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ORIGINAL RESEARCH

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Clinical anesthetic effect of intraseptal injection combined with periodontal ligament injection in treatment of deep caries in mandibular deciduous molars

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Abstract

Background: There was no comfortable and effective local anesthesia for treating deep caries in mandibular deciduous molars. **Methods**: This study had two parts: pre-experiment and main-experiment. In pre-experiment, 40 children with deep caries in mandibular deciduous molars randomly received local anesthesia by PL injection (PL group) or IS injection (IS group) before the treatment. In main-experiment, another 60 children received local anesthesia by PL injection (PL2 group) or IS combined with PL injection (IS + PL group). In both the pre-experiment and main-experiment, children separately gave the scores of injection and treatment pain through Wong-Baker FACE® Pain Rating Scale (WB). **Results**: The injection pain in PL and IS groups were 5.10 $\pm$ 2.29 and 2.30 $\pm$ 0.73 ($p < 0.001$). The anesthesia success rates for PL and IS groups were 90% and 60% ($p < 0.01$). The injection pain in PL2 and IS + PL groups were 5.67 $\pm$ 2.11 and 2.73 $\pm$ 0.98 ($p < 0.001$). The anesthetic success rates for PL2 and IS + PL groups were 83.3% and 86.7% ($p > 0.05$). The treatment pain in PL2 and IS + PL groups were 1.68 $\pm$ 1.49 and 1.85 $\pm$ 1.48 ($p > 0.05$). **Conclusions**: The anesthetic effect of IS combined with PL injection, and PL injection alone were similar, however IS combined with PL injection had lower pain sensation during the anesthesia, which might be conducive in the oral treatment of children. **Clinical Trial Registration**: The registration number of the UK's Clinical Study Registry is ISRCTN30082181.

Keywords

Intraseptal injection; Periodontal ligament injection; Anesthesia; Pain; Deciduous molars

1. Introduction

Pain is the primary concern to cause tension, discomfort, and long-term dental fear in children [1]. Children with such negative psychological state have avoidance behavior towards the processes of diagnosis and treatment by the pediatric dentists [2]. It is thus vital to control pain and minimize the discomfort during this process. The most effective method in clinical practice is local anesthesia. Presently, PL injection using single tooth anesthesia (STA) is the most common in oral treatment [3]. STA painless anesthesia apparatus provides real-time pressure information *via* computer to identify the location of ligament tissue for delivering enough anesthetic volume on the right target under less pressure [4]. Its transmission speed is slow and lower than the pain threshold of patients. It is thus a painless injection with minimal tissue damage [4]. However, many children indicate pain even with injection into mandibular deciduous molars using STA. Besides, the PL injection needs to be injected on buccal and lingual sides of affected mandibular deciduous molars because of the high bone density of mandibular. PL injection also results in PL swelling and pain after the treatment. Moreover, the PL injection causes periodontal tissue injury which may lead to postoperative pain lasting for 4 weeks [5]. Studies report that IS injection is simple and convenient [6]. This study compares the comfort and anesthetic effect of IS and PL injections in mandibular deciduous molars to explore a conducive local anesthesia in pediatric dentistry.

2. Materials and methods

2.1 Study objects

Forty and sixty cases of deep caries in mandibular deciduous molars of 4–6 years' age were recruited from January 2022 to January 2023. Cases were divided into two parts based on the inclusion criteria: pre-experiment (40 cases) and main-experiment (60 cases). Cases from the two parts were dealt in sequential order without crossing each other.

2.2 Inclusion criteria

Parents agreed for the experiments; children aged 4–6 years; communication ability with pediatric dentist or nurse; taken food in 2 hours before treatment; mandibular deciduous molars completely erupted; deep caries; no obvious spontaneous, night or occlusal pain or periapical periodontitis symptom; X-ray showed low density shadow close to the pulp and no obvious low density shadow at root tip.

2.3 Exclusion criteria

Parents refused the experiment; children unable to cooperate; no eating in 2 hours before treatment; temporary or long-term systemic disease; allergic to anesthetics; oral mucosal diseases; wearing orthodontic appliances; mandibular deciduous molar did not completely erupt; no deep caries; obvious spontaneous, night or occlusal pain or periapical periodontitis symptom; X-ray showed low density shadow at root tip or had root canal therapy.

2.4 Study procedure

(1) Children were diagnosed with deep caries by inquiry, clinical examination, and X-ray; (2) The study was divided into two parts: pre-experiment and main-experiment. Pre-experiment was followed by the main-experiment. Pre-experiment: PL (periodontal ligament) injection group and IS (intraseptal) injection group; main-experiment: PL2 group and IS + PL (intraseptal injection combined with periodontal ligament injection) group; (3) Local anesthesia were given separately as per the study procedure; (4) Routine treatment; (5) Children with unbearable pain during the treatment were given supplemental PL injection. Such cases were the failures and excluded from the experiment.

