SENSITIVITY AND SPECIFICITY OF VISUAL ANALOG SCALE AND TOOTH VITALITY SCANNER IN EVALUATION OF LOWER LIP AND CHIN NUMBNESS COMPARED TO SCORING NEUROSENSORY TEST

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ABSTRACT
The aim of this study is to assess the sensitivity and specificity of visual analog scale (VAS) and tooth vitality scanner (TVS) in the evaluation of lower lip and chin numbness compared to scoring neurosensory test (SNST) and to compare the correlation between VAS, TVS, and SNST after simulating of inferior alveolar nerve (IAN) injury by inferior alveolar nerve block (IANB). Materials and methods: Fifty-seven patients who required unilateral tooth removal under local anesthesia using IANB as a simulation of IAN injury. VAS, SNST, and TVS were performed at the lower lip and chin in 4 intervals: pre-injection (baseline), 2-5 (mild numbness); 8-12 (moderate numbness); 15-18 (severe numbness) minute post-injection. Results: At the lower lip and chin during mild and severe numbness, VAS showed a low specificity but a high sensitivity. Whereas, TVS at both the lower lip and the chin during mild to moderate numbness showed a low sensitivity while moderate to high specificity at all interval. Conclusions: To monitor nerve injury and increase the test's sensitivity, TVS is a useful supplement to VAS. When combined with other methods to measure numbness in the lower lip and chin, the multiple testing approach improves the sensitivity and specificity of the assessment.
Keywords: Numbness, Inferior Alveolar Nerve Injury, Neurosensory Assessment

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INTRODUCTION

Inferior alveolar nerve (IAN) has the highest incidence of nerve injury as a result of various dental procedures, especially in the mandibular area. The reported incidence of IAN injury following mandibular third molar surgical removal was 0.26%-8.4% and could reach 40% (Kushnerev & Yates, 2015) following dental implant procedures. The symptoms caused by IAN injury can express in various alteration grades of the sensory function in both the lower lip and chin regions depending on the degree of nerve injury. (Kang, Sah et al., 2020) This sensory alteration or numbness may result in stress and anxiety along with compromised quality of life for the patients. Therefore, it is necessary to follow-up, not only evaluation of the neurological disturbance, but also psychological supportive care. (Meshram, Meshram et al., 2013) The evaluation of neurosensory disturbance could either be subjective or objective (Yam, Loh et al., 2018). Numerous studies used either subjective, objective, or both methods and reported contrasting results. The objective evaluations are done by direct recordings of the afferent nerve function which required the special and expensive instruments and should only be performed by a skilled examiner (Van der Cruyssen, Van Tieghem et al., 2020). Additionally, it is not commonly used in the lip and chin area. In the present, subjective test, such as questionnaire, VAS, TVS, or clinical neurosensory test (CNT), is more commonly used. A study showed that there was a significant correlation between sensation score from asking the patients and sensory action potential which is one of the objective neurosensory tests (Calabria, Sellek et al., 2013). Some studies classified and used CNT as an objective test and the result could be transformed into a numerical score for the ease of follow-up (Geha, Gleizal et al., 2006). Additionally, there was an evidence showed that CNT had corresponded with the degree of nerve injury (McDonald & Surgery, 1998) TVS was used in evaluating indirect tooth innervation of the IAN repositioning combined with static light touch and two-point discrimination test on lip and chin (Khajehahmadi, Rahpeyma et al., 2013). However, it is recommended that multiple subjective tests are performed to achieve a more accurate result and the nerve injury-associated sensory dysfunction should not be based only on threshold testing results without consideration of patients' subjective reports of altered sensation (Yamamoto, Fujii-Abe et al., 2017).

However, there are no studies that evaluated the accuracy of VAS and TVS compared to scoring neurosensory test (SNST), CNT with a numerical scoring system, as a reference test. And whether TVS should be introduced as a new method of evaluating neurosensory disturbance is a controversial issue. The aim of this study is to assess the sensitivity and specificity of VAS and TVS compared to SNST which was used as a reference test, and the correlation between them would be assessed in the current study.

