Trigeminal neuralgia is a common pain syndrome in patients with MS. Trigeminal neuralgia is found in 2%-47% of patients with MS and typically occurs more than 10 years after MS is diagnosed, but can be the first MS symptom in as many as 15% of patients.

Vascular compression of the trigeminal nerve is the underlying cause in most cases of TN.23,24,28 Patients with suspected but unproven neurovascular compression are said to have ITN. Among other causes, MS is the most common, with patients with TN-MS representing 2%-8% of all patients with TN.15,20,36,45

Medical management is frequently unsatisfactory for patients with TN-MS. Although antiepileptic agents such as carbamazepine or valproic acid are the first-line medical therapy for TN-MS, as with ITN, these agents are poorly tolerated by patients with MS due to side effects that may enhance symptoms of weakness, dizziness, and ataxia7,26,30,36 or the liver toxicity associated with some immunomodulatory medications used in treating MS. Patients with TN-MS invariably exhaust pharmacological options and seek surgical treatment earlier during the course of their disease than those with ITN.7,30,31,36

Most centers treating large volumes of patients with...
TN use GR\textsuperscript{32,36,40} or RFTC\textsuperscript{4,6,30} as first-line treatments in patients with TN-MS. Despite this, there is limited and conflicting literature on these procedures in these patients. Two GR series comprising more than 50 patients with TN-MS showed good initial pain relief but very different results for durability of pain relief.\textsuperscript{32,40} The literature on RFTC alone or in combination with GR (RFTC-GR) in TN-MS is limited, with no series including more than 20 patients with TN-MS.\textsuperscript{5,7,11,16,22,30}

The purpose of this study was to retrospectively analyze a single-center experience of 822 patients with typical TN, 63 of whom had TN-MS and 759 of whom had ITN, and compare the pain relief and durability results achieved by 22 GR and 50 RFTC-GR procedures performed in patients with TN-MS with the results achieved by 470 GR and 287 RFTC-GR procedures performed in patients with ITN.

**Methods**

**Patient Selection**

An institutional review board–approved search of the medical records at The Johns Hopkins Hospital between 1998 and 2010 revealed 910 patients who were evaluated and had a diagnosis of TN. The diagnostic criteria for typical TN were pain in the distribution of the trigeminal nerve; an intermittent, paroxysmal course; shock-like, lancinating character; light touch triggers; and response to TN medications. Eighty-eight patients (10%) who had a component of atypical TN, such as constant pain or significant sensory loss unexplained by a prior procedure, were excluded. Among the remaining 822 patients (90%) with typical TN, 63 (8%) had TN-MS and 759 (92%) had ITN. The MS diagnosis was made on the basis of the criteria of McDonald et al.\textsuperscript{39} The breakdown of eligible patients, patients treated, and those with outcomes available (not lost to follow-up) is presented in Table 1. Only the first treatment with each modality in each patient was analyzed, except in cases in which patients with bilateral TN underwent treatment to both sides of the face. Patients who underwent both GR and RFTC-GR at this institution were included in the analysis for both procedures. Analysis of time to treatment failure included only those procedures that achieved complete pain relief without medications for TN.

Patient demographics are described in Table 2. Female sex was predominant in all treatment groups. At the time of surgery, patients with TN-MS were younger and had experienced a shorter duration of symptoms than their counterparts with ITN. Bilateral TN symptoms were more common in patients with TN-MS. Prior surgery was uncommon for all patients undergoing GR. Patients with TN-MS undergoing RFTC-GR were less likely than their counterparts with ITN to have undergone prior GR or MVD.

**Operative Technique**

The procedures were performed by 4 neurosurgeons with minimal procedural variation. All interventions were performed under general laryngeal mask anesthesia with a lateral fluoroscopic image of the skull. An SMK needle was passed percutaneously to the level of the fora...
men ovale to obtain CSF return, although this was not an absolute criterion for proceeding with glycerol injection. One milliliter of air was injected to outline the trigeminal cistern. The head of the bed was elevated to 60°, and 0.3–0.4 ml of anhydrous glycerin was slowly injected. For the RFTC-GR procedure, a Radionics stylet was passed through the needle. Motor response to stimulation confirmed localization. The patient then underwent ablation starting at 60°C for 60 seconds, with increasing time and temperature as necessary.

