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The Efficacy of Distraction and Counterstimulation in the Reduction of Pain Reaction to Intraoral Injection by Pediatric Patients

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Aim: The aim of this clinical investigation was to determine the efficacy of distraction and counterstimulation in the reduction of pain during the administration of local anesthetics in pediatric dental patients.

Methods and Materials: A total of 78 healthy children (male: 40, female: 38) ages four to five years (mean age: 4.72 years old) without any history of previous intraoral injection were included in the present study. The subjects had at least one carious primary molar. The subjects were randomly allocated into three groups. Group SA received topical anesthesia followed by an inferior alveolar nerve block (simple anesthesia). Group C+SA received counter stimulation using intraoral and extraoral finger vibration in addition to the Group SA protocol. Group CD+SA incorporated verbal distraction in addition to topical and local anesthesia and counterstimulation. A sound, eye, and motor (SEM) scale was used for quantification of pain reaction. Data were analyzed using an analysis of variance (ANOVA).

Results: The SEM values for Groups SA, C+SA, and CD+SA was 8.25, 5.07, and 3.41, respectively. According to the SEM scale a severe pain reaction was observed in Group SA but not in the other groups. The pain reaction for Group SA was significantly higher than the two other groups ($P<0.05$). Moreover, the subjects in Group CD+SA exhibited significantly less pain compared to those in Group C+SA.

Conclusion: Both distraction and counterstimulation are effective in reducing pain reaction in a clinical setting. However, it may be more plausible to use both techniques simultaneously to achieve more favorable results with reference to a reduced pain reaction in pediatric dental patients.

Keywords: Inferior alveolar nerve block, distraction, counterstimulation, SEM scale

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Introduction

Pain is defined as "an unpleasant sensory and emotional experience arising from actual or potential tissue damage or described in terms of such damage."[1] Clinical pain is characterized by the presence of discomfort and abnormal sensitivity in the general context of patient symptomatology. Administration of local anesthetic via an intraoral injection is associated with acute pain symptoms as a result of the soft tissue injury caused by the needle stick. Several methods have been proposed for reduction of injection pain because of the importance of pain control in pediatric behavior management.

Intraoral injection is associated with acute pain symptoms.

Warming and buffering the local anesthetic solution may contribute to reducing the injection pain.[2-8] The use of small diameter needles, slow insertion of the needle, gentle traction of mucosa at the insertion site, and slowly injecting the anesthetic solution can minimize the pain of anesthetic administration. Longer-acting anesthetics can reduce the pain and discomfort indirectly by minimizing the required number of repeated needle sticks. Injecting through a previously anesthetized area is helpful.[2,9-11] Iontophoresis has been reported to be helpful in the administration of local anesthesia, but this technique requires special instrumentation and training.[12] Hypnosis can reduce the anxiety and pain inherent in dental procedures, but its use also requires special training.[13] Tactile stimulation (e.g., stroking the mucosa adjacent to an injection site) is often somewhat helpful. Moreover, counterstimulation, which is a gentle vibration or stroking of the mucosa, and the use of topical anesthesia have been shown to be effective in reduction of injection pain.[14]

Distraction is a tactic designed to divert a patient's attention away from their current behavior to focus their interest in something else. The effectiveness of distraction and counterstimulation as adjunctive methods for injection pain relief has not been scientifically determined. There are only empirical and anecdotal comments regarding the effectiveness of these methods in reducing pain associated with intraoral anesthetic injections in a contemporary pediatric dental practice setting.

The aim of the present study is to clinically investigate the efficacy of distraction and counterstimulation in reducing anesthetic injection pain in pediatric dental patients based on the hypothesis counterstimulation may counteract the local sensory element of pain and distraction may reduce the central nervous system component of pain perception.

Methods and Materials

Study Population

A total of 78 children ages four to five years (mean age: 4.72 years old) were included in the present randomized clinical trial. The subjects presented to the Department of Pedodontics of the Tabriz School of Dental Sciences for the treatment of carious primary teeth. The selected subjects were in complete physical and mental health without any confounding medical history. Moreover, all patients were cooperative and categorized as Frankel's Class III or IV. The following criteria were considered for inclusion in the study:

- Existence of carious primary mandibular molars necessitating an inferior alveolar nerve block
- No previous experience with intraoral injections
- No allergy to lidocaine
- No history of pain secondary to pulpitits favoring a biased context due to special pain syndromes such as hyperalgesia or allodynia
- No confounding disorders, especially bleeding diathesis
- No history of unpleasant experiences in medical settings

The study procedure as well as probable risks and discomforts were explained to the parents or legal guardians of the patients. The study procedure was approved by research and ethics committees of the Tabriz University of Medical Sciences.