RESEARCH METHODOLOGY

In this analytic cross-sectional study (observational study), participants were chosen from patients who have undergone tooth extraction or surgical removal under local anesthesia (LA) using an IANB at the Oral and Maxillofacial Surgery Clinic, Dental Hospital, Faculty of Dentistry, Prince of Songkla University from November 2021 to May 2023. This study used an IANB as a simulation of lower lip and chin numbness from IAN injury, to save the time for studying regarding to neurosensory tests. LA is one of the conventional steps needed in oral surgery. The present study used IANB as a simulation of IAN injury and does not require any extra treatment time and the treatment continues routinely. The research protocol was approved by the Research Ethics Committee (REC) at the Faculty of Dentistry, Prince of Songkla University, Songkhla, Thailand (EC6412-080). Sample size calculation was done according to the pilot study (Suchatpong & Vittayakittipong, 2021), the correlation between the VAS and SNST tested at the lower lip was 0.38. Given a type I error of 0.05 and a type II error of 0.2, the required sample size was deemed to be 52. And to compensate for 10% dropouts, the sample size was adjusted to 57 participants.

Participants aged 18-60 years with acceptable communication skill, required unilateral IANB for routine oral surgery with no pre-operative pain on the day of the operation, and the tooth to be tested with TVS is free from dental caries, cervical defects, and restorations. Participants with systemic diseases involving nerve disturbance, including diabetes mellitus, previous maxillofacial surgery, or trauma, along with cardiovascular devices, taking any medications that would alter pain perception, allergic to local anesthesia, pregnant, or showed no response at the maximum level of baseline TVS were excluded. Informed consent was obtained from all the participants prior to the study. The testing procedures were explained and demonstrated to each participant before each test.

Demographic data such as age, gender, and experience with IANB was collected from all participants. The assessments were performed in a room that is free of disturbing noises while the participant was lying on his or her back with eyes closed. Two vertical lines were drawn at the midline and from the corner of the mouth to the chin and another horizontal line across the labiomental fold, dividing the space into two including lower lip and chin areas. As shown in Figure 1.

Figure 1 Outline determining the areas to be tested

The tests were done 4 times by the same examiner at pre-injection (T0 = baseline), 2-5 (T1 = mild numbness); 8-12 (T2 = moderate numbness); 15-18 (T3 = severe numbness) minutes post-injection. Tests were done in the same order by the same examiner in all participants. The time recording started at the beginning of the injection by a single professional oral surgeon. The anesthesia technique used in all cases were IANB (Malamed, 2019) using 1.5 ml of 2% mepivacaine (epinephrine 1:100,000). Three tests, consisting of VAS, SNST, and TVS, were performed. The test began with VAS, followed by SNST, TVS, then a repeated VAS. As shown in Figure 2.

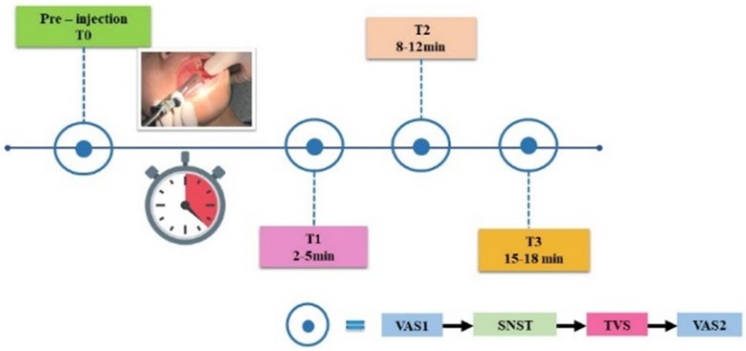

Figure 2 Timeline for evaluating numbness of the lower lip and chin

The Measurement Procedures

1) The VAS is a 100 mm uninterrupted horizontal line. Zero = normal sensation (no numbness) and 10 = abnormal sensation (total numbness). VAS is performed twice at the specified time interval, at the beginning and after TVS, and the average score. The score was graded into normal (0), mild (0.01-3.99), moderate (4-6.99), and severe (7-10).

