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journal or publication title	東日本歯学雑誌
volume	23
number	2
page range	183-188
year	2004-12-31
URL	http://id.nii.ac.jp/1145/00008895/

[ORIGINAL]

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Abstract

The injection pressure and discomfort at the start of injection of a local anesthetic into the oral mucosa were quantitatively assessed and their relationship verified. The subjects were 28 healthy adult males, and 30G x1/2" disposable needles and an electric type syringe were used. Three seconds after the start of the local anesthetic injection, the injection pressure was measured and discomfort was assessed. A volume of 0.5 ml of local anesthetic solution was injected submucosally at injection speeds of 30 or 160 sec/ml. The injection pressure was measured continuously in real time, using an invasive sphygmomanometer and analytical software. Discomfort was assessed using a Visual Analogue Scale. A significant correlation was evident between the intensity of discomfort and injection pressure ($r_s=0.51542$, $p=0.00500$). According to the results of simple regression, there was a VAS–Discomfort score of 51 meaning that more than half of the VAS scores corresponded to the injection pressure of 348.1mmHg. It is therefore recommended that local anesthetic is injected at less than 348.1mmHg at the start of injection, to minimize discomfort for patients.

Key words : Discomfort, Local anesthetic injection, Injection pressure, Dental anesthesiology, Infiltration anesthesia

I. Introduction

Patients receiving dental infiltration anesthesia generally experience discomfort related to injections resulting from puncture of the oral mucosa and tissue or injection of anesthetic solution. When promoting safety in dental care, it is therefore important to establish a method of local anesthetic injection that is comfortable. Generally speaking, slowness and low injection pressure is the key to painlessness and a comfortable delivery¹⁾. However, the relation between patient discomfort and injection pressure is unclear.

The present study, quantitatively assessed injection pressure and discomfort at the start of injection of a local anesthetic into the oral mucosa, and determined the relationship between injection pressure and discomfort.

受付：平成16年9月27日

II. Subjects and Methods

1. Subjects

Subjects were 28 healthy adult males who were clinical trainees and interns at the School of Dentistry or Dental clinic of our university. The average age was 26.7 ± 3.6 (SD) years; state and trait anxiety inventory²⁾ [the Japanese version of the State-Trait Anxiety Inventory-From X(STAI) scores were 45.7 ± 9.5 (mean \pm SD); range, 29-70]. Written consent was obtained from all subjects after explaining the primary objectives of the study.

