Oral Diseases (2004) 10, 217–220

http://www.blackwellmunksgaard.com

Experimental Oral Medicine

Effects of near-infrared irradiation to stellate ganglion in glossodynia

M Nakase, K Okumura, T Tamura, T Kamei, K Kada, S Nakamura, M Inui, T Tagawa

Department of Oral and Maxillofacial Surgery, Faculty of medicine, Mie University, Tsu, Japan

OBJECTIVE: This study was designed to assess the effect of stellate ganglion near-infrared irradiation (SGR) on glossodynia and the mechanism of action.

STUDY DESIGN: Thirty-seven patients with glossodynia received SGR once weekly for 4 weeks. The response to treatment was evaluated on the basis of the change in pain intensity, assessed with a visual analogue scale (VAS) before and after 4 weeks of treatment. The temperature and blood flow of the tongue were also measured before and after first SGR. As control, eight healthy subjects were studied.

RESULTS: Tongue pain as assessed by the VAS decreased in 28 of the 37 patients (75.7%). Mean pain intensity decreased significantly from 5.1 ± 2.2 to 1.9 ± 2.1 ($P < 0.05$). Tongue blood flow at rest in the patients with glossodynia [7.2 ± 1.6 ml min^{-1} (100 g)$^{-1}$] was significantly lower than that in the healthy subjects [7.8 ± 0.23 ml min^{-1} (100 g)$^{-1}$]. Five minutes after SGR, the temperature of the tongue rose 1.5 ± 0.21°C, and blood flow increased to 8.5 ± 1.2 ml min^{-1} (100 g)$^{-1}$. Tongue blood flow (at rest) after 4 weeks of SGR had increased to 7.7 ± 1.1 ml min^{-1} (100 g)$^{-1}$.

CONCLUSION: SGR is an effective treatment for glossodynia. The mechanism by which SGR improves symptoms associated with glossodynia is thought to be as follows: SGR inhibits abnormally increased sympathetic activity associated with glossodynia. This is followed by normalization of decreased tongue blood flow, thereby alleviating pain.

Oral Diseases (2004) **10**, 217–220

Keywords: glossodynia; near-infrared irradiation; stellate ganglion; tongue temperature; tongue blood flow

Correspondence: Minoru Nakase, Department of Oral and Maxillofacial Surgery, Faculty of Medicine, Mie University, 2-174 Edobashi, Tsu, Mie 514-8507, Japan. Tel: +81 59 232 1111 (Ext. 5635), Fax: +81 59 231 5207, E-mail: nakase96@clin.medic.mie-u.ac.jp
Received 9 January 2003; revised 22 September 2003; accepted 15 December 2003

Introduction

Glossodynia is characterized by chronic pain of the tongue despite no distinct organic changes (Ship *et al*, 1995). Its prevalence is estimated to range between 1.6 and 2.2% in men (Forman *et al*, 1989; Bergdahl and Bergdahl, 1999) and 0.7 and 5.5% in women (Lipton *et al*, 1993; Hakeberg *et al*, 1997; Bergdahl and Bergdahl, 1999). Potential factors related to glossodynia include age (Bergdahl and Bergdahl, 1999), postmenopausal climacteric disorders (Basker *et al*, 1978), oral dryness (Grushka, 1987; Bergdahl and Bergdahl, 1999), vitamin deficiency (Lamey *et al*, 1986), anemia, drugs (Bergdahl and Bergdahl, 1999), and psychosocial disorders (Browning *et al*, 1987; Lamb *et al*, 1988; Carlson *et al*, 2000). The cause of glossodynia remains unclear. The treatment of glossodynia is therefore largely empirical and depends on the patients' condition and physician preference. No established treatment is available. Previous studies have evaluated the response of glossodynia to non-steroidal anti-inflammatory agents (Sardella *et al*, 1999), antiepileptic drugs (Grushka *et al*, 1998; Woda *et al*, 1998), Kampo (Oriental) medicines (Bessho *et al*, 1998), and antidepressants (Maina *et al*, 2002). Stellate ganglion block (SGB) has been reported to be effective for the management of orofacial pain (Lynch and Elgeneidy, 1996). However, potential complications of SGB preclude its indiscriminant use in patients with glossodynia. Yoshizawa *et al* (1994) reported that low-reactive-level laser therapy of the area around the stellate ganglion produced a response similar to that obtained with SGB, but to our knowledge no study has assessed the effect of laser treatment on glossodynia. We studied the effect of near-infrared irradiation of the stellate ganglion (SGR) in patients with glossodynia. To gain insight into the mechanism underlying the improvement in symptoms, we also assessed changes in tongue temperature and blood flow induced by SGR.