Children receiving different local anesthesia were randomly determined by the sealed opaque envelopes. All anesthesia and treatments were made by the same pediatric dentist. Study procedure is showed in Fig. 1.

2.5 Anesthesia procedure

(1) The topical anesthetic was applied via topical anesthetic gel to the mucosa of planned injection point for 2 min (Compound Lidocaine Cream, 5%, 230205, Tongfang Pharmaceutical Group Co., LTD, Beijing, China); (2) Groups were administered with atecaine adrenaline injection (Articaine Hydrochloride and Epinephrine Tartrate Injection, 1.7 mL/branch, 20001673, Merignac, France) using STA painless anesthesia equipment (STA-5220, Milestone Scientific Inc, Beijing, China); (3) In PL and PL2 groups, the needle was injected in periodontal ligament of central buccal and lingual side (Fig. 2A,B); In IS group, the needle was injected to 2 mm below the tip of mesial or distal interdental papilla until the contact with bone (Fig. 2C); In IS + PL group, the needle was injected to 2 mm below the tip of mesial or distal interdental papilla until the contact with bone. The needle was then injected into periodontal ligament of central lingual side (Fig. 2B,C); (4) The total injection amount was 1.7 mL; (5) The injection and follow-up treatment to all the children were given by same pediatric dentist (Jin Sun); (6) Therapeutic procedure was conducted after 1 min of anesthesia.

2.6 Evaluation methods

Pain was scored by asking the children to select facial expression for representing his/her feeling of discomfort according to Wong-Baker FACE® Pain Rating Scale (Fig. 3) [7, 8]; (1) Pain score at injection: children selected the facial expression immediately after anesthesia; (2) Pain score during treatment: children selected the facial expression immediately after the treatment.

2.7 Sample size

According to the pre-experiment, a sample size of 15 for each group had 90% power to detect a difference. The standard deviation was 2.29 with 5% two-sided significance level. A sample size of 30 was set for each group in the main-experiment to compensate the failure of anesthesia.

2.8 Statistical analysis

WPS office (12.1.0.15398, WPS, Beijing, China) was used for the statistical analysis. The data were expressed as mean ± standard deviation (SD) or n. Unpaired two-tailed Student's *t*-test was employed for comparing the two groups (age, injection pain, success rate of anesthesia and treatment pain). Chi-test evaluated whether there was a relationship between qualitative variables (sex). There was statistically significant difference with $p < 0.05$.

3. Results

3.1 Basic data of research objects

There was no significant difference in the age and sex of two groups in the experiments ($p > 0.05$) (Tables 1 and 2).

TABLE 1. Comparison of basic information in pre-experiment.

	PL Group	IS Group	*p*
Age (yr)	5.05 ± 0.99	5.10 ± 0.91	0.87
Sex (number)			
Male	9	8	0.32
Female	11	12	

PL: periodontal ligament; IS: intraseptal.

TABLE 2. Comparison of basic information in main-experiment.

	PL2 Group	IS + PL Groups	*p*
Age (yr)	5.13 ± 1.04	5.03 ± 0.99	0.71
Sex (number)			
Male	12	14	0.25
Female	18	16	

PL: periodontal ligament; IS: intraseptal.