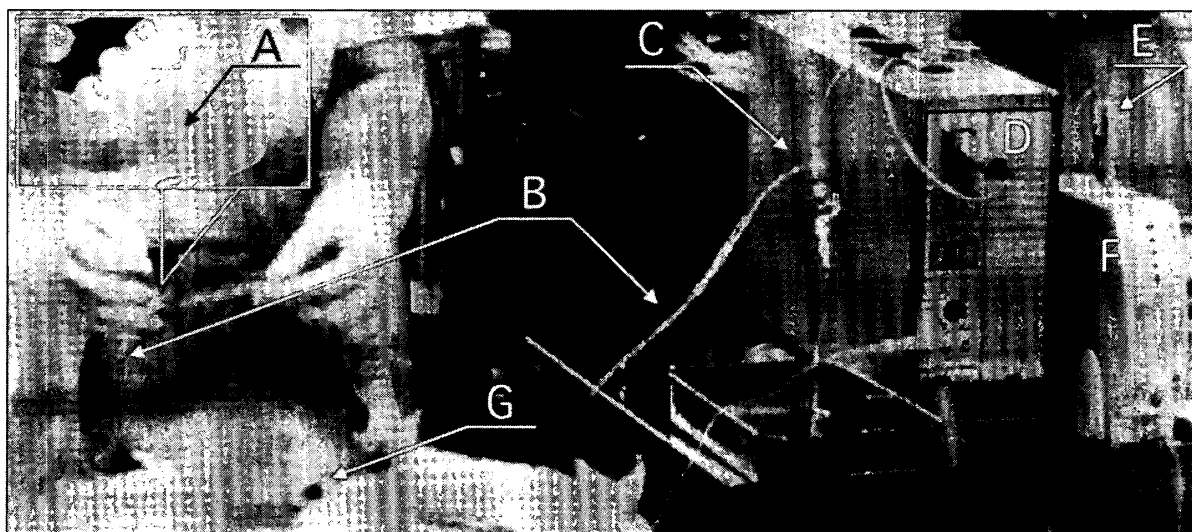


Fig.1 Measurement of injection pressure

- A : Puncture and injection of local anesthetic, the hand piece was held like a pen
- B : The pressure transducer and connection to tubes
- C : A pressure transducer (TP300T ; NIHON KOHDEN Co.,Ltd.)
- D : An invasive sphygmomanometer
- E : Local anesthetic cartridges ; 2% lidocaine hydrochloride solution with 1/80,000 epinephrine
- F : An electric-type syringe (The Wand™)
- G : Monitoring ; ECG, HR, BP, RR, BT, %SpO₂

2. Syringe needles, syringes and injections

The needles used were The Wand™ (manufactured by Misawa Medical Industry Co., Ltd.), a special disposable needle with the following specifications : 30G x1/2", outer diameter 0.30 mm, and length 12 mm.

The syringe was an electric-type syringe, The Wand™ (manufactured by Milestone Scientific Co., Ltd.). This device comprises a syringe body (specifically designed for local anesthetic cartridges), a syringe /needle hand piece, ultrafine tubing connecting the syringe body to the syringe/needle hand piece, and a foot pedal to control the injection. The injection speed of this device could be adjusted to two levels : fast (30sec/ml) and slow (160sec/ml)³⁾. The person operating the handpiece was not the same as the person performing the injection and foot pedal operation. Injection speed was randomly adjusted to slow or fast with handpiece operators and subjects not informed of the injection speed.

3. Local anesthetic solution

The local anesthetic was 2% lidocaine hydrochloride with 1/80,000 epinephrine (supplied in a dental

local anesthetic cartridge).

4. Syringe needle puncture site and injection of local anesthetic solution

The hand piece was held like a pen, resting on the right ring finger and pinkie. While stretching the movable labial gingival mucosa at the right lower canine position, the needle bevel was pointed away from the labial side to perform submucosal puncture. Using an injection speed of either about 30 or about 160 sec/ml, 0.5ml of local anesthetic solution was injected submucosally while visually checking enlargement of the wheal at the injection site.

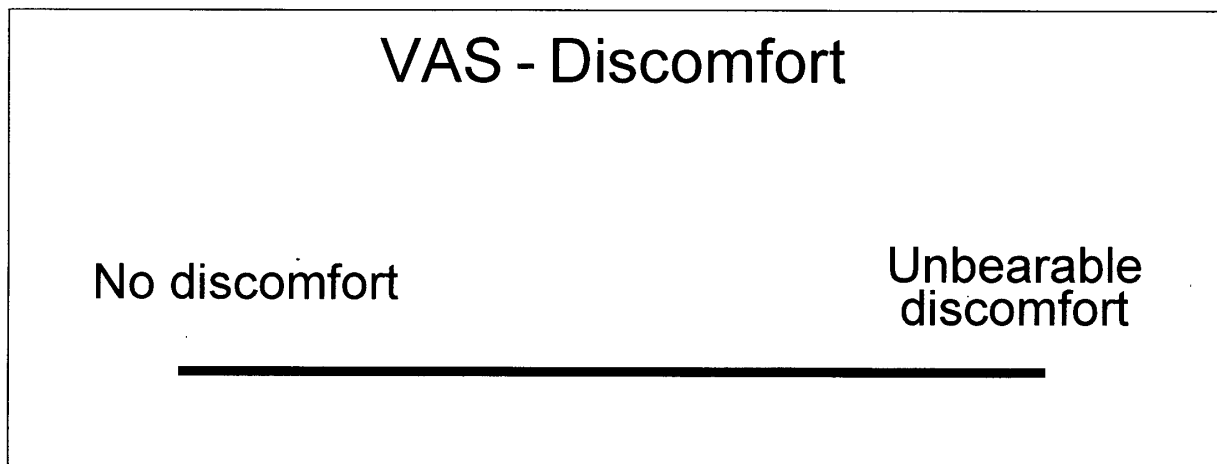


Fig.2 Visual Analogue Scale : VAS-Discomfort

Discomfort was assessed by VAS. In the current study, the standard VAS was used ; a horizontal line, 100mm in length (0~100 ; left to right), labeled with the phrase "No discomfort" at the left end and by the phrase "Unbearable discomfort" at the right end. The subject indicates the level of discomfort perceived by a mark on the linear scale, indicating a numerical score between 0 and 100

