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The current place of surgical interventions for the management of trigeminal neuralgia

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SUMMARY

Purpose of review: To investigate the current evidence base and clinical indications for various surgical procedures in the management of trigeminal neuralgia (TN). This review is pertinent with the current focus of the health sector to reduce polypharmacy, drug dependence and improve quality of life for chronic pain sufferers.

Recent findings: The current review outlines the various peripheral, central, ablative and non ablative surgical techniques that have been employed. Clinical outcomes with success rates, recurrence rates are discussed. More importantly, we noted downwards trend of morbidity and mortality of surgical complications over the last decade.

Summary: Surgical interventions have a place in the management of TN, and orofacial pain specialists should at least be familiar with them and be able to provide rational advice to patients. Surgical treatments divide into two main categories: ablative (destroying the nerve) or non-ablative (preserving nerve function and relieving the pressure on the nerve). Prognostic factors have evolved to favour diagnostic accuracy, older patients, and non- ablative surgery i.e., microvascular decompression.

Keywords: Trigeminal neuralgia; Surgical management; Microvascular decompression; Percutaneous rhizotomy.

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INTRODUCTION

Trigeminal neuralgia (TN) is a neuropathic chronic pain disorder. As with many other chronic orofacial pain disorders, our understanding of this disease has evolved considerably.

Chronic pain disorders are multifactorial, debilitating and require a comprehensive assessment and management plan involving various health professionals including neurologists, psychiatrists, counsellors, pain specialists, radiologists, and surgeons [1]. The lifetime prevalence of TN ranges from 0.16 - 0.3%, however patients with TN often are underdiagnosed or misdiagnosed [2]. Symptoms of TN can mimic many other orofacial pain disorders and an astute clinician is required to differentiate these entities. There is no curative treatment for TN at this moment and management heavily relies on accurate diagnosis, patient acceptance, compliance, and a multidisciplinary approach [3].

Management strategies are initially pharmaceutical, and a certain proportion of patients eventually opt for surgical treatment [4]. There is a lack of robust evidence base for surgical treatment options nevertheless, there are strong advocates for surgical procedures. Where the goal is to reduce polypharmacy, drug dependence and improve a patient's quality of life; surgical procedures can be an effective tool in the clinician's armamentarium.

CURRENT CLASSIFICATION OF TN

Trigeminal neuralgia is a clearly defined entity. Typically, it is characterised by periodic sharp, lancinating pain affecting one side of the face and lasting a few seconds to two minutes [2,4]. The episodes are triggered by innocuous stimuli on the affected distribution of one or more divisions of the trigeminal nerve. The pain intensity is always severe in nature with or without a background of continuous pain [5,6]. These clinical signs are pathognomonic of trigeminal neuralgia however further investigations are pertinent to reach a more complete diagnosis. The current International Classification of Orofacial Pain (ICOP) further categorises TN to classical, secondary, and idiopathic TN. Historically, the classification was divided into primary and secondary however the updated taxonomy accounts for the various aetiological factors of TN [5,7]. Classical TN is diagnosed when neurovascular compression is seen with morphological changes of the trigeminal nerve root in the skull base

[5]. Secondary TN occurs as a result of another disorder such as multiple sclerosis, presence of a space occupying lesion or arteriovenous malformation [5,7]. A diagnosis of idiopathic TN is made when there is no obvious cause for TN symptoms. Sensory and imaging investigations do not find any abnormalities. It is important to note, in idiopathic TN, morphological changes of the trigeminal nerve are not seen despite the presence of some contact between the vessels and nerve root. The ICOP-1 discusses other causes of trigeminal neuralgia-like pain; however, this is outside the scope of the present review [6]. Surgical treatment has varying degrees of effectiveness dependent on timing of treatment, type of surgery and type TN diagnosis. A thorough pain assessment and diagnostic workup must be performed prior to consideration of surgical procedures.

SURGICAL MANAGEMENT OF TN

The evidence base for management of trigeminal neuralgia is focused on carbamazepine and anticonvulsant medications to limit symptoms. Often, patients require titrated doses of multiple centrally acting agents and these each come with their own side effects. Tolerance increases and clinical effectiveness decreases. Various surgical techniques have been employed over the years to treat TN. Despite their reported success [4,8], the lack of high quality experimental literature limits its widespread use. Interventional treatment can include peripheral techniques or central techniques. Peripheral techniques include neurectomy, cryotherapy and localised alcohol injections. These methods aim to destroy or disrupt the affected peripheral nerve fibres [1,6]. Central procedures, on the other hand, aim to destroy or disrupt the nervous tissue around the Gasserian ganglion of the trigeminal nerve root in the skull base. Central surgical procedures can be further categorised into ablative and non- ablative procedures. Percutaneous trigeminal rhizotomy encompasses the three types of ablative surgeries: radiofrequency thermocoagulation, glycerol injection and balloon compression. Non-ablative procedures include microvascular decompression and stereotactic gamma knife radiosurgery [1,6]. In general, peripheral techniques have limited utility and are reserved for patients who cannot undergo central procedures or are unresponsive to pharmacological therapies. Central techniques have shown some success. Despite this, recommendations for microvascular decompression or stereotactic radiosurgery are made with caution due to the lack of prospective large scale studies comparing surgical outcomes.

