exposure. Surgical procedures such as microvascular decompression or radiofrequency thermoregulations require general anesthesia and carry considerable morbidity and mortality risks. Balloon compression requires an overnight stay and causes mild sensory loss with immediate pain relief, although masseter muscle weakness is very common and lasts several weeks. The radiosurgical tool, Gamma Knife radiation, does not require general anesthesia and patients are discharged the same day as the procedure. However, it does not provide immediate pain relief and often requires month(s) to achieve pain relief. Radiofrequency gangliolysis requires paresthesia elicitation to confirm the targeted area. Invasive treatments such as Gamma Knife radiation and vascular decompression are associated with a high initial success rate (98%), but the rate decreases to 64% over the next 10 years (14,15). Ninety-three percent of our patients

(14 out of 15) presented with pain symptoms that were refractory to medical or surgical treatment. We achieved good or excellent sustained pain relief in 87% of these patients with minimal side effects.

The Gasserian ganglion lies in the middle cranial fossa within the Meckel's cave and gives rise to 3 branches--ophthalmic (V1), maxillary (V2), and mandibular (V3)--which exit the skull through 3 distinct foramina: the superior orbital fissure, the foramen rotundum, and the foramen oval (Fig. 2A). The foramen rotundum opens into the posterior part of the pterygoid palatine fossa which is located medial to the lateral pterygoid plate. An injection anterior and medial to the lateral pterygoid plate into the upper part of the pterygoid palatine fossa will place the injectate in close vicinity to the foramen rotundum (Fig. 2B). The injectate can travel posteromedially through the foramen rotundum into the middle cranium. The tortuous maxillary artery enters from the infratemporal fossa into the pterygoid palatine fossa in a posterior-anterior and lateral-to-medial course. At the level of the injection in a lateral to medial sagittal view of the upper part of the pterygoid palatine fossa, the maxillary artery appears in the posterior quadrant as a deep structure. Visualizing vascular structures in real time has the advantage of minimizing the potential of inadvertent needle puncture (16). We were able to visualize the maxillary artery in all of our cases. The injectate was placed in the pterygopalatine fossa, which contains the sphenopalatine ganglion, and communicates with the foramen rotundum, supraorbital fissure, and vidian canal which may contribute to the success of these blocks.

Although we were able to identify the vasculature within the infratemporal fossa, we elected to administer a non-particulate steroid in addition to the local anesthetic for the first injection as most of these patients had undergone previous intracranial surgeries. Although we observed no signs of local systemic toxicity or intravascular injection, these initial injections resulted in excellent analgesia but provided short-lasting relief in 4 patients. On subsequent injections, 40 mg of a particulate steroid (triamcinolone acetonide) was used to achieve a prolonged pain relief. The median number of injections required to produce a sustained pain relief was 3 which is similar to the number of injections required by other authors (17,18). None of the patients reported immediate or long-term side effects either related to the injectate or the procedure and none required a hospital stay following these procedures. Future studies evaluating different pharmacological interventions are warranted.

In the current study, we performed the block in non-homogenous group of patients that presented with trigeminal neuralgia, atypical facial pain, and pain symptoms in the distribution of the trigeminal nerve that was attributed to other cranial pathology. This did not allow us to differentiate the efficacy of this block in these subgroups. We did not confirm the injectate spread to delineate the trigeminal ganglion or its branches by fluoroscopic guidance which we demonstrated in a previous report. However, all patients reported sensory analgesia in the distribution of the branches of the trigeminal nerve.

Conclusion

Our case series describing initial data on feasibility, safety, and efficacy of ultrasound-guided trigeminal nerve block have important clinical implications since the treatment of trigeminal neuralgia is often refractory to current therapeutic strategies. We conclude that the use of ultrasound guidance for injectate delivery in the pterygopalatine fossa appears to be a promising new tool for the treatment and diagnosis of trigeminal neuralgia. Although limited by a low number of subjects, our data suggest that this new technique is a simple, free of radiation or magnetization, safe, and may be an effective percutaneous procedure to provide sustained pain relief in trigeminal neuralgia or atypical facial pain patients who have failed previous medical interventions.

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