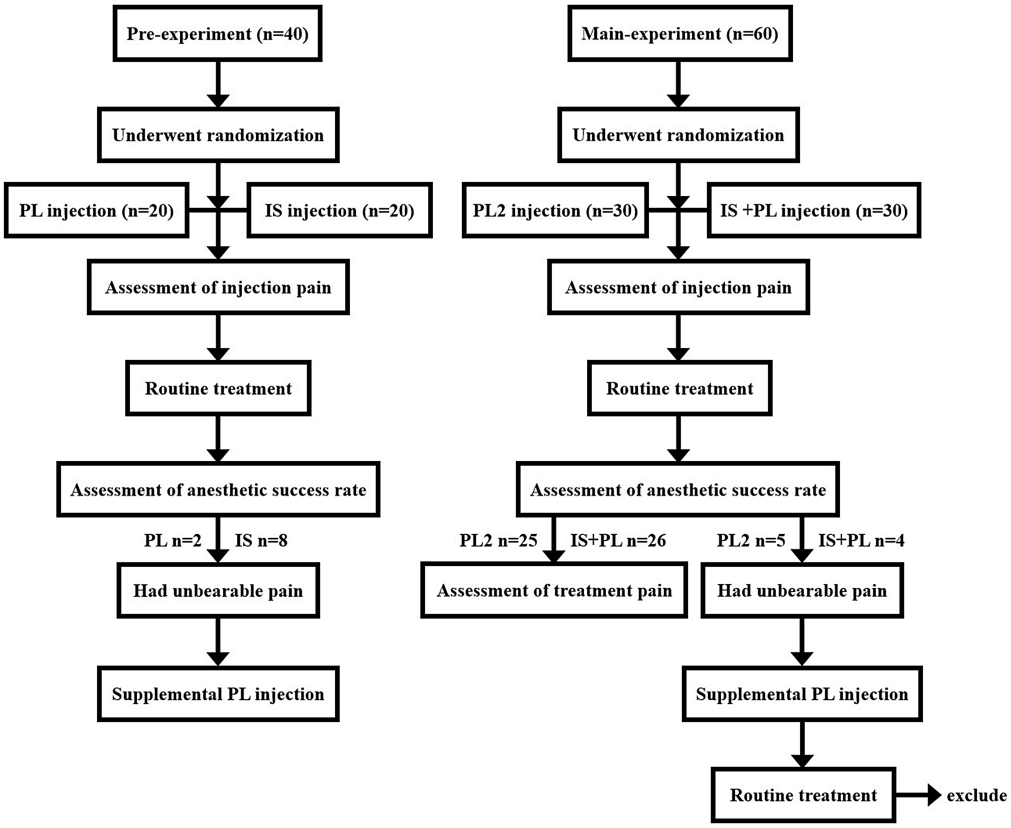

FIGURE 1. Study procedure. PL: periodontal ligament; IS: intraseptal.

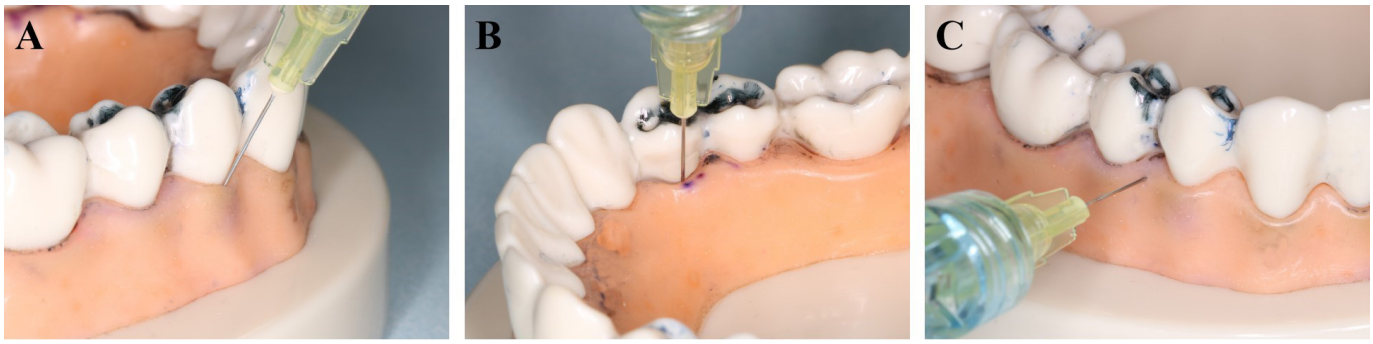

FIGURE 2. Illustrative figures for different injections types. (A) PL injection at central buccal side; (B) PL injection at central lingual side; (C) IS injection.