Study Procedure

During the first therapeutic session fluoride therapy was performed for the subjects, and only cooperative children (Frankel's Class III or IV) were included in the study procedure. The 78 subjects were then randomly allocated into three experimental groups (n=26). The patients were coded and a blinded researcher was asked to allocate them into three equal groups by randomized selection of the numbers. After application of topical anesthetic agent (Benzocaine®, Dentsply,York, UK) on dried mucosa for 1 minute using a cotton applicator, a standard inferior alveolar nerve block (simple anesthesia) was administered to subjects in the first group (Group SA). The injection technique involved aspiration followed by a gradual injection of 1 ml of 2% Lidocaine with 1/100000 epinephrine (2% Xylocaine®, Dentsply,York, UK) over 1 minute using a 32 mm (short) 27 gauge needle (Accuject®, Dentsply, York, UK). Prior to injection, the temperature of all needles and anesthetic solution was equalized through their placement in an autoclave with an internal temperature of 40˚C. This was necessary to offset any biased discomfort due to temperature discrepancy which could compromise the reliability of findings.

For the second group (Group C+SA), in addition to the aforementioned protocol, counterstimulation (C) of the injection region was added. The counterstimulation method involved the use of the thumb for vibration of soft tissue adjacent to the intraoral injection site with a slight pressure and the vibration of an equivalent extraoral site using the forefinger. The range of vibration movement was approximately 1 mm (short back and forth/up and down movements) and the frequency of vibration was 1 cycle/sec.

The injection protocol for the third group (Group CD+SA) was similar to group Group C+SA but a distraction exercise was added for this group. These subjects were asked to raise their right and left legs in turn in a monologous voice by the clinician. All injections were performed by the same pediatric dentist.

Assessment Method

A second pediatric dentist assessed the children's pain reaction during the injection procedure using the sound, eye, and motor (SEM) scale. The assessment criteria of SEM scale are based on three types of data, namely child sounds, eye signs, and body movements. On a random basis, a third experimenter performed the SEM evaluation along with the second experimenter to an assessment of inter-examiner reliability of the SEM data. The classification system of SEM scale is presented in Table 1.

Statistical Analysis

All quantitative data are presented as mean ± standard deviation. The statistical analysis of data was performed based on the analysis of variance (ANOVA). Post-hoc analysis of data was performed based on the Scheffe's test. Intra-

Table 1. SEM scale for the assessment of pain or comfort.

Parameter	Comfort	Mild Discomfort	Moderate Discomfort	Painful
	Grade 1	Grade 2	Grade 3	Grade 4
Sound	None	Non-specific sound (probable pain)	Verbal complaint, louder sound	Verbal complaint, shouting, crying
Eye	No sign	Dilated eye without tears (anxiety sign)	Tears, sudden eye movements	Crying, tears covering the face
Motor	Relaxed body and hand status	Muscular contraction and contraction of hands	Sudden body and hand movements	Hand movements for defense, turning the head to the opposite side

Table 2. SEM values for the experimental groups.

Group	Sound	Eye	Motor	Sum
SA (n=26)	2.75	2.67	2.83	8.25
C+SA (n=26)	1.67	1.67	1.73	5.07
CD+SA (n=26)	1.26	1.03	1.12	3.41

examiner agreement of data was evaluated using Kappa statistics. In the present study p<0.05 was considered to indicate statistical significance.

Results

The study population consisted of 78 children (male: 40, female: 38) ages four to five years (mean age: 4.72 years old). No adverse event was observed during the course of the study.

Intra-examiner Agreement of Data

The intra-examiner agreement of data for SEM scale was excellent (r=0.87).

Univariate Analysis of SEM

The results using the SEM scale are presented in Table 2.

A painful reaction according to the SEM scale (grade 4) for all three modules as demonstrated by Group SA. Only one case in Group C+SA demonstrated a grade 4 (painful) on the SEM scale for the motor module. No severe pain reaction was observed in Group CD+SA. Five cases in Group SA demonstrated a grade 4 reaction in the motor module (defensive hand movements, turning the head to the opposite side) which is of clinical importance. Such dramatic reactions like a head turn or hand movements for preventing the injection may lead to traumatic injuries of oral soft tissue or events such as breaking of the needle.