5. Measurement of injection pressure and assessment of discomfort

Three seconds after the start of the local anesthetic injection, the injection pressure was measured and discomfort was assessed.

1) Measurement of injection pressure

For the connectors of the pressure transducer and connection to tubes, the methods of Rood⁴⁾ and Pashley⁵⁾ were modified. A pressure transducer (TP300T ; NIHON KOHDEN Co., Ltd.) was connected between the hub of the needle and the syringe, and the injection pressure was measured continuously in real time from immediately before the puncture till removal of the needle, using an invasive sphygmomanometer (AP-641G ; NIHON KOHDEN, Co., Ltd.) and analytical software (GMview 2-CORE ; GMS Co., Ltd.). The sphygmomanometer had a maximum measurement limit of 2,000mmHg (Fig.1).

2) Quantitative analysis of the degree of discomfort

Discomfort was assessed using a Visual Analogue Scale (VAS). Operationally, a VAS is a horizontal line, 100mm in length⁶⁾, labeled with the phrase "no discomfort" at the left end and by the phrase "unbearable discomfort" at the right end. The subject marks the perceived level of discomfort on this linear scale, indicating a numerical score between 0 and 100 (Fig.2).

6. Results and statistical analysis

The statistical analysis was conducted with Excel (Microsoft, Redmond, Wash.) software. Spearman's rank correlation coefficients (rs) were calculated.

III. Results

A significant correlation was observed between intensity of discomfort and pressure at the start of injection ; $r_s = 0.51542$, $p=0.00500$ (two-sided test). Injection pressure ranged from 33 to 496 mmHg and the VAS-discomfort score ranged from 0 to 78 (Fig.3).