2) The SNST is an evaluation tool composed of light touch sensation (LT), brush directional stroke (BDS), two-point discrimination (TPD), and sharp-blunt discrimination (SB); with total

scores of 3 each, possible scores will range from 0-12 where 0 = normal sensation and 12 = total numbness. Baseline measurements were done prior to anesthesia injection. The score was graded into normal (0), mild (1-4), moderate (5-8), and severe (9-12).

2.1) LT was done using a #0 paint brush (Figure 3A) to create 1 cm light strokes on 3 random skin regions. The participants were asked whether they felt the strokes. A correct answer = 0 point, a wrong or unclear answer = 1 point. The total score was 3 for each region.

2.2) BDS was performed using the same paint brush (Figure 3A) to create 2 cm light strokes on 3 random skin regions in different directions (up, down, left, and right). The participants were asked for the brush directions. A correct answer = 0 point, a wrong or unclear answer = 1 point. The total score was 3 for each region.

2.3) TPD was performed using a two-point discriminator (Figure 3B) fabricated from electric fuses with two separated wires. The two wires were placed simultaneously and perpendicular to the skin, starting from the of 16 mm and decreased by 2 mm each time until the minimum distance of 2 mm was reached, or the participants could no longer discriminate between the two points. The value recorded was the nearest distance where the participants could still tell the two points apart. The score for each duration was the difference between the minimum discriminated distance in the duration (T1, T2, or T3) and pre-injection distance (T0), as shown in Table 1. The total score was 3 for each region and the T0 score was determined to be 3.

Table 1 The difference between distances measured pre- and post-injection.

The difference between distances measured pre (T0) and post injection (T1, T2, T3)	**score**
No difference	0
2 mm	1
4 mm	2
6 mm or above	3

2.4) SB was performed using a no.5 explorer tip. The curved side of the explorer was used as the blunt tester as shown in Figure 3C. The explorer was applied onto the skin either with the sharp or blunt end randomly for 3 times and the participant were asked whether they felt it was sharp or a blunt. A correct answer = 0 point, a wrong or unclear answer = 1 point. The total score was 3 for each skin region.

3) Tooth vitality scanner testing (TVS) was done twice on mandibular first (#4) and second premolars (#5) of the injected side using the electric pulp stimulator (Vitality Scanner 2006; SybronEndo, Orange, CA) by the same SNST examiner (Figure 3D). Before the test, the participants were asked to hold a metal lip clip and released it as soon as they felt any sensation during the test to stop the electrical current. The number indicated on the screen was recorded. Negative results indicated no response at a maximum TVS level of 80 meaning total pulpal anesthesia. TVS grading (premolar), normal (0-50.9), mild (51-65.9), moderate (66-79.9), severe (80)

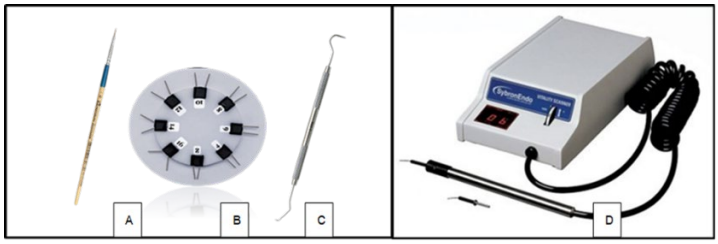

Figure 3 Instruments for nerve injury assessment, A: Light touch sensation and brush directional stroke using a number 0 paint brush, B: Two-point discriminator, C: Depth marked explorer used for sharp-blunt discrimination, D: Tooth vitality tester.

Statistical data analysis was performed using SPSS Statistics software (SPSS® 23.0, SPSS Inc.). The non-parametric test was used if the distribution of data was not normal. The validity of VAS, TVS compared with SNST were represented by sensitivity and specificity. Spearman's correlation coefficient was used between the VAS, SNST, and TVS at T1-T3. Statistically significant was set at $p < 0.05$.