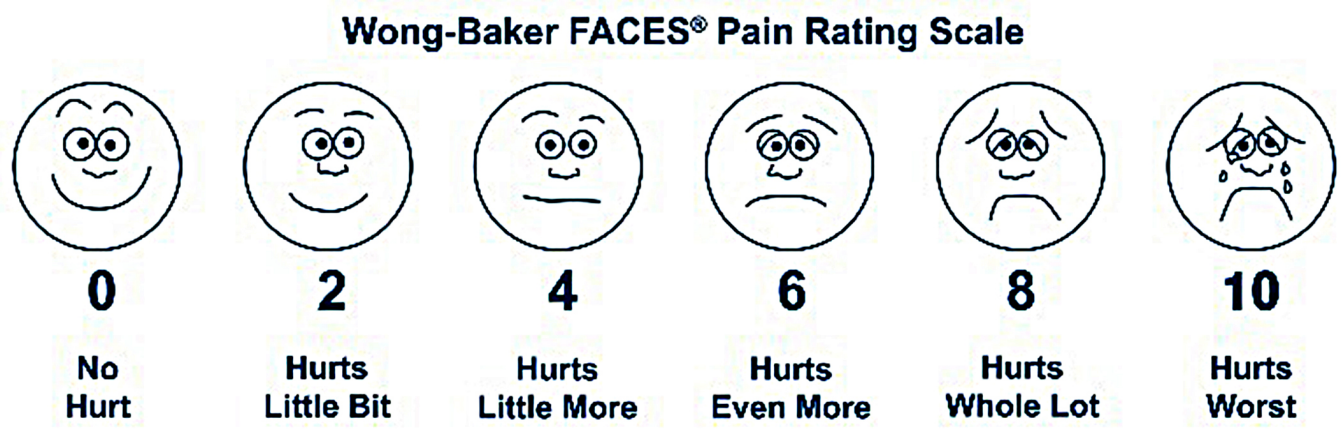

FIGURE 3. Wong-Baker FACE® pain rating scale.

3.2 Comparison of injection pain between PL and IS groups in pre-experiment

Children were asked immediately after the injection to select facial expression that best represented his/her feeling of discomfort according to Wong-Baker FACE® Pain Rating Scale. Results are shown in Table 3. The difference was statistically significant ($p < 0.001$).

TABLE 3. Comparison of pain between PL and IS groups during injection.

	PL Group	IS Group
Score	5.10 ± 2.29	2.30 ± 0.73
p	<0.001	

PL: periodontal ligament; IS: intraseptal.

3.3 Comparison of anesthesia success rate between PL and IS groups in pre-experiment

Children received routine treatment after the injection. It was found that IS group had lower anesthesia success rate compared to PL group ($p < 0.05$) (Table 4). Four children required supplemental anesthesia in IS group as they felt unbearable pain in the beginning of treatment. Intraseptal injection was thus not enough.

TABLE 4. Comparison of anesthesia success rate between PL and IS groups.

	PL Group	IS Group
Rate	90%	60%
p	0.03	

PL: periodontal ligament; IS: intraseptal.

3.4 Comparison of injection pain between PL2 and IS + PL groups in main-experiment

The pattern of anesthetic application was improved by considering the above findings: IS injection combined with PL injection. Children gave scores as of previous method immediately after the injection in another 60 cases of deep caries. Results are shown in Table 5. The difference was statistically significant ($p < 0.001$).

TABLE 5. Comparison of pain between PL2 and IS + PL groups during injection.

	PL2 Group	IS + PL Groups
Score	5.67 ± 2.11	2.73 ± 0.98
p	<0.001	

PL: periodontal ligament; IS: intraseptal.

3.5 Comparison of treatment pain between PL2 and IS + PL groups in main-experiment

The anesthetic success rates of PL2 and IS + PL groups were similar with no statistically significant difference ($p > 0.05$) (Table 6). Immediately after treatment, children gave scores as of previous method. Results are shown in Table 7. There was no statistically significant difference ($p > 0.05$).

TABLE 6. Comparison of anesthesia success rates between PL2 and IS + PL groups.

	PL2 Group	IS + PL Groups
Rate	83.3%	86.7%
p	0.72	

PL: periodontal ligament; IS: intraseptal.

TABLE 7. Comparison of pain between PL2 and IS + PL groups during treatment.

	PL2 Group	IS + PL Group
Score	1.68 ± 1.49	1.85 ± 1.48
p	0.69	

PL: periodontal ligament; IS: intraseptal.

4. Discussion

Intraseptal (IS) injection was employed for the surgical flap hemostasis and preoperative anesthesia of periodontal curettage [6]. Brkovic BM *et al.* [9] proposed that IS injection could be used for the preoperative anesthesia of single tooth extraction. Gazal G *et al.* [10] suggested that IS injection might be an additional anesthesia after the failure of conventional injection method. Dianat O *et al.* [11] found that supplemental IS injection following the inferior alveolar nerve block injection was more effective for mandibular molars with irreversible pulpitis compared to the typical injection. In IS injection, a needle was inserted to 2 mm below the tip of interdental papilla until the contact with bone, and injected till the gingival papilla color changed from pink to white [6]. The mechanism was that the anesthetic solution moved from buccal bone to lingual bone through porous crestal alveolar bone in alveolar septum, and into the cancellous bone surrounding the tooth, and infiltrated the nerves in periodontal ligament and apical foramen [10, 12]. Studies had reported the success rate as 98% [10, 12]. PL injection was accepted as the most effective anesthesia method [9], however, the anesthetic effect of IS injection was similar to that of subperiosteal injection and PL injection. The pain response of IS injection was less than the other two injection methods [6]. Woodmansey K *et al.* [12] believed that IS injection was safe and efficient. Malamed SF *et al.* [13] suggested that IS injection was more conducive for the onset of anesthesia since the inflammation accumulation of insertion point in alveolar septum was less.