Follow-up and Data Collection

Outpatient records and telephone interviews were used to assess results of surgical intervention in this population. Telephone interviews were patient initiated and were conducted by a physician’s assistant with 29 years of experience in taking care of patients with TN. Retrospective review of clinical data included the following: demographics, medical history, TN symptomatology and prior management, and postoperative pain relief, numbness, and complications.

Initial pain relief and hypesthesia were assessed at the first follow-up appointment, typically 1 month after the procedure. There were 4 possible pain relief outcomes: complete pain relief without TN medications, complete relief with TN medications, partial relief, and no pain relief. Recurrences were defined as return of TN pain requiring ongoing medication or subsequent treatment of ipsilateral TN. Patients who did not experience pain recurrence were censored when complete relief was last recorded in the medical record.

Postoperative numbness was assessed using the Barrow Neurological Institute facial hypesthesia scale and scoring system. According to this scale, a score of I indicates no facial numbness, II indicates mild facial numbness that is not bothersome, III indicates somewhat bothersome facial numbness, and IV indicates very bothersome facial numbness. The presence or absence of 13 relevant complications was recorded systematically.

Statistical Analysis

STATA (release 11, StataCorp.) was used for all analyses. Continuous variables were compared using a t-test; categorical variables were compared using the Fisher exact test. Hypesthesia scores were compared by applying the extended McNemar test for 3 × 3 tables. Time to recurrence was calculated using Kaplan-Meier analysis and log-rank tests. Bivariate and multivariate Cox proportional hazard regression analyses were performed to identify predictors of success. All reported p values were 2-sided, and the corresponding tests attained significance at p < 0.05.

Results

Pain Relief

Pain relief results are presented in Table 3. After 15 of the GR procedures (68%) in patients with TN-MS

<table>
<thead>
<tr>
<th>Variable</th>
<th>GR</th>
<th>RFTC-GR</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. of procedures</td>
<td>22</td>
<td>50</td>
</tr>
<tr>
<td>no. of female patients</td>
<td>15/20 (75)</td>
<td>29/46 (63)</td>
</tr>
<tr>
<td>mean age (yrs)</td>
<td>53 ± 9</td>
<td>58 ± 11</td>
</tr>
<tr>
<td>mean interval since onset (yrs)</td>
<td>4 ± 3</td>
<td>6 ± 7</td>
</tr>
<tr>
<td>side (lt/rt ratio)</td>
<td>0.32 ± 0.68</td>
<td>0.44 ± 0.56</td>
</tr>
<tr>
<td>no. of patients w/ bilat TN symptoms</td>
<td>3/20 (15)</td>
<td>6/46 (13)</td>
</tr>
<tr>
<td>distribution</td>
<td>V1</td>
<td>V1 &amp; V2</td>
</tr>
<tr>
<td></td>
<td>0 (0)</td>
<td>2 (9)</td>
</tr>
<tr>
<td></td>
<td>0 (0)</td>
<td>15 (30)</td>
</tr>
<tr>
<td></td>
<td>0 (0)</td>
<td>7 (16)</td>
</tr>
<tr>
<td></td>
<td>0 (0)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>prior therapy</td>
<td>GR</td>
<td>RFTC</td>
</tr>
<tr>
<td></td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>0 (0)</td>
<td>12 (3)</td>
</tr>
<tr>
<td></td>
<td>0 (0)</td>
<td>2 (0)</td>
</tr>
<tr>
<td></td>
<td>0 (0)</td>
<td>12 (3)</td>
</tr>
<tr>
<td></td>
<td>0 (0)</td>
<td>18 (4)</td>
</tr>
</tbody>
</table>

* Values in parentheses represent percentages. Mean values are presented as the mean ± SD.
† Percentages are based on the number of procedures.
and 315 of the procedures (67%) in those with ITN, the patients were pain free without medications (p = 0.736, Fisher exact test on the distribution of outcomes). After 36 RFTC-GR procedures (72%) in patients with TN-MS and 210 of these procedures (73%) in those with ITN, the patients were pain free without medications (p = 0.657). The difference between GR and RFTC-GR for patients with TN-MS was not significant (p = 0.447). In patients with TN-MS, repeat procedures achieved pain relief at least as good as initial procedures for both GR (p = 0.626) and RFTC-GR (p = 0.325). Logistic regression performed to identify predictors of initial pain relief among all patients confirmed that the diagnosis of MS was not associated with pain relief outcomes in GR or RFTC-GR.