RESEARCH RESULTS

A total of 57 healthy participants were included in this study. The participants' average age was 21.56 ± 2.42 years, with 16 men (28.1%) and 41 females (71.9%). The range of ages was 17-27. 44 students (77.2%) made up the majority of the participants, who were university undergraduates. Of them, 38 participants (66.7%) had graduated high school. Furthermore, 49 out of the individuals, or 86%, have had IANB.

The Sensitivity And Specificity Assessment

At the lower lip (L) and chin (C) during T1 and T3, VAS showed a low specificity (T1 [L/C] = 19/13, T3 [L/C] = 47/59) but a high sensitivity (T1 [L/C] = 84/73, T3 [L/C] = 84/70) as shown in Figure 4A and 4B.

TVS at both the lower lip and the chin during T1 showed a similar trend, with a low sensitivity (TVS#4 [L/C] = 20/15, TVS#5 [L/C] = 24/21) and a high specificity (TVS#4 [L/C] = 75/67, TVS#5 [L/C] = 75/71), and a moderate to high specificity (TVS#4 [L/C] = 53/56, TVS#5 [L/C] = 74/71) at T3 as shown in Figure 4C and 4D.

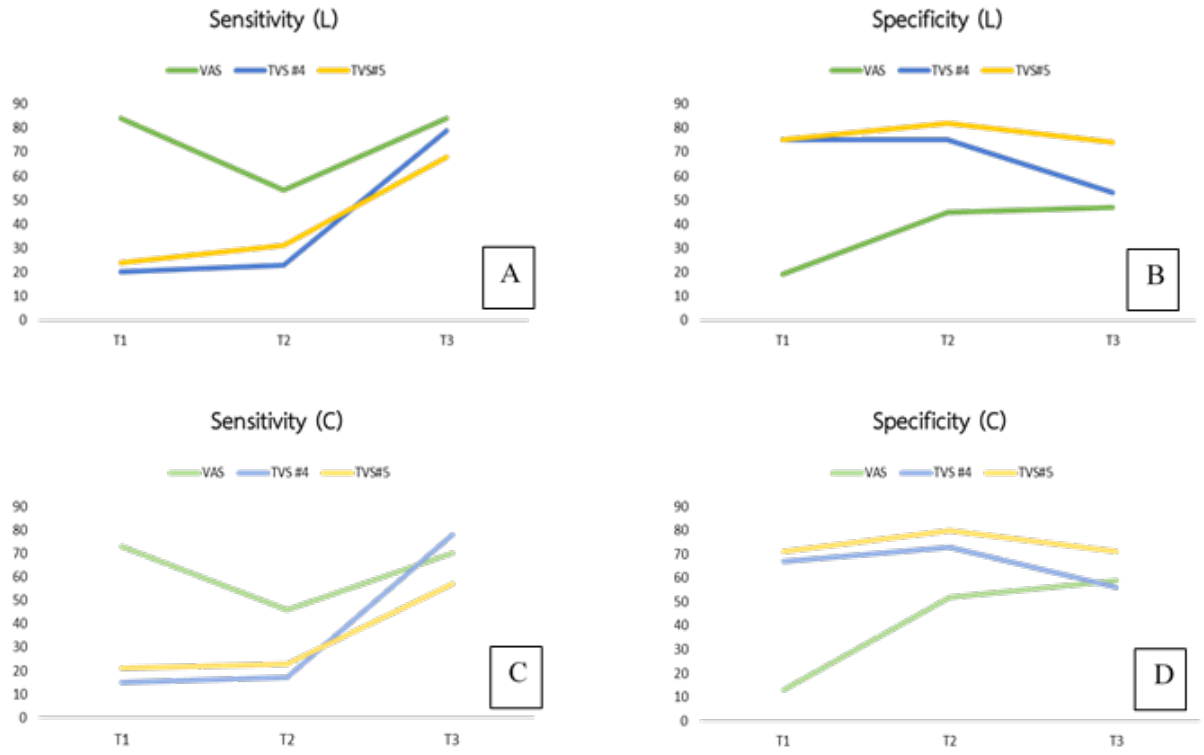

Figure 4 Sensitivity and specificity of VAS, TVS#4, and TVS#5 at lower lip and chin at all time intervals, A: sensitivity of lower lip, B: specificity of lower lip, C: sensitivity of chin, D: specificity of chin.

