A Surgical Approach to Treat Painful Neuromas of the Supraorbital and Supratrochlear Nerves with Implantation of the Proximal Stump into the Orbit

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Abstract
Frontal neuralgia causally related to trauma to the supraorbital and supratrochlear nerves remains a difficult problem to resolve. A peripheral nerve approach to this problem would involve neuroma resection and relocation of the proximal nerve stump to a location away from the vulnerable supraorbital ridge. A retrospective chart review was done to identify patients with frontal pain related to supraorbital trauma who underwent operative interventions to solve this problem by neuroma resection and relocation of the proximal stumps into the orbit. Eight patients were identified for inclusion in this study. At a mean of 16 months after surgery, there was a significant change in the visual analog score from a mean of 9.4 to 2.8 ($p < 0.05$), with 88% of the patients reporting a $>50\%$ reduction in pain postoperatively. There was one treatment failure. There were no postoperative complications. The strategy of relocating the proximal end of the supraorbital and supratrochlear nerves into the posterior orbit after resecting the painful neuromas can successfully manage posttraumatic craniofacial pain related to these injured nerves.

Keywords
► supraorbital
► supratrochlear
► frontal neuralgia
► headache

Trauma to the supraorbital (SO) region can injure the SO and supratrochlear (ST) nerves as they transit from an intraorbital to a subcutaneous location to innervate the forehead and anterior scalp. Compression of the SO and ST nerves at well-described entrapment sites can contribute to headache syndromes that often present with migraine-like features, termed frontal or SO neuralgia.1,2 In addition to frontal headaches, true posttraumatic neuromas of these nerves may present with disabling dysesthesia and focal tenderness that can be triggered by innocuous behaviors. Decompression of the SO and ST nerves is well documented for the treatment of compression-induced frontal headacheschea; however, few approaches have been described for the management of painful posttraumatic neuromas of these nerves.6,7

To prevent a recurrence, a strategy to manage the proximal, “live” end, after neuroma resection, is necessary.8 One described approach to the painful in-continuity neuroma of the SO and ST nerves is to resect the neuromas and direct the proximal nerve stumps of the SO and ST nerves towards one another through a biodegradable conduit.6 This approach has the inherent risk of neuroma recurrence, in a vulnerable superficial location, once the conduit resorbs and can only be used when both nerves are resected. In contrast, another approach has been reported7 in which the SO and ST nerves are divided and the proximal end of the nerve(s) is implanted within the soft tissue contents of the orbit. This approach could theoretically result in an intraorbital neuroma recurrence that produces pain with globe movement when irritated by extraocular muscle contractions.

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The purpose of this report is to describe a larger cohort of patients who underwent SO and ST neuroma resection with implantation of the live end(s) into the orbital contents to evaluate the effects of this procedure on patients’ symptoms and subsequent ocular function.

Methods
Inclusion Criteria
A retrospective review was performed to identify patients who had undergone SO and ST nerve resection by the two senior authors (A.L.D. and E.W.). Patients were included only if their pain did not improve despite at least 1 year of comprehensive conservative management, including desensitization, lifestyle modification, and multimodal medical therapy under the direction of an independent neurologist. Surgical intervention was pursued only after failed medical management and a successful preoperative block of the affected nerve(s), defined as at least 50% reduction in pain and headache symptoms.

Surgical Technique
The patient is positioned supine on the operating table with the head of the bed elevated 45 degrees to decrease venous pressure. Under general anesthesia, the contralateral upper lid is taped closed and the operative eye is protected with a lubricated corneal shield. The incision is marked along the supratarsal crease, 8 to 9 mm superior to the lid margin. Local anesthetic, 1% xylocaine with 1:100,000 epinephrine, is injected subcutaneously along this marking. Using 3.5× loupe magnification, the incision is taken through the skin and orbicularis oculi muscle. Meticulous hemostasis is maintained with a needle-point cautery at the lowest possible setting. The dissection is carried through the orbital septum into the space below the SO ridge where both the SO and ST nerves are identified. These nerves do not have to be followed distally as they would if a nerve compression were being treated by neurolysis. Upon identification, the SO/ST nerves are injected with the local anesthetic to protect the central nervous system from pain impulses related to nerve manipulation and division. The nerve(s) to be resected are then cauterized and divided distally at the supraorbital notch or as they enter the bony foramina (Fig. 1). The globe is gently retracted inferiorly with a malleable retractor. Each nerve is then placed under gentle tension, and then cauterized as proximal as possible within the bony orbit, and divided just distal to the site of cauterization (Fig. 2). The proximal nerve ends are allowed to retract and find their own “resting place” within the orbital contents; they are not directly implanted into the orbital fat. The orbit is inspected to ensure hemostasis. The wound is closed with 6–0 interrupted or running nylon sutures. The incision is dressed with bacitracin and gauze. Postoperatively, the patient is instructed to avoid strenuous activity or bending for 3 days to prevent increased pressure within the orbit. The sutures are removed on the fifth postoperative day. Following suture removal, the patient is encouraged to shower, allowing the water to run over the denervated scalp and forehead as a form of desensitization and sensory reeducation.

Outcome Measures
Pain was evaluated pre- and postoperatively using a standard visual analog scale (VAS), ranging from 1 to 10. Field of gaze and associated pain were evaluated and recorded. Tenderness to palpation over the course of the nerves was evaluated. A successful outcome was defined as a ≥ 50% reduction in patient reported VAS pain scores without evidence of painful neuroma recurrence after at least 1 year of follow-up. Medication usage was also tracked as a measure of quality-of-life improvement.