Subjects and methods

Between 1999 and 2001 we studied 56 patients with glossodynia who presented at the Department of Oral and Maxillofacial Surgery, Mie University Hospital.

Table 1. Patient Characteristics in the three groups

Characteristics	*S G R (n = 37)*	*Gargle (n = 19)*	*Healthy (n = 8)*
Sex			
Female	29	15	5
Male	8	4	3
Age (Years) mean ± SD (Range)	66.0 ± 9.3 (46–83)	64.9 ± 12.4* (40–91)	63.1 ± 16.0* (42–82)
Duration of disease, mean ± SD, Months	18.8 ± 12.1	6.9 ± 6.8	–
The site of pain			
Unilateral	28	12	–
Bilateral	9	7	–

*Not significant versus SGR group

Thirty-seven of these patients received SGR (SGR group), and 19 gargled with sodium azulene sulfonate solution (gargle group) as control. Eight healthy subjects (healthy group) were also given SGR, and the temperature and blood flow of the tongue were measured. No healthy subject had glossodynia or any pain of the face. The characteristics of the three groups are shown in Table 1. Informed consent to participate in this study was obtained from all subjects.

Irradiation equipment and methods

The SGR was carried out with the use of a Super Lizer™ near-infrared irradiation device (Tokyo Iken Co., Ltd., Tokyo, Japan). Irradiation was given at wavelengths of 0.6–1.6 μm, including a combination of red and near-infrared radiation. The maximum output was 1500 mW. The irradiation conditions were as follows: output, 100%; on/off ratio, 1:2; duration of irradiation, 10 min; and total irradiation energy density, 194.8 J cm^{-2}. Similar to the procedure for SGB, the location of the stellate ganglion on the affected side was confirmed. If pain was bilateral, the side with more intense pain was evaluated. The Super Lizer™ probe was placed in contact with the skin directly overlying the ganglion, and the ganglion was irradiated. Irradiation was performed a total of four times at weekly intervals. Subjects in the gargle group gargled with 100 ml of a 4–6% solution of sodium azulene sulfonate three times daily for 4 weeks.

Evaluation of response

The intensity of pain was evaluated before and after 4 weeks of treatment according to a 10-cm visual analogue scale (VAS) ranging from 0 (no pain) to 10 (worst pain possible). The subjects were interviewed weekly, and the worst pain during the previous week was recorded on the VAS. The response to treatment was evaluated as excellent (complete resolution of pain), moderate (a decrease of one or more points on the VAS), or poor (worsening of, or no change in, pain).