There were no significant differences (p>0.05) between the SEM module values within each group (SA, C+SA, and CD+SA).

Multivariate Analysis of SEM

The between-group difference between Group SA and and Group C+SA was statistically significant (P<0.05). All three modules of SEM in Group C+SA were consistently lower than Group SA. Moreover, the SEM value for Group CD+SA surpassed Group SA (P<0.05). The results of post-hoc between-group differences demonstrated the pain reaction in Group C+SA was significantly more than Group CD+SA ($P<0.05$), highlighting the important role of distraction.

Discussion

The aim of the present study is to clinically investigate the efficacy of distraction and counterstimulation in reducing anesthetic injection pain in pediatric dental patients based on the hypothesis counterstimulation may counteract the local sensory element of pain and distraction may reduce the central nervous system component of pain perception.

Distraction and counterstimulation are more effective when used together.

The results demonstrated both distraction and counterstimulation are effective in decreasing the pain reaction. However, simultaneous implementation of both techniques is substantially more effective.

The nociceptors (pain receptors) end in the dorsal horn of the spinal cord. The thinly myelinated A-fibers end in Lamina I and V and the unmyelinated C-fibers in Lamina II. These sensory fibers activate a large number of second order interneurons and project neurons in the spinal cord. The nociceptive signals, after complex processing in the dorsal horn, are transferred to the thalamus and subsequently to the cortex where they are interpreted as pain occurs.[14] Parallel outputs from the dorsal horn go to the ventral horn and activate flexor motor neurons generating the withdrawal flexor reflex. Therefore, the sensation of pain and flexion withdrawal reflex occur together.[15]

According to the gate control theory of pain hypothesized decades ago by Melzack and Wall A-β nerve fibers transmit information from vibration receptors (Pacinian corpuscles and Meissner corpuscles) and touch receptors in the skin. They stimulate inhibitory interneurons in the spinal cord that in turn act to reduce the amount of pain signal transmitted by A-δ and C fibers from the skin to second-order neurons that cross the midline of the spinal cord and then ascend to the brain.[16,17] An epitome is the immediate stroking of a site of trauma to relieve the pain. Thus, counterstimulation, akin to stroking or pinching the skin, can alleviate pain sensation.[18] Vibration may, in some cases, also have a placebo effect that is additive to the neurophysiological effect to reduce pain transmission from the peripheral pain receptors to the brain.

Three sources of pain are involved in painful reaction during a dental injection. The immediate sharp pain reaction occurs during the needle stick. During deep penetration of the needle inherent damage to internal anatomical structures causes a second surge of pain. The third pain stimulus is associated with the outflow of anesthetic solution and distention of local soft tissues.

In the present study the distraction method acted to divert the attention of the patients. This method is most helpful in diverting the focus of attention of the patient and minimizing the pain from the needle stick. Moreover, the application of this method via voice control suppressed any unfavorable behavior during the primary stages of development.

Counterstimulation involved both the intraoral and corresponding extraoral injection site. The vibration of the intraoral injection site decreased the pain response from all three sources according to the gate control theory. However, some accessory functions are probable. Vibrational movement of the thumb facilitated the dissemination of the anesthetic solution throughout the injection site preventing localized distention of the soft tissue. The extraoral stimulation acted to close the pain gates through spinal cord interneurons and served as an accessory distraction method to divert the attention of the patient.

The present study demonstrated severe motor pain reaction was a probable finding in simple local anesthesia. However, the application of distraction and counterstimulation substantially reduced these motor reflexes. One explanation may be the suppression of pain signals through a neural gate control mechanism as well as the function of inhibitory interneurons leading to a decreased dissemination of dorsal horn signals toward the ventral horn.

While the application of counterstimulation was effective in the reduction of pain reaction, the addition of the distraction technique substantially improved the final outcome. The implication is counterstimulation alone is less effective in the prevention of a needle stick pain reaction. Simultaneous implementation of distraction methods for offsetting these primary stage signals (needle stick pain signals) is essential.

Future studies may be directed toward the use of mechanical vibration devices for counterstimulation. Moreover, the additional delivery of electrical signals to aid in suppression of pain gates has some interesting possibilities.

Conclusion

Simple administration of standard local anesthesia for pediatric dental patients is not plausible due to exaggerated pain response. Both distraction and counterstimulation are effective in reducing pain reaction in a clinical setting. However, it may be more plausible to use both techniques simultaneously to achieve more favorable results with reference to reduced pain reaction in pediatric dental patients.

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