The Correlation Assessment

The median values of VAS, SNST, and TVS increased at lower lip and chin at all-time intervals (T1, T2, and T3). At T1, VAS only correlated with TVS at lower lip. However, all values were significantly correlated at T2 and T3 except for VAS and TVS#5 as shown in Figure 5A. At the chin, the only 2 uncorrelated values were SNST and TVS at T1 while T2 and T3, SNST was significantly correlated with the other 2 values. However, VAS and TVS were not significantly correlated at T3 as shown in Figure 5B.

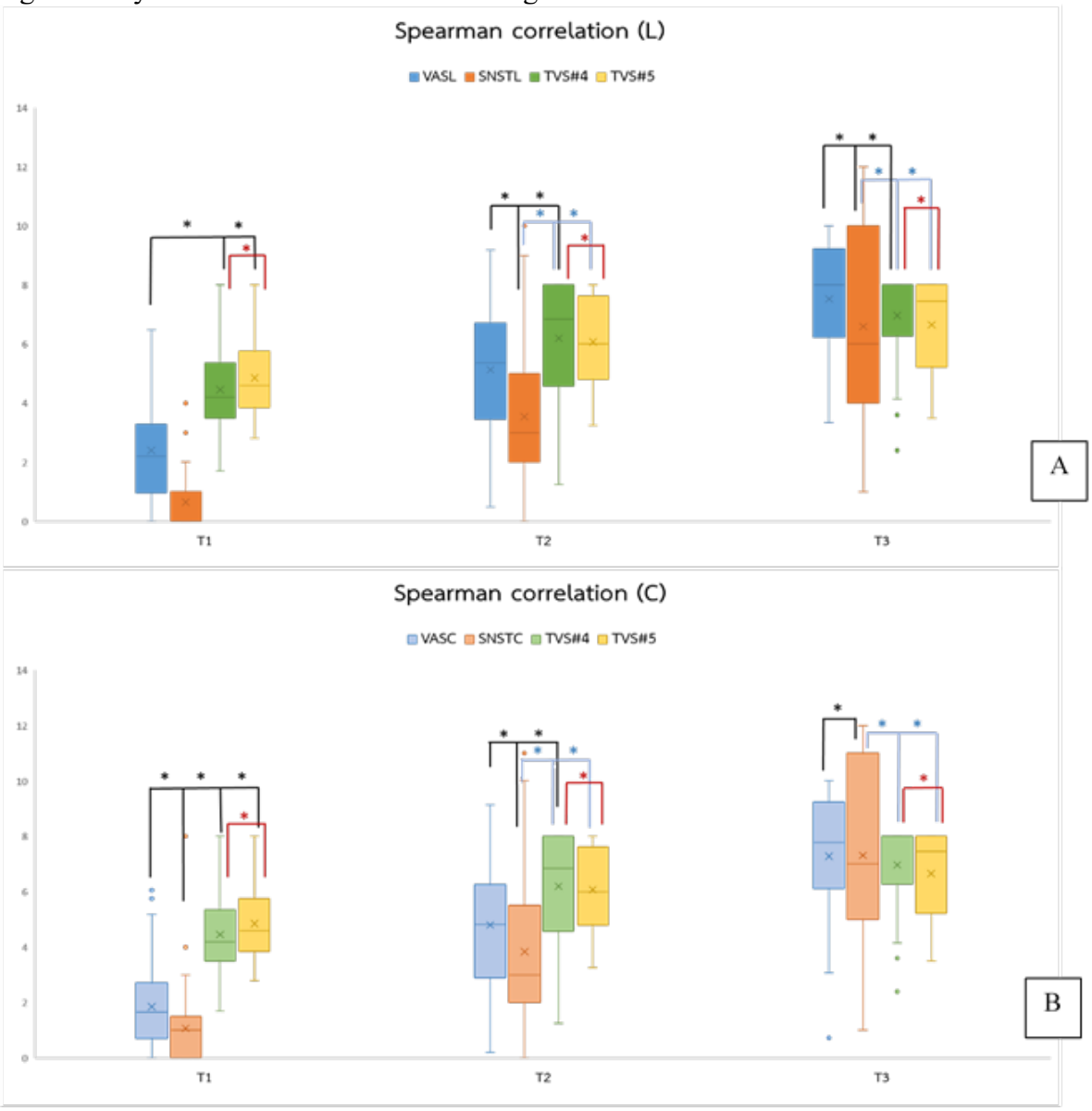

Figure 5 Spearman correlation of VAS, SNST, TVS#4, and TVS#5 at lower lip (A) and chin (B) during T1-T3 (* = significant correlation)

The Multiple Tests

When used with TVS#4 or TVS#5, VAS at both lower lip and chin significantly increased sensitivity to high level, but specificity stayed at low to moderate level throughout all time intervals. The sensitivity and specificity of multiple tests (parallel testing) were calculated from each test as shown in Figure 6.