Change in tongue surface temperature

The temperature of the surface of the tongue was measured with a thermograph (Nihon Avionics, Tokyo, Japan) at the first and last SGR. The temperature of the point that the patient indicated to be the most painful

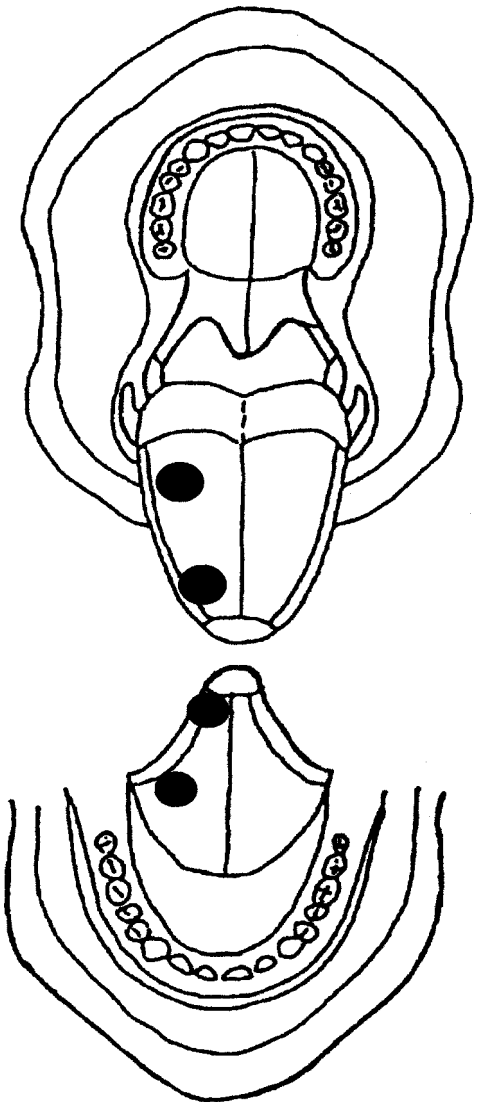

Figure 1 Schematic drawing of the tongue and the measurement sites (●) of the blood flow in glossodynia patients. The blood flow was monitored on the affected side at the anterior and posterior of dorsal and sublingual surface

was measured between 13:00 and 15:00 hours. The room temperature of the clinic was maintained at 25–27°C. The patient rested in a sitting position for about 10 min before starting treatment and temperature measurement. Tongue temperature was measured four times: at rest, and 1, 5, and 15 min after the completion of irradiation. At the time of temperature measurement, the patient was instructed to open the mouth and stick out the tongue. The temperature was read after 5 s.

Change in tongue blood flow

The blood flow of the tongue was measured with a laser blood flow monitor™ (Moor Instruments Inc., Exeter, UK). Blood flow was measured at the same times as tongue temperature. Blood flow was measured on the affected side at the four points as shown in Figure 1, and the mean value was calculated. In subjects with bilateral pain, the side receiving SGR was evaluated.

Statistical analysis

The statistical significance of differences between variables was determined with the *t*-test. *P*-values of <0.05 were considered to indicate statistical significance.

Results

The response to SGR was excellent in 12 patients, moderate in 16, and poor in nine. Mean pain intensity on the VAS decreased significantly from 5.1 ± 2.2 (mean ± s.d.) before treatment to 1.9 ± 2.1 after 4 weeks of treatment ($P < 0.05$). In the gargle group, the response to the treatment was excellent in one patient, moderate in nine, and poor in nine; the VAS score decreased slightly but not significantly from 4.0 ± 1.0 to 3.3 ± 1.5.

The mean temperature of the tongue surface increased significantly after the completion of the first SGR. As compared with the baseline temperature (at rest), mean tongue temperature was 1.7 ± 0.33°C higher 1 min after treatment, 1.5 ± 0.21°C higher after 5 min, and 1.5 ± 0.22°C higher after 15 min (Figure 2).

At the final session of SGR, the increment in tongue temperature as compared with the baseline value had decreased considerably (0.056 ± 0.64°C after 1 min, 0.11 ± 0.49°C after 5 min, and 0.00 ± 0.90°C after 15 min). In the healthy group, the increase in tongue temperature was also minimal (0.57 ± 0.88°C after 1 min, 0.50 ± 0.71°C after 5 min, and 0.07 ± 1.2°C after 15 min; Figure 2).