Peripheral surgical interventions

The three prevalent peripheral interventions are neurectomy, cryotherapy and localised injections of alcohol. Neurectomy is an ablative process where the offending trigeminal nerve branch is avulsed. Cryotherapy is also an ablative process where the offending branch is frozen without complete exposure of the nerve branch [6]. The mechanism involves causing axonotmesis by applying a specialised probe between temperatures of −60°C and −140°C at the affected nerve site [1,6]. Pain reduction has been reported inconsistently in small case series with short term follow up. Zakrzewska noted median pain relief duration of up to 6 months in their case series of 145 patients [4]. Complications with peripheral interventions are not uncommon and can result in further neuropathic pain such as hypoesthesia, paraesthesia, sensory deficits [1]. Recurrence of pain is noted at six to twelve months and therefore, peripheral interventions are administered at repeated intervals [4].

Alcohol injections aim to anaesthetise the affected trigeminal branch by depositing a small amount of absolute alcohol at the site [6]. Treatment with alcohol injections have a higher recurrence rate but with fewer complications than neurectomy and cryotherapy [6]. A fluoroscope is used to ensure accurate needle position then volumes of 0.3-0.7ml of pure alcohol are deposited at affected site. Han, et al. discusses the benefits of repeated alcohol peripheral nerve blocks in long term reduction of pain at 1-, 2-, 3- and 5-years post procedure (86.2%, 65.5.%, 52.5% and 33.4%, respectively) [9]. Additional complications such as reactivation of herpes zoster virus and bone necrosis have been documented [1].

Data comparing peripheral interventions is lacking and thus one technique cannot be favoured for another with respect to success rates [1]. Recommendations should be made on a case-by-case basis with respect to individual circumstances. The ease and minimally invasive nature of peripheral interventions are beneficial for patients who are limited by their general medical status, finances, or access to specialised medical attention.

Ablative central procedures

Percutaneous trigeminal rhizotomy is a branch of ablative central surgical procedure that is used to treat TN. Ablation is achieved either by percutaneous radiofrequency, glycerol injection or balloon compression of the semilunar ganglion [6,10]. These procedures have the benefit of targeting central mechanisms without the need for craniotomy or a general anaesthetic. Percutaneous radiofrequency rhizotomy (PRR) applies controlled heat (69-90°C) to selectively ablate nociceptors (Aδ, C fibres) while sparing mechanoreceptors (Aβ) [6]. PRR allows for somatotropic mapping and selective division lesioning. The insertion point is 3 cm lateral to the angle of the mouth to gain access to the foramen ovale [1]. Surgical complications include corneal numbness and masseter weakness (10-12%) [6]. This approach boasts a high success rate however also has the highest rates of complications among the percutaneous rhizotomy approaches. Initial pain relief is as high as 97% which decreases to 58% at 5 years post procedure [6]. Percutaneous glycerol injection rhizotomy (PGR) utilizes the neurotoxin, anhydrous glycerol, to ablate nerve fibres. With careful manipulation, the needle location can be verified with the fluoroscopy and direct feedback from the patient allows for selective ablation [1]. The procedure is technique sensitive; this is reflected in its variable success rates. In general, initial pain relief is 90% which reduces to 54% at 3 years [7]. Corneal numbness and dysesthesias are complications that may occur (8%) however less frequently than in PRR. Mean duration of recurrence is at 16 months post procedure compared with mean duration of recurrence for balloon compression (21 months).

Percutaneous balloon compression rhizotomy (PBC) involves a similar approach to PRR and PGR. A small balloon is inserted then inflated at the root entry zone of the trigeminal nerve. This mechanical compression causes destruction of nerve fibres. Again, initial results can be from 91-100% pain reduction with a mean duration of recurrence at 12-18 months (2.5-5%) [7]. Issues with numbness, dysesthesias, transient masseter weakness and possible arterial or cranial nerve injuries have been reported [7]. Often, complication rates correlate to the level of compression of the nerve fibres.