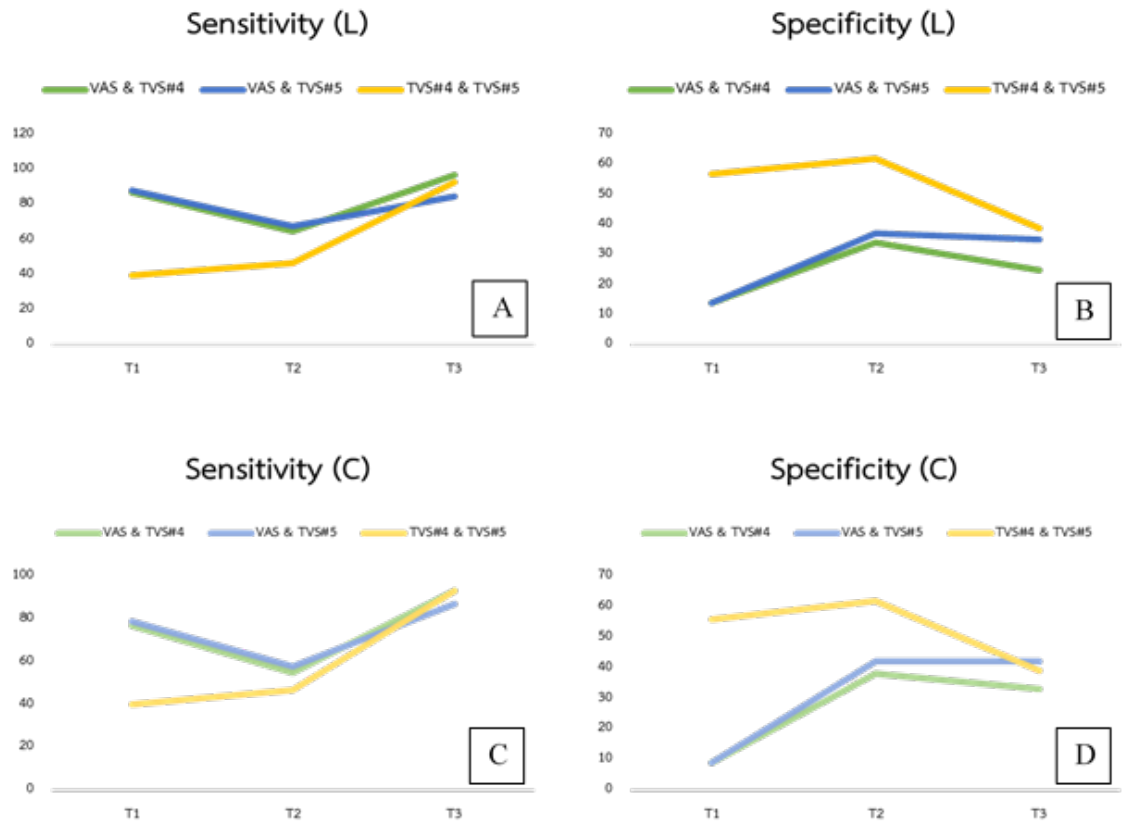

Figure 6 Sensitivity and specificity of paired parallel tests from VAS, TVS#4, and TVS#5 at lower lip and chin, A: sensitivity of lower lip, B: specificity of lower lip, C: sensitivity of chin, D: specificity of chin.

DISCUSSION & CONCLUSION

The majority of research on nerve damage was conducted on patients who had actual nerve damage. Very few of them used IANB as a simulation of nerve damage. Ku MS et al. in 2011 used IAN block as a simulation of IAN nerve impairment in 30 patients, and TVS tip was applied on the skin of the mandibular area including lower lip and chin to assess IAN impairment. Most patients were able to sense the electrical stimuli from TVS both at lower lip and chin. Following anesthesia, a considerable difference in TVS score was found at between lower lip and chin. According to the study's findings, TVS could be used to evaluate IAN impairment. (Ku, Kim et al., 2011) A study in 2021 (Suchatpong & Vittayakittipong, 2021) evaluated lower lip and chin numbness using IANB as a simulation of an IAN injury. There was a correlation found between the VAS and SNST for moderate to severe lower lip numbness. This study is regarded as one of the first to simulate a nerve damage using IANB and measure the validity of the method using neurosensory evaluations.

SNST was also utilized in this study as a reference test for validity assessment because prior research had demonstrated a substantial correlation between SNST and the extent of nerve injury. According to a study in 1998, CNT was shown to give a 77% accuracy in comparison to microsurgical finding, the gold standard, in the measurement of nerve impairment severity. (Zuniga, Meyer et al., 1998) Moreover, CNT was used as a reference test in many other studies. Van der Cruyssen F. et al. (2021) performed a systematic review of 8 studies comparing the diagnostic accuracy of magnetic resonance neurography (MRN) in post-traumatic trigeminal neuropathy (IAN and/or lingual nerve) by using CNT as a reference test. The result showed a moderate to good correlation between the MRN and NST findings. (Van der Cruyssen, Peeters et al., 2021) This study was the first to assess the sensitivity and specificity of VAS compared