Mean blood flow of the tongue at rest in the SGR group [7.2 ± 1.6 ml min^{-1} $(100\ g)^{-1}$] was significantly lower than that in the healthy group [7.8 ± 0.23 ml min^{-1} $(100\ g)^{-1}$] ($P < 0.05$). One minute after the completion of treatment in the SGR group, blood flow had increased significantly to 8.3 ± 1.4 ml min^{-1} $(100\ g)^{-1}$ ($P < 0.05$), followed by a slight increase to 8.5 ± 1.2 ml min^{-1} $(100\ g)^{-1}$ after 5 min. Even after 15 min, tongue blood flow [7.9 ± 1.1 ml min^{-1} $(100\ g)^{-1}$] was significantly higher than the baseline value (Figure 3). After the completion of 4 weeks' treatment, mean tongue blood flow at rest [7.7 ± 1.1 ml min^{-1} $(100\ g)^{-1}$] in the SGR group was not significantly higher than the value before treatment, but was similar to the mean value in the healthy group [7.8 ± 0.23 ml min^{-1} $(100\ g)^{-1}$]. The SGR-induced change in tongue blood flow in the healthy group was relatively small [8.2 ± 0.50 ml min^{-1} $(100\ g)^{-1}$ after 1 min, 7.9 ± 0.44 ml min^{-1} $(100\ g)^{-1}$ after 5 min, and 7.8 ± 0.48°C after 15 min; Figure 3], similar to the results obtained for tongue temperature. SGR was not associated with any complications or adverse effects.

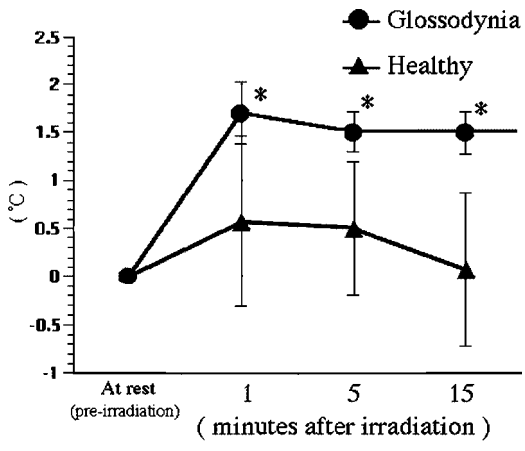

Figure 2 Temperature changes of the tongue after SGR in glossodynia patients ($n = 37$) and healthy subjects ($n = 8$). Tongue temperature was measured four times: at rest (preirradiation), and 1, 5, and 15 min after the completion of irradiation. In glossodynia patients, tongue temperature significantly elevated at these three intervals compared with preirradiation (baseline). Data represent mean ± s.d. $*P < 0.05$

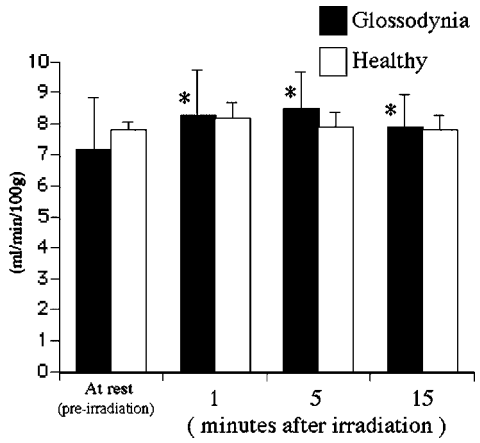

Figure 3 The blood flow of the tongue before and after SGR in glossodynia patients ($n = 37$) and healthy subjects ($n = 8$). The blood flow of the tongue was measured four times: at rest (preirradiation), and 1, 5, and 15 min after the completion of irradiation. In glossodynia patients, the blood flow significantly elevated at these three intervals compared with preirradiation. Data represent mean ± s.d. $*P < 0.05$