While percutaneous rhizotomy procedures aim at selective ablation, sensory loss of all nerve fibres has been noted [6,10]. Rhizotomy procedures are well tolerated by most patients, are suitable for those that are medically unfit for a general anaesthetic or where TN has recurred after a previous surgical intervention. The procedure duration is shorter and recovery time is reduced making it a more appealing option for risk averse patients [10]. Zakrzewska's systematic review in 2014 could not locate any randomised controlled trials comparing the various rhizotomy procedures [4]. A low quality study showed no significant differences between PRR and PGR. One study attempted pulsed radiofrequency however due to minimal effectiveness the technique was abandoned mid-trial, and patients were placed on medications such as carbamazepine [4]. Despite the advantages of percutaneous rhizotomies, the procedure carries a cumulative risk of deafferentation. This is seen as significant sensory loss especially in cases of repeat percutaneous interventions [7]. An absence of initial success or pain reduction should alert the clinician into reviewing the classical TN diagnosis. A limited retrospective cohort study compared PRR for patients with a diagnosis of classical or idiopathic (atypical) TN [11]. No significant differences were noted at 12 month follow up in pain reduction. Kao and colleagues concluded that PRR is an effective treatment for TN with or without neurovascular compression [7]. While this may be reflective of their findings it must be noted that if a neurovascular compression with morphological changes does exist then leaving it untreated can cause further demyelination of the nerve root and thus recurrence. A 2022 systematic review supports this concept [12]. It noted that patients with neurovascular compression undergoing PBC are more likely to have recurrence (OR = 3.5, 95% CI) than those who underwent microvascular decompression, a central procedure [12]. Other limitations of this cohort study include the short follow up duration and lack of any reported complications. Thus, inferences with respect to use of percutaneous rhizotomy in atypical or idiopathic TN should be made cautiously.

Non ablative central procedures

Non ablative central surgical techniques are microvascular decompression and stereotactic radiosurgery. These aim to separate or distort the affected nerve root from the impinging vasculature.

Microvascular decompression: Microvascular decompression (MVD) is one of the most popular surgical techniques for trigeminal neuralgia [2,4]. It is non-ablative surgery and boasts a high success rate with a low long term recurrence rate [1]. The pathophysiology of classical TN is hypothesised to be from chronic demyelination due to the pulsatile stimulation of intracerebral blood vessels andtheir contact with the fifth cranial nerve root [5,6]. Hence, the basis of MVD is to separate the offending blood vessels from the nerve at the root entry zone. The technique was first described by Dandy in 1932 and further refined by Janetta in 1967 to its present day technique [13]. The procedure requires entry to the posterior fossa of the cranium via a suboccipital retrosigmoid craniotomy. The area is explored to identify the offending vessels by carefully lifting the cortex [1]. The most common vessel attached is the superior cerebellar artery followed by the anterior inferior and posterior inferior cerebellar arteries [8,13,14]. Venous compression and arteriovenous complexes have also been implicated in classical TN [13,14]. Once located, the adhesions on the causative vessel are dissected from the nerve root. A separator (Teflon sponge) is placed between the vessel and nerve to prevent reattachment [15]. Finally, the craniotomy is closed with a Titanium or resorbable plate [8]. The procedure is performed under a general anaesthesia and pain relief is achieved as the patient recovers from the anaesthesia. Owing to its invasive nature, MVD is recommended as a first line surgical treatment options for classical TN in younger and healthier patients.

Stereotactic radiosurgery: Stereotactic radiosurgery is a minimally invasive central surgical procedure to treat TN. The mechanism of action is via delivery of focused radiation doses emitted at the root entry zone at the site of vascular compression [16]. The Leksell Mode B Gamma Knife is most commonly used and a G frame is fixed on the patient's head [15]. Under local anaesthetic orsedation, a 4mm collimator shot is targeted at the distal cisternal portion of trigeminal nerve and another at the root entry zone. The two iso-centre dose method delivers a mean maximum radiation dose of 86.5 Gy and the dose to the brainstem is limited to 20 Gy [16].

Accurate MRI mapping and sequencing is crucial for radiosurgery to be performed with good results. Success rates vary but generally radiosurgery is not considered as efficacious as MVD. Pain relief has a delayed onset in 61-92% of cases and improves over time with maximal pain relief achieved at 24 months [1,6]. Similar to other surgical interventions, complications of numbness and dysesthesias are reported post MVD. A study comparing radiosurgery with PGR found greater pain relief with glycerol despite the increased morbidity of glycerol rhizotomy then stereotactic radiosurgery [16]. A study investigated MVD procedures on patients previously treated with stereotactic radiofrequency. Clinical factors there had no bearing on outcomes were pain distribution, Barrow Neurological Institute (BNI) score or length of hospital stay [15]. In comparison with radiosurgery, MVD was shown to be more efficacious at immediate, 1, 2, 4, 5-year intervals (16). MVD can be indicated as first line therapy for younger, fitter patients or for those unable or unwilling to tolerate anticonvulsant medications and their adverse effects. Recommendations for central procedure should be made on individual basis. Other aetiologies of TN have shown mixed results. Multiple sclerosis consistently shows poor outcomes with surgical interventions of TN and thus MVD is thought to be ineffective. Stereotactic radiosurgery was proposed for multiple sclerosis patients with TN (4) due to long term improvement however more experimental data is required to test this hypothesis. Repeated stereotactic radiosurgery interventions have been performed to manage recurrent TN (4.4% - 23.3%) [4,15]. While this may be an option for long term sufferers or idiopathic TN diagnosis; no data on the effects ofcumulative high radiation doses have been published in this patient subset.