to SNST as a reference test. This study has found that VAS give a high sensitivity at mild and severe numbness, moderate sensitivity at moderate numbness, and low specificity at all-time points. Therefore, VAS was considered more proper for used as a screening tool for the lower lip and chin numbness. VAS is appropriate for the initial evaluation of post-operative IAN injury due to its simplicity of use and lack of additional equipment requirements. Particularly for general practitioners who may not be acquainted with CNT. Whereas, TVS was more suitable as a confirmation test due to its moderate to high specificity at all period of numbness and low sensitivity at mild to moderate numbness. (McNamara & Martin, 2018) In addition, at moderate to severe numbness, it was discovered that the premolars' TVS and VAS had a mild to moderately significant correlation with SNST. Consequently, using a combination of these 3 tests could enhance validity and reliability of the lower lip and chin numbness evaluation.

This analytic cross-sectional study concluded that VAS had high sensitivity and low specificity for both mild and severe numbness, which is good for screening purposes. Whereas TVS had high specificity at severe numbness and low sensitivity at mild to moderate numbness. It is therefore more suited as a confirmation test, particularly at the second premolar. At moderate to severe numbness, it was discovered that the premolars' TVS and VAS had a slight to moderately significant correlation with SNST. To monitor nerve injury and increase the test's sensitivity, TVS is a useful supplement to VAS. When combined with other methods to measure numbness in the lower lip and chin, the multiple testing approach improves the sensitivity and specificity of the assessment.