Discussion

Glossodynia has been treated with non-steroidal anti-inflammatory drugs, antiepileptic agents, Kampo medicines, and antidepressants, with reported response rates of 10.0% (Sardella *et al*, 1999), 70.0% (Grushka *et al*, 1998), 85.0% (Bessho *et al*, 1998), and 69.6% (Maina *et al*, 2002), respectively. One study has reported that SGB, widely used at pain clinics to control pain, is effective for the treatment of orofacial pain including glossodynia (Lynch and Elgeneidy, 1996). However, SGB has a risk of complications (toxic effects caused by drug injection into the vertebral artery, pneumothorax, and upper brachial plexus paralysis) (Cousins and Bridentbaugh, 1988), as well as anxiety associated with injection. These potential complications limit its usefulness for the treatment of glossodynia.

We used SGR instead of SGB to avoid potential complications. Pain decreased in 28 of the 37 patients (75.7%) with glossodynia. Several explanations have been advanced for the resolution of orofacial pain by SGB (Bell, 1969; Cousins and Bridentbaugh, 1988). Blockade of the stellate ganglion suppresses the sympathetic nervous system, causing dilatation of peripheral vessels in the face,

the region governed by this ganglion. Peripheral vasodilation improves blood flow to the site of pain caused by disturbed blood flow, thereby reducing pain.

Our study showed that tongue blood flow in patients with glossodynia is lower than that in healthy subjects. This finding is consistent with the results of Heckmann *et al* (2001). Our finding in which SGR increased tongue blood flow in patients with glossodynia suggests that the effectiveness of SGR for glossodynia may involve the following mechanism (whether SGR and SGB have similar effects remains unclear). SGR is thought to inhibit sympathetic outflow, producing vasodilation and increasing blood flow in the tongue. This increase in blood flow may alleviate pain. The rise in tongue temperature as confirmed by thermography is attributed to the increase in tongue blood flow. When SGR was performed in healthy subjects, there was no appreciable change in the temperature or blood flow of the tongue. Patients with chronic pain such as that associated with glossodynia have abnormally increased sympathetic activity (Sherman *et al*, 1987; Cousins and Bridentbaugh, 1988), suggesting that SGR is effective in the presence of increased sympathetic activity.

To our knowledge no previous study has examined SGB-induced changes in tongue blood flow. However, Kakuyama *et al* (2000) reported that SGB increased facial skin blood flow about 1.9-fold in patients with chronic facial pain. In our study, SGR increased tongue blood flow by only 18%, indicating that the increase in blood flow with SGR is far lower than that with SGB. This poorer effect probably results from the fact that SGR does not completely block the stellate ganglion, in contrast to SGB. In fact, during treatment no patient who received SGR had distinct signs or symptoms suggestive of Horner's syndrome, often associated with SGB. However, SGR improved pain in 75.7% of our patients with glossodynia. These findings indicate that SGR does not increase blood flow to the same extent as does SGB. Each session of SGR induces a mild, transient increase in tongue blood flow. With repeated treatment, tongue blood flow in patients with glossodynia gradually approaches a normal level, which may lead to the decrease in pain. Repeated or long-term use of SGR is considered safe, with virtually no risk of complications. These features make SGR a very useful treatment of glossodynia.

As psychic factors can play an important role in glossodynia, placebo-controlled studies should be done to compare response between SGR and pseudo-SGR. Long-term changes in tongue blood flow after SGR and the relation between tongue blood flow and symptoms should also be further evaluated.

Acknowledgements

We are grateful to Prof. Kazuo Maruyama of Department of Anesthesiology for his instruction in SGR technique.

References

Basker RM, Sturdee DW, Davenport JC (1978). Patient with burning mouths. *Br Dent J* **145:** 9–16.

Bell WH (1969). Nonsurgical management of the pain-dysfunction syndrome. *JADA* **79:** 161–170.

Bergdahl M, Bergdahl J (1999). Burning mouth syndrome: prevalences and associated factors. *J Oral Pathol Med* **28:** 350–354.