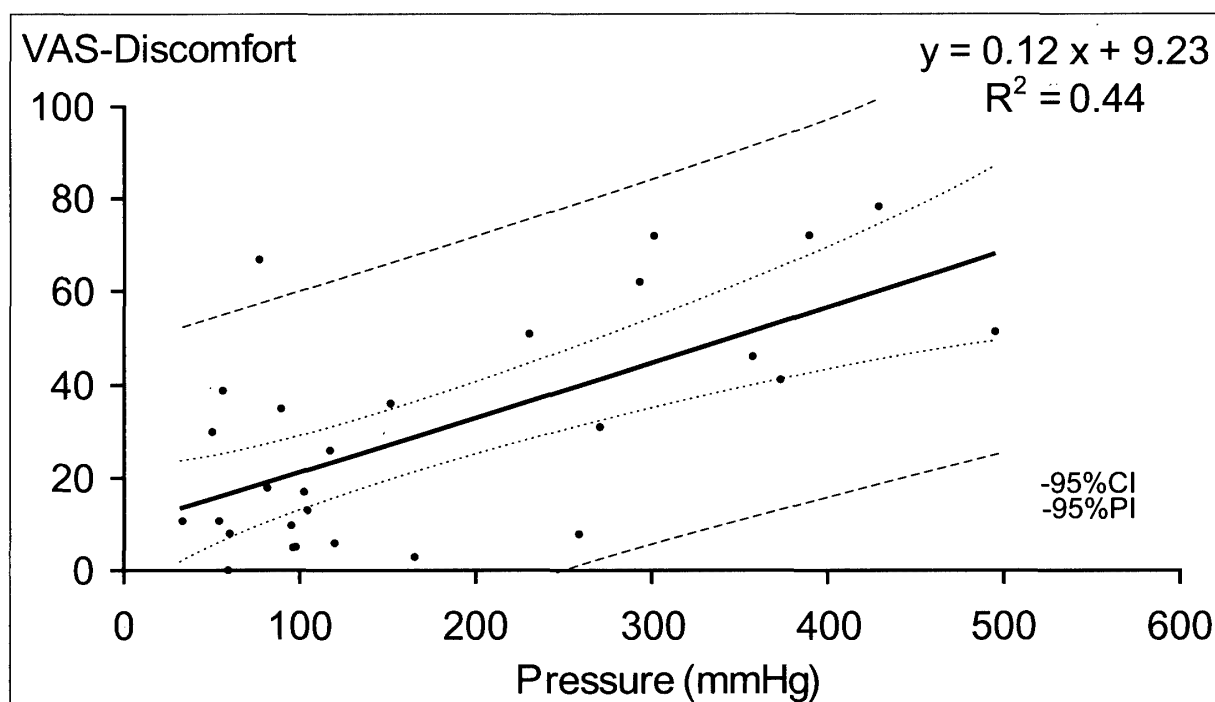


Fig.3 The relationship between VAS-discomfort score and local anesthetic injection pressure at the start of injection. The regression line is plotted (bold line). Injection pressure was a significant predictor of increased discomfort.

IV. Discussion

There are reports of the correlation between pain and injection speed of local anesthetic to the interdental papillary gingiva in systemically anesthetized rats⁷⁾, and humans⁸⁾. However, there are no other reports on the measurement of injection pressure to support the finding that injection pressure is related to discomfort.

The present study established a positive correlation between pressure at the start of injection and intensity of discomfort at this time. It can therefore be recommended that local anesthetic be injected under low pressures to minimize discomfort in patients.

The score of 51 by the "VAS-Discomfort" as a visual analogue scale means that the score was above half on the VAS scores scale, and it is important to keep the VAS-Discomfort score under 51 at

the time of injection. According to the results of simple regression, the VAS—Discomfort score of 51 corresponds to an injection pressure of 348.1 mmHg. Therefore, to minimize discomfort, it is important for dentists to inject by pressures of less than 348 mmHg at the start of local anesthetic injections. To observe the impact of injection pressure at the time of injection on discomfort, there was no surface coating of anesthetic gel or use of nitrous oxide inhalation sedation prior to the needle insertion. As a result, almost all subjects (one of 28 subjects) complained of discomfort at the mucosal puncture and on injection of anesthetic.

Considering factors affecting injection pressure in dental local anesthetic injections, fine nerve fibers exhibit higher resistance to pressure and ischemia than thick nerve fibers⁹⁾. Birchfield et al. reported that the intrapulpal anesthetic method for the dental pulp utilizes both the action of the local anesthetic and the effect of pressure¹⁰⁾. However, a search of the literature found no other reports on real-time measurements of injection pressure at the start of injection that recorded discomfort in the same experimental system using volunteers as subjects. The injection pressure of local anesthetics was determined to be influenced by the following factors: volume injected into the tissue per unit time; permeability of the injected solution into bone, soft tissue, and blood vessels; and the effects of tissue pressure and stretching of the movable mucosa due to the volume of injected solution⁵⁾.

Most accidents occurring in the field of dentistry are induced by injection of local anesthetic. A dentist has to strive for comfort in injections, for the safety of dental patients. According to a previous study of the relationships between injection and patient psychological characteristics in terms of anxiety, patients with high trait anxiety tend to have low pain thresholds¹¹⁾, and were found to suffer extreme discomfort on seeing a large pistol-type metallic syringe¹²⁾, dental injection needles generally have an external diameter of over 0.28 mm and a length of over 16 mm¹³⁾. In order to maximize the likelihood of a comfortable infiltration anesthetic procedure, it is necessary to apply surface anesthesia or 30% nitrous oxide/70% oxygen inhalation sedation¹⁴⁾.

V. Conclusion

A dental local anesthetic solution was injected under the movable mucosa in volunteers. A positive statistical correlation was evident between injection pressure at the start of injection and intensity of discomfort. Accordingly, the discomfort level at the start of injection was also found to be directly related to injection pressure. It is therefore considered important to establish a method that does not cause discomfort at local anesthetic injections involving less than 348.1 mmHg injection pressure under the movable mucosa.

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