REFERENCES

Calabria, F., Sellek, L., Gugole, F., Trevisol, L., Bertolasi, L., & D'Agostino, A. (2013). The use of sensory action potential to evaluate inferior alveolar nerve damage after orthognathic surgery. *Journal of Craniofacial Surgery, 24*(2), 514-517.

Geha, H. J., Gleizal, A. M., Nimeskern, N. J., & Beziat, J. L. (2006). Sensitivity of the inferior lip and chin following mandibular bilateral sagittal split osteotomy using Piezosurgery. *Plastic and reconstructive surgery, 118*(7), 1598-1607.

Kang, F., Sah, M. K., & Fei, G. (2020). Determining the risk relationship associated with inferior alveolar nerve injury following removal of mandibular third molar teeth: A systematic review. *Journal of stomatology, oral and maxillofacial surgery, 121*(1), 63-69.

Khajehahmadi, S., Rahpeyma, A., Bidar, M., & Jafarzadeh, H. (2013). Vitality of intact teeth anterior to the mental foramen after inferior alveolar nerve repositioning: nerve transpositioning versus nerve lateralization. *International journal of oral and maxillofacial surgery, 42*(9), 1073-1078.

Ku, M. S., Kim, J. W., Jeon, Y. H., Kwon, T. G., & Lee, S. H. (2011). Evaluation of the change of lower lip sensation after inferior alveolar nerve block by using the electric pulp tester. *Journal of the Korean Association of Oral and Maxillofacial Surgeons, 37*(6), 464-469.

Kushnerev, E., & Yates, J. M. (2015). Evidence-based outcomes following inferior alveolar and lingual nerve injury and repair: a systematic review. *Journal of Oral Rehabilitation, 42*(10), 786-802.

Malamed, S. F. (2019). *Handbook of local anesthesia-e-book*. Elsevier health sciences.

McDonald, A. R. (1998). The accuracy of clinical neurosensory testing for nerve injury diagnosis. *Journal of Oral and Maxillofacial Surgery, 1*(56), 8.

McNamara, L. A., & Martin, S. W. (2018). Principles of epidemiology and public health. *Principles and practice of pediatric infectious diseases*, Elsevier: 1-9. e1.

Meshram, V. S., Meshram, P. V., & Lambade, P. (2013). Assessment of nerve injuries after surgical removal of mandibular third molar: a prospective study. *Asian Journal of Neuroscience*, 2013.

Suchatpong, P. and P. Vittayakittipong (2021). *The evaluation of lower lip numbness: a comparison between visual analog scale and scoring neurosensory test, Faculty of Dentistry, Prince of Sonkla University*, 1-39.

Van der Cruyssen, F., Peeters, F., Croonenborghs, T. M., Fransen, J., Renton, T., Politis, C., ... & Jacobs, R. (2021). A systematic review on diagnostic test accuracy of magnetic resonance neurography versus clinical neurosensory assessment for post-traumatic trigeminal neuropathy in patients reporting neurosensory disturbance. *Dentomaxillofacial Radiology, 50*(1), 20200103.

Van der Cruyssen, F., Van Tieghem, L., Croonenborghs, T. M., Baad-Hansen, L., Svensson, P., Renton, T., ... & De Laat, A. (2020). Orofacial quantitative sensory testing: Current evidence and future perspectives. *European Journal of Pain, 24*(8), 1425-1439.

Yam, M. F., Loh, Y. C., Tan, C. S., Khadijah Adam, S., Abdul Manan, N., & Basir, R. (2018). General pathways of pain sensation and the major neurotransmitters involved in pain regulation. *International journal of molecular sciences, 19*(8), 2164.

Yamamoto, T., Fujii-Abe, K., Fukayama, H., & Kawahara, H. (2017). Hypoesthesia associated with mandibular movement after sagittal split ramus osteotomy. *Oral and Maxillofacial Surgery, 21*, 313-319.

Zuniga, J. R., Meyer, R. A., Gregg, J. M., Miloro, M., & Davis, L. F. (1998). The accuracy of clinical neurosensory testing for nerve injury diagnosis. *Journal of oral and maxillofacial surgery, 56*(1), 2-8.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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