Bessho K, Okubo Y, Hori S, Murakami K, Iizuka T (1998). Effectiveness of kampo medicine (Sai-boku-to) in treatment of patients with glossodynia. *Oral Surg Oral Med Oral Pathol* **86:** 682–686.

Browning S, Hislop S, Scully C, Shirlow P (1987). The association between burning mouth syndrome and psychosocial disorders. *Oral Surg Oral Med Oral Pathol* **64:** 171–174.

Carlson CR, Miller CS, Reid KI (2000). Psychosocial profiles of patients with burning mouth syndrome. *J Orofac Pain* **14:** 59–64.

Cousins MJ, Bridentbaugh PO (1988). *Neural blockade*, 2nd edn. JB Lippincott: Philadelphia.

Forman R, Settle RG, Brightman V, Feldman R (1989). The prevalence by history of burning mouth symptoms among veterans. *J Dent Res* **68:** 278.

Grushka M (1987). Clinical features of burning mouth syndrome. *Oral Surg Oral Med Oral Pathol* **63:** 30–36.

Grushka M, Epstein J, Mott A (1998). An open-label, dose escalation pilot study of the effect of clonazepam in burning mouth syndrome. *Oral Surg Oral Med Oral Pathol* **86:** 557–561.

Hakeberg M, Berggren U, Hagglin C, Ahlqwist M (1997). Reported burning mouth symptoms among middle-aged and elderly women. *Eur J Oral Sci* **105:** 539–543.

Heckmann SM, Heckmann JG, Hilz MJ *et al*. (2001). Oral mucosal blood flow in patients with burning mouth syndrome. *Pain* **90:** 281–286.

Kakuyama M, Toda H, Osawa M, Fukuda K (2000). The bilateral effect of stellate ganglion block on the facial skin blood flow. *Regional Anesthesia and Pain Med* **125:** 389–392.

Lamb AB, Lamey PJ, Reeve PE (1988). Burning mouth syndrome: psychological aspects. *Br Dent J* **165:** 256–260.

Lamey PJ, Hammond A, Allam BF, McIntosh WB (1986). Vitamin status of patient with burning mouth syndrome and the response to replacement therapy. *Br Dent J* **160:** 81–84.

Lipton JA, Ship JA, Larach RD (1993). Estimated prevalence and distribution of reported orofacial pain in the United States. *J Am Dent Assoc* **124:** 115–121.

Lynch ME, Elgeneidy AK (1996). The role of sympathetic activity in neuropathic orofacial pain. *J Orofacial Pain* **10:** 297–305.

Maina G, Vitalucci A, Gandolfo S, Bogetto F (2002). Comparative efficacy of SSRIs and amisulpride in burning mouth syndrome. *J Clin Psychiatry* **63:** 38–43.

Sardella A, Uglietti D, Demarosi F, Lodi G, Bez C, Carrassi A (1999). Benzydamine hydrochloride oral rinses in management of burning mouth syndrome. *Oral Surg Oral Med Oral Pathol* **88:** 683–686.

Sherman RA, Barja RH, Bruno GM (1987). Thermographic correlates of chronic pain: analysis of 125 patients incorporating evaluation by a blind panel. *Arch Phys Med Rehabil* **68:** 273–279.

Ship JA, Grushka M, Lipton JA, Mott AE, Sessle BJ, Dionne RA (1995). Burning mouth syndrome: an update. *JADA* **126:** 842–853.

Woda A, Navez M, Picard P, Gremeau C, Picard EL (1998). A possible therapeutic solution for stomatodynia (burning mouth syndrome). *J Orofac Pain* **12:** 272–278.

Yoshizawa A, Minejima T, Seki M (1994). The effect of low reactive level laser therapy and linear polarized irradiation around the area of stellate ganglion. *J Physical Med* **5:** 13–18.