Sensory Change

There was an increase in numbness in all treatment groups (Table 4). Before 91% and after 77% of the GR procedures for TN-MS, the patients had fully intact sensation (p = 0.375); before 87% and after 77% of the GR procedures for ITN the patients had fully intact sensation (p < 0.001). Loss of sensation associated with RFTC-GR appeared greater, as before 86% and after 66% of the RFTC-GR procedures for TN-MS, patients had fully intact sensation (p = 0.009); before 82% and after 60% of the RFTC-GR procedures for ITN the patients had fully intact sensation (p < 0.001).

Complications

Following GR, herpes simplex virus reaction was the most common complication in patients with TN-MS (2 cases [9%]) and ITN (37 cases [8%]) (p = 0.690) (Table 5). Corneal anesthesia was more common in patients with TN-MS undergoing GR (2 cases [9%]) than in those with ITN (9 cases [2%]) (p = 0.082). Two isolated complications (corneal anesthesia and temporomandibular joint dysfunction) observed in patients with TN-MS undergoing RFTC-GR were also observed in those with ITN who underwent RFTC-GR. There were no deaths (mortality rate 0%) in the immediate postoperative window.

Time to Recurrence

The mean duration of follow-up in this series was 25 ± 29 months (25 ± 29 months for patients with TN-MS and 24 ± 30 months for those with ITN) for patients who experienced complete relief without medications. The proportion of patients who experienced recurrence and who were censored is presented in Table 1. Recurrence times were comparable among patients with TN-MS and ITN in both treatment groups. The median time to recurrence after GR was 20 months in the TN-MS population and 25 months in the ITN population (p = 0.403) (Fig. 1). The median time to recurrence after RFTC-GR was 26 months in the TN-MS population and 21 months in the ITN population (p = 0.449) (Fig. 2). Patients with TN-MS experienced similar recurrence times whether they were treated with GR or RFTC-GR (p = 0.431) (Fig. 3). Comparable median recurrence times were achieved by repeat GR (p = 0.513) and repeat RFTC-GR procedures in patients with TN-MS (p = 0.070). Among all patients, the presence of MS status was not a significant predictor of durability of pain relief on Cox multivariate regression.

Discussion

In this retrospective study of a single-center cohort of 822 patients with typical TN, the pain relief and durability of 22 GR and 50 RFTC-GR procedures performed in patients with TN due to MS were compared directly with each other and with 470 GR and 287 RFTC-GR procedures performed in patients with ITN. Patients with TN-MS achieved initial pain relief and durability outcomes comparable to those with ITN after treatment with either RFTC-GR or GR. Within the TN-MS population, RFTC-GR and GR achieved similar pain relief and durability outcomes with no detectable differences in complication rates. These results reinforce the usefulness of GR and RFTC-GR as first-line treatments of TN-MS.

### TABLE 3: Initial pain relief outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>No. of Procedures (%)</th>
<th>GR</th>
<th>RFTC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TN-MS</td>
<td>ITN</td>
<td>TN-MS</td>
</tr>
<tr>
<td>no pain, no medications</td>
<td>15 (68)</td>
<td>315 (67)</td>
<td>36 (72)</td>
</tr>
<tr>
<td>no pain w/ medications</td>
<td>0 (0)</td>
<td>29 (6)</td>
<td>4 (8)</td>
</tr>
<tr>
<td>improved pain</td>
<td>4 (18)</td>
<td>70 (15)</td>
<td>7 (14)</td>
</tr>
<tr>
<td>pain unchanged</td>
<td>3 (14)</td>
<td>56 (12)</td>
<td>3 (6)</td>
</tr>
<tr>
<td>total</td>
<td>22</td>
<td>470</td>
<td>50</td>
</tr>
</tbody>
</table>