Results
Demographics and Baselines
A review of the authors’ charts identified three new patients, which are added to the five originally reported in 2016 to a total of eight patients. Thirty-eight percent of patients were female, and the mean age was 42 years (range: 18–68). Patients experienced 94 ± 37 months of headache symptoms prior to
neuroma resection with an average preoperative VAS of 9.4 ± 0.9. All patients reported the onset of symptoms within 30 days of an inciting traumatic event. Blunt trauma was the most common mechanism of injury (75%). Three of these patients underwent operative repair of resulting craniofacial fractures; one to repair an ipsilateral zygomatic arch via a Gillies approach, another patient underwent orbital floor plating via a lower lid incision, and another was taken for a decompressive craniotomy. Iatrogenic injuries were suspected in two patients after undergoing a revision brow lift and sinus surgery, respectively. In each case, neuropathic forehead pain was noted in the immediate postoperative period. All patients required at least one pain medication preoperatively. A positive Tinel's sign over the ST and SO nerves in the brow or forehead was identified in all patients. Preoperative blocks were successful in relieving pain in all patients prior to proceeding with neuroma resection.

**Operative Outcomes**

All patients underwent concurrent SO and ST nerve resection on the ipsilateral side of reported trauma and pain. At an average of 19.6 months of follow-up (range: 12–34; median: 19 months), the mean postoperative VAS was 2.8 ± 2.3 (p < 0.05). Seven out of eight patients (88%) reported a more than 50% reduction in pain without evidence of recurrence and were deemed a success. No patients reported pain with extraocular muscle movements. There was one failure, who reported no improvement in headache symptoms and was ultimately lost to follow-up. Although it is unclear why this patient was a failed, it is likely due to a multifactorial pain pathogenesis in a patient with a possible central sensitization. Another patient reported a significant reduction in pain, but noted occasional, bothersome “pins-and-needles” dysesthesias in the brow alone, possibly related to collateral regeneration. Sixty-three percent of patients were able to stop all pain medications following surgery. There were no surgical complications.

**Discussion**

Following trauma, injured axons sprout in an attempt to reconstitute their distal connections. When regenerating axons are unable to reach distal endoneurial tubes, they continue to proliferate at the site of disruption, forming a disorganized mass of fibrous and neural tissue, termed a neuroma. In cases of complete nerve transection, a terminal neuroma results. Traction, compression, blunt trauma, or partial nerve injuries can disrupt axonal continuity while the epineural architecture remains intact. In these cases, scar or displacement can obstruct regenerating axons, forming a neuroma-in-continuity within the epineurium. Based on the traumatic etiologies and clinical presentations seen in our series, it was assumed that internal architectural damage led to the formation of painful neuromas-in-continuity, and distal exploration was not undertaken. On examination, all patients were found to have a center of pain to percussion along the course of the ST and SO nerves in the brow or forehead was identified in all patients. Preoperative blocks were successful in relieving pain in all patients prior to proceeding with neuroma resection.

**Fig. 2** The supraorbital nerve has been injected with lidocaine and transected at the level of the notch. Slight traction is applied, and the most proximal aspect of the exposed nerve is cauterized with bipolar (a). Sharp transection is then performed just distal to the spot of cauterization (b). The proximal stump retracts several millimeters into with orbital contents and the distal segments are sent for pathology.

The surgical management of painful neuromas must address the proximal live end of the nerve stump to minimize the risk of recurrence. This is of particular importance when managing neuromas of the SO or ST nerves due to their vulnerable superficial location. Leaving the cut ends in the subcutaneous forehead, SO ridge, or eyelid risks recurrence in a vulnerable location. Neuromas at these sites can result in disabling pain that can be triggered by innocuous behaviors such as blinking or wearing a hat, as described by patients in our cohort.

A variety of techniques have been described to minimize the risk of recurrence following neuroma resection. Traditionally, implantation of the proximal end into a deep muscle has been the preferred approach. In the forehead, however, there is limited muscle bulk in which to bury the SO or ST nerve ends. Implantation of nerve ends into bone is another well-described technique; however, the frontal bone is not sufficiently thick to use this approach for traumatic neuromas of the SO and ST nerves.
We have described a series of patients in which the proximal ends of the SO and ST nerves were implanted within the orbital contents as a strategy to prevent a painful recurrence. This approach is analogous to the management of iliohypogastric and ilioinguinal neuroma resection in which the terminal nerve ends are implanted within the peritoneal cavity. With these approaches, there exists a theoretical risk of a terminal neuroma recurrence within the deep soft tissues. In the orbit, this may manifest as pain with globe movement as a hypersensitive terminal neuroma is triggered by contractions of recti muscles. None of the patients described in our cohort reported orbital pain, both at rest or with full field of gaze.

Another potential strategy to minimize recurrence is to reconstruct the SO and ST nerves in an end-to-end fashion with an acellular nerve allograft. However, this approach requires more extensive dissection, often through scared tissue beds, to identify the distal end. This also introduces the risk of a recurrence at both the proximal and distal coaptation sites, which would be located in the vulnerable and dynamic subcutaneous tissues of the brow and forehead.

In a 2008 study, Ducic and Larson described a related approach in which the cut ends of the SO and ST nerves were sutured into opposite ends of a neural conduit at the level of the brow. Although they reported an impressive 83% success rate in six patients at an average of 14 months of follow-up, one must carefully consider the potential for neuroma recurrence once the neural conduit resorbs.

This case-series report is limited by its retrospective nature and small sample size. Although we reported good success with this novel technique, further studies are needed to better characterize outcomes. This may be challenging, however, as neuromas of the SO and ST nerves are uncommon, and the diagnosis is often overlooked by nonsurgical specialists.

References