SURGICAL OUTCOMES

MVD has remained a good option for classical TN patients. The literature shows sound longterm success with neuropathic side effects of dysesthesia and hypoesthesia remaining low [4,8,13,17]. A thorough risk-benefit analysis should be performed for patients considering MVD as a central procedure. While complication rates have decreased, the morbidity of each complication is more grave than facial or corneal numbness as seen in peripheral procedures. Thus, patient selection is key to the success of MVD. Historically, increased age has been attributed as a risk factor for recurrence and increased morbidity.

Conversely, Sun, et al. study suggests the presence of individual comorbidities rather than age alone as risk factor for increased complications. Two observational studies showeda 70-80% pain reduction at 5 year follow up [4,17]. Additionally, Zakwrewska's review noted MVD with higher success rate than any other medical or surgical management alone [16]. This comparison is indirect and so must be interpreted with care. Recurrence rates of MVD become comparable to percutaneous rhizotomies at the 10 year follow up when 30-40% relapse is seen [6]. Moreover, neuropathic and sensory deficits are more likely to occur in repeat MVD procedures. Wang, et al. reported an increase in sensory deficits to 31.6% on repeat surgery compared with 0.6% at initial MVD [15]. Morbidity includes ipsilateral hearing loss (5%), aseptic meningitis, infarcts, haematomas, cerebrospinal fluid leaks and even death (2%) [8]. In recent years, increased safety of general anaesthetics has allowed MVD to become less precarious and has aided in reducing post-operative complications. Barker, et al. 1996 study reported a 10% morbidity which has since reduced to 0.3-3% in 2003 [8,18]. Other described complications are subdural hematoma, permanent tinnitus, and restrictive abduction movement of one eye [15]. Despite this, MVD has the highest patient satisfaction rates especially if it is chosen as the first line intervention for classical TN [1,10].

PATIENT SELECTION

As has been discussed, patient selection is instructive of surgical success in TN cases. Huang, et al. well designed and executed retrospective cohort study explored predictive and prognostic factors for success and recurrence [13]. They utilised the BNI scoring system to quantify pain relief and measure outcomes. Patients who received the greatest benefit were those with a preoperative BNI score of 4, a diagnosis of classical/typical TN (93%) and had arterial involvement (61%) [18]. These were found to be independent variables of success in MVD. They corroborated Sun, et al. findings that advanced age (up to 70 years old) was not a risk factor for poorer outcomes [17]. Factors related to less favourable outcomes were atypical/idiopathic TN and venous compression (33.3% and 50% improvement, respectively) [13]. In cases where neurovascular compression is present but excessive could prove problematic and increase morbidity. They concluded that the BNI scoring system was an effective and predictive tool for surgical success. Additionally, accurate diagnosis plays a crucial role in determining treatment plan. High resolution 3D MRI scans with accurate assessment, increased physician experience aid in making a diagnosis [2,4]. A less favourable outcome of MVD may prompt a clinician to reconsider the original diagnosis. For patients with idiopathic TN, ablative procedures i.e. PRR, PGR or PBR may be more beneficial [2,4,12].

CONCLUSION

Well conducted observation studies have flagged the place of surgical treatment options for treating trigeminal neuralgia. Ideal first line surgery for neurovascular compression with morphological changes would be microvascular decompression. Its use is limited due its invasive nature and morbidity. Percutaneous radiofrequency thermocoagulation rhizotomy is a sound ablative surgical option for those that are not fit for a general anaesthetic or do not have significant morphological changes on the trigeminal nerve root. All strategies have their associated risks and recurrence is inevitable with each procedure. Hence, surgical procedures have their place in treating TN and clinicians must be aware of their relative benefits.

KEY POINTS

- Clinicians should be familiar with the available peripheral and central interventional techniques for management of TN
- Microvascular decompression has greater success and less recurrence in patients with BNI score 4, classical TN diagnosis and solely arterial compression of the semilunar ganglion
- Percutaneous radiofrequency rhizotomy is a sound option for risk averse, medically complex, or patients > 8 years into TN diagnosis
- All interventional treatments have complications of neuropathic pain which increases with repeated procedures.

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CONFLICTS OF INTEREST

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