### TABLE 4: Preoperative and postoperative hypesthesia*

<table>
<thead>
<tr>
<th>Outcome</th>
<th>No. of Procedures (%)</th>
<th>GR</th>
<th>RFTC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TN-MS</td>
<td>ITN</td>
<td>TN-MS</td>
</tr>
<tr>
<td></td>
<td>Preop</td>
<td>Postop</td>
<td>Preop</td>
</tr>
<tr>
<td>BNI Hypesthesia Scale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>20 (91)</td>
<td>17 (77)</td>
<td>411 (87)</td>
</tr>
<tr>
<td>II</td>
<td>2 (9)</td>
<td>5 (23)</td>
<td>58 (12)</td>
</tr>
<tr>
<td>III or IV</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>total</td>
<td>22</td>
<td>22</td>
<td>470</td>
</tr>
</tbody>
</table>

* BNI = Barrow Neurological Institute.
While most studies have found that GR achieves initial pain relief in 80%-90% of patients with TN-MS,19,36,38,40 there is a wide range of durability outcomes reported. The 2 largest studies bookend this range, with Kondziolka et al.32 reporting that 75% of 53 patients with TN-MS remained pain free with or without medications 36 months after GR and Pickett et al.40 reporting a median recurrence of 12 months in 54 patients with TN-MS. The durability of GR reported in smaller studies has been within this range,19,36 as were our results showing a median recurrence at 20 months after 22 GR procedures in patients with TN-MS.

Early reports suggested that GR outcomes are worse in patients with TN-MS than in those with ITN. Dieckmann et al.39 reported a 40% recurrence rate for 34 patients with TN-MS at 24 months, which compared unfavorably with a 10% recurrence rate in 252 patients with ITN. Similarly, Linderoth and Håkanson36 observed a 61% recurrence in 23 patients with TN-MS compared with 38% recurrence in the entire population of patients with TN undergoing GR, with the overall population undergoing longer follow-up than for patients with TN-MS.

Recent studies have begun to dispel the notion that GR is less effective in patients with TN-MS than in those with ITN. In a series of 480 patients who underwent 620 GR procedures, Kondziolka et al.32 found that 75% of all patients and an identical 75% of 53 patients with TN-MS were pain free with or without medications at 36 months. Bergenheim et al.3 also found no difference in outcomes for 13 patients with TN-MS in a study of 99 patients undergoing GR. Our results support these more recent findings by showing no difference in initial pain relief or durability of relief in patients with TN-MS and ITN who undergo GR.

Combined treatment with RFTC and GR is a frequently used protocol in our institution. We reserve RFTC

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**TABLE 5: Complications**

<table>
<thead>
<tr>
<th>Complication</th>
<th>GR No. (%)</th>
<th>ITN No. (%)</th>
<th>p Value</th>
<th>GR No. (%)</th>
<th>ITN No. (%)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSV reaction</td>
<td>2 (9)</td>
<td>37 (8)</td>
<td>0.690</td>
<td>0 (0)</td>
<td>10 (3)</td>
<td>0.223</td>
</tr>
<tr>
<td>paresthesia</td>
<td>0 (0)</td>
<td>15 (3)</td>
<td>1.000</td>
<td>0 (0)</td>
<td>5 (2)</td>
<td>0.594</td>
</tr>
<tr>
<td>corneal anesthesia</td>
<td>2 (9)</td>
<td>9 (2)</td>
<td>0.082</td>
<td>1 (2)</td>
<td>7 (2)</td>
<td>1.000</td>
</tr>
<tr>
<td>TMJ dysfunction</td>
<td>0 (0)</td>
<td>4 (1)</td>
<td>1.000</td>
<td>1 (2)</td>
<td>3 (1)</td>
<td>0.540</td>
</tr>
<tr>
<td>dysesthesia</td>
<td>0 (0)</td>
<td>3 (1)</td>
<td>1.000</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>anesthesia dolorosa</td>
<td>0 (0)</td>
<td>1 (0)</td>
<td>1.000</td>
<td>0 (0)</td>
<td>3 (1)</td>
<td>1.000</td>
</tr>
<tr>
<td>hearing loss</td>
<td>0 (0)</td>
<td>2 (0)</td>
<td>1.000</td>
<td>0 (0)</td>
<td>1 (0)</td>
<td>1.000</td>
</tr>
<tr>
<td>CN VI palsy</td>
<td>0 (0)</td>
<td>1 (0)</td>
<td>1.000</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>meningitis</td>
<td>0 (0)</td>
<td>1 (0)</td>
<td>1.000</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>hematoma</td>
<td>0 (0)</td>
<td>1 (0)</td>
<td>1.000</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>hemifacial spasm</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>masseter weakness</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>facial palsy</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
</tr>
</tbody>
</table>