The alveolar bone density of children was lower than that of adults, and apical foramen of deciduous teeth was bigger [14, 15]. It was suggested that IS injection might be more suitable for treating children based on its anesthetic mechanism and above-stated advantages, however, there were no relevant research reports. In this study, the pain degree and anesthetic effect were compared for the PL injection and IS injection

combined with PL injection in children of 4–6 age having deep caries. Purpose was to find a better anesthesia method in children's oral treatment.

Pain was the main concern of children's refusal to receive oral treatment, which hindered the normal diagnosis and treatment by dentists. Pain control was thus critical [16, 17]. In this regard, the dentists needed an objective and quantitative method to evaluate the impact of pain control. Wong-Baker FACE® Pain Rating Scale had been applied in clinics since 1981. It was a common method of pain assessment in children [7, 18]. This scale had 6 degrees of facial expressions from smiling to crying. Children could show their feelings of discomfort by selecting the facial expression [8]. Herein, the children were asked to select the facial expression immediately after anesthesia (injection pain) and after treatment (treatment pain).

PL and IS injections were separately dealt in the existing local anesthesia techniques. To infer if IS injection combined with PL injection was superior for treating deep caries in mandibular deciduous molars, it was required to verify and compare the injection pain and success rate of existing techniques. In pre-experiment, the results showed that injection pain in PL group was 5.10 ± 2.29, while in IS group was 2.30 ± 0.73, and the difference was statistically significant ($p < 0.001$). It revealed that the IS injection pain was lower than PL injection pain. However, the anesthetic success rates of PL and IS groups were 90% and 60% ($p < 0.01$). Therefore, only the IS injection was not enough. In main-experiment, the pattern of applying anesthetic was improved: IS injection combined with PL injection. Results exhibited that the injection pain in PL2 group was 5.67 ± 2.11, PL + IS group was 2.73 ± 0.98, and the difference was statistically significant ($p < 0.001$). The pain of IS injection combined with PL injection was lower than PL injection. The anesthetic success rates of PL2 and IS + PL groups were 83.3% and 86.7% ($p > 0.05$), which meant both injections had similar success rates. The treatment pain in PL2 group was 1.68 ± 1.49, and IS + PL group was 1.85 ± 1.48, with no statistically significant difference ($p > 0.05$). The data indicated that anesthetic effect of IS injection combined with PL injection, and PL injection alone were similar in treating children. IS injection combined with PL injection had lower pain sensation during anesthesia compared to PL injection. The findings suggested that IS injection combined with PL injection was comfortable and effective local anesthesia and thus suitable for treating children with deep caries in mandibular deciduous molars.

There were few reports on the defects of IS injection such as the anesthetic spilled over from the needle point to patient's mouth causing taste discomfort [19]. The long-term follow-up data was lacking for the IS injection [19]. In this study, 40 and 60 cases of deep caries in deciduous teeth were treated and analysed from January 2022 to January 2023. However, there was still a gap and long-term effect of injection or possible adverse consequences after anesthesia could be focused in the follow-up study. Moreover, IS injection combined with PL injection could be studied in root canal therapy of deciduous teeth or in the treatment of young permanent teeth, which were the common therapies in children and adolesents. Additionally, the post-treatment follow-up visits were not conducted for the children after anesthesia and treatment. This was vital for supplementing the comfort level of IS injection combined with PL injection.

5. Conclusions

In the field of pediatric oral anesthesia, this study compared the anesthetic effects of two injection strategies: IS injection combined with PL injection, and PL injection alone. Our research demonstrated that, when evaluating the overall anesthetic success rates and effects in the treatment of deep caries in mandibular deciduous molars, these two approaches showed the similar outcomes. Nevertheless, IS injection combined with PL injection led to a markedly lower level of pain sensation compared to PL injection. Given children's heightened sensitivity to pain and fear, this combination strategy might be more suitable for them in the pediatric oral treatment, enhancing their treatment experience.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

WL—conceptualization. XSC—data curation, investigation. JHH—data curation, investigation. YL—funding acquisition, project administration, supervision. JS—writing-original draft, writing-review & editing.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The experimental procedure was approved by the ethics committee of the Research Ethics Committee of Shenzhen Maternity and Child Healthcare Hospital (ethics NO. SFYLS [2022]025). The registration number of the UK's Clinical Study Registry is ISRCTN30082181. The parents of children who accepted the experiment fully understood the experimental procedure and signed the informed consent.

ACKNOWLEDGMENT

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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