* CN = cranial nerve; HSV = herpes simplex virus; TMJ = temporomandibular joint.
without GR for patients with preoperative numbness in the V1 distribution in which the nontarget effects of glyceral heighten the risk of corneal anesthesia. The only other study of RFTC-GR was by Brisman1 who reported on a heterogeneous group of 235 procedures, including 167 RFTC procedures performed over a 7-year period and 68 RFTC-GR procedures performed over the subsequent 3 years. Brisman reported comparable outcomes for the 2 protocols and drew comparisons with the RFTC series without providing a rationale for the adoption of a new protocol.

Even broadening the scope to include both protocols, the literature on RFTC for TN-MS is more limited than that on GR for TN-MS, with no series including more than 20 patients with TN-MS. Many studies do not report actuarial recurrence,6,11,30 which makes it difficult to draw comparisons. In 2 small series,15,22 each with 9 patients with TN-MS treated with RFTC, the median time to pain recurrence was 22 months. Our results show prolonged durability of relief in a larger number of patients, with a median pain recurrence of 26 months in 30 initial RFTC-GR procedures.

There are conflicting reports about whether RFTC outcomes in the TN-MS population are equivalent to those in the ITN population. Kanpolat et al.30 compared 17 RFTC procedures in patients with TN-MS and 1600 RFTC procedures in patients with ITN and found that a lower percentage of TN-MS patients were pain free at 6 months and 5 years of follow-up. By contrast, in the aforementioned series by Brisman1 including 16 patients with TN-MS and 219 patients with ITN treated with RFTC, 65% of patients in both groups remained pain free at 24 months. Yoon et al.50 saw a median recurrence of pain 24 months after 108 RFTC procedures, with comparable results in 7 patients with TN-MS and the ITN population. Our results showed no difference in initial pain relief or median recurrence for patients with TN-MS and ITN undergoing RFTC-GR.

There are few comparisons of GR and RFTC in the literature on TN.21,25 Possibly because GR is used as a first-line procedure and RFTC is reserved for recurrent pain,8,21,34 In the TN-MS population, however, RFTC-GR has been more commonly used as a first-line procedure for TN-MS (Table 2). No significant differences were observed in pain relief or durability of GR compared with RFTC-GR in the TN-MS population. This is consistent with the only prior direct comparison of GR and RFTC for TN-MS, in which Golfino and Shetter22 reported on 12 patients with TN-MS who underwent 17 GR procedures and 9 RFTC procedures with a mean interval to recurrence of 22 months in both procedure types.

There was a decrement in sensation associated with both ablative techniques, which was greater for RFTC-GR. Prior studies have shown a correlation between sensory loss and pain relief in both RFTC12,35,48 and GR.5,14,41,46 Given this correlation, one might have expected improved pain relief outcomes in patients undergoing RFTC-GR. Indeed, a greater proportion of patients undergoing RFTC-GR than GR alone achieved complete pain relief without medications; however, this difference was not statistically significant. The lack of statistically significant sensory loss in patients with TN-MS undergoing GR is likely attributable to low patient numbers, given that the proportionate loss of sensation was comparable to the ITN population.

Surgical alternatives to GR and RFTC in patients with TN-MS include MVD, SRS, and PBC. Long eschewed because it targets a compressive pathology instead of primary demyelination, MVD has been recently reevaluated as a treatment for TN-MS on the hypothesis that independent processes of demyelination and vascular compression may have a synergistic effect causing pain spasms.1,10 In the largest study of MVD for TN-MS, the mean recurrence time was 13.5 months in 35 patients with TN-MS, and 30% experienced sustained relief beyond 7 years. Durability was considerably better in 138 patients with ITN, 70% of whom remained pain free at 7 years.9 With comparable durability achieved by percutaneous ablative procedures, we believe that the additional potential morbidity associated with MVD makes it difficult to justify in patients with TN-MS.

Given the relatively poor outcomes of MVD in patients with TN-MS, an effort must be made to discern the etiology of a patient’s TN before surgery. Trigeminal neuralgia may be the first symptom of MS to present, as it was in 12 (19%) of 63 patients with TN-MS in this study. Demographic clues may suggest TN-MS, since these patients are typically younger and more often experience bilateral symptoms.5,7,26,29 Otherwise, TN-MS is clinically indistinguishable from ITN, with the same paroxysmal, lancinating character, and pain triggers.18,44 At our institution, screening for MS includes physical examination, history, and MRI assessment of active or previously established demyelinating lesions, but it does not require testing of CSF markers (for example, oligoclonal bands or IgG index) for all patients. Other investigations are imperfect. Magnetic resonance imaging may demonstrate neurovascular contact; however, this does not specifically rule out TN-MS, since it may be present in TN-MS and does not predict successful MVD treatment.7,20 As an inevitable consequence, some patients with TN-MS may be treated with MVD before their underlying diagnosis is discovered and experience poor outcomes associated with the procedure.43

Stereotactic radiosurgery is a treatment alternative...
Trigeminal neuralgia in multiple sclerosis

that continues to be refined as a treatment for TN-MS. Multiple series have shown that SRS delivers some degree of pain relief to greater than 80% of patients with TN-MS, with conflicting reports about the rate of complete relief without medications, ranging from 35% to 62% of patients. Stereotactic radiosurgery has been shown to be less effective in patients with TN-MS than in those with ITN in both retrospective and prospective trials. Stereotactic radiosurgery is the most minimally invasive treatment of TN and has few side effects, but it has a latent period between the procedure and pain relief that may be more problematic in the TN-MS population because of the poor medication tolerance. At this institution, we reserve SRS for patients with TN-MS with a high comorbidity burden, those who have experienced pain recurrence despite repeated treatments with other modalities, and those who request it.

There are no series on PBC for TN-MS, although these patients have been included in studies of PBC encompassing all TN etiologies without mention of disparate outcomes. We do not perform PBC at our institution.

Trigeminal neuralgia due to MS presents a management predicament because it occurs at a younger age, the patients tolerate the medications less well, and the condition cannot be treated definitively with MVD. While percutaneous ablative procedures achieve good pain relief results in patients with TN-MS, these procedures have a finite duration of effect. The results of this study suggest that repeat GR and RFTC-GR may be used with outcomes comparable to initial procedures. Similar observations of comparable results for repeat GR were made by Pickett et al., who performed 97 GR procedures in 53 patients and Linderoth and Håkanson after 34 procedures in 23 patients.

The limitations of this study include its retrospective, nonrandomized, observational nature, which is shared by much of the literature on TN surgery. The number of patients with TN-MS was small, although it compared favorably with many other series. Patients with MS were not differentiated by disease activity or MS subtype. Follow-up intervals were irregular, and follow-up did not occur for some procedures, although this was less than 8% of the total. The Barrow Neurological Institute hyp esthesia scale has not been psychometrically validated. Comparisons with other series are limited by differing institutional protocols. Guidelines for standardized TN surgery outcomes reporting to which this study adheres will facilitate comparisons across studies.

Conclusions

Pain relief and durability outcomes of GR and RFTC-GR were no different in patients with TN-MS than in those with ITN, reinforcing the usefulness of these procedures as the preferred surgical treatment of TN-MS. Glycerol rhizotomy and RFTC-GR achieved comparable pain relief and durability in patients with TN-MS, suggesting that both can be used to good effect in this patient population. Initial and subsequent treatments achieved similar outcomes across both modalities, suggesting that repeat GR or RFTC may be used effectively as an ongoing management strategy in TN-MS.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Lim, Bender, Pradilla, Batra, See, James, Carson. Acquisition of data: Bender, See, James. Analysis and interpretation of data: Bender, Batra. Drafting the article: Bender, Pradilla, Batra, Pardo. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Lim. Statistical analysis: Batra. Study supervision: Lim, Pradilla, Carson.

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