Combined inferior alveolar nerve block anaesthesia and local infiltration anaesthesia in extraction of impacted mandibular third molars: a randomised controlled trial

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Key points

Improvement of painless dental treatment.	Compared to conventional inferior alveolar nerve block, combined anaesthesia improves the anaesthetic effect in the extraction of the mandibular third molar.	The application of combination of inferior alveolar nerve block anaesthesia and local infiltration anaesthesia in the extraction of mandibular molars is worth promoting in the clinic.

Abstract

Aim To compare the anaesthetic effect of combination of inferior alveolar nerve block anaesthesia and local infiltration anaesthesia with nerve block anaesthesia techniques in the extraction of mandibular third molars.

Materials and methods One hundred and fifty healthy adult volunteers were divided into three groups and were administered three different local anaesthetic techniques before tooth extractions: group A (inferior alveolar nerve, lingual nerve and buccal nerve block anaesthesia with lidocaine), group B (inferior alveolar nerve, lingual nerve and buccal nerve block anaesthesia with mepivacaine) and group C (inferior alveolar nerve block anaesthesia with lidocaine and infiltration anaesthesia with mepivacaine). The patients' reported pain on anaesthesia injection and tooth extraction, the surgeon's assessment of anaesthetic effect, the severity of intra-operative bleeding and post-operative complications were evaluated.

Results There was no significant difference in visual analogue scale (VAS)-pain of anaesthesia among the three groups. Compared with groups A and B, group C had reduced VAS-pain of tooth extraction scores. Additionally, the surgeon's assessment of anaesthetic effect improved and intra-operative bleeding decreased.

Conclusions The combination of inferior alveolar nerve block and infiltration anaesthesia provides a stronger anaesthetic effect in the extraction of mandibular third molars.

Introduction

Mandibular third molar impaction is a common disease encountered in oral and maxillofacial surgery. This condition often causes a series of other diseases, such as wisdom tooth pericoronitis, mandibular second molar distal cervical caries and jaw osteomyelitis. Therefore, most of the impacted third mandibular molars need to be extracted surgically. Mandibular third molars are often more difficult to extract than other teeth because of the anatomical variation in the mandibular third molar and obstruction by soft tissue, bone and adjacent teeth. The process of tooth extraction is traumatic and time-consuming. Pain control is a prerequisite for the success of tooth extraction and the chief concern of patients is whether the operation will be painful. Pain is also the most direct and impactful feeling in the treatment process.

Although in-hospital general anaesthesia and nitrous oxide/oxygen inhalation sedation have gradually been popularised and applied in oral clinical treatment, local anaesthesia is still the most commonly used anaesthesia method in the extraction of impacted mandibular third molars. The classical inferior alveolar nerve block anaesthesia method consists of anaesthetising the inferior alveolar nerve, lingual nerve and buccal nerve with one injection. This safe and effective anaesthesia method is common in clinical treatment. However, when this method is used in the clinic, many patients complain of severe intra-operative pain despite the anaesthetic. This method involves inserting the needle near the mandibular foramen to anaesthetise the inferior alveolar nerve and lingual nerve,[1] but it rarely blocks the buccal nerve.[2,3] According to the literature, the success rate of inferior alveolar nerve block with 2% lidocaine for anaesthesia of the mandibular molars fluctuates between 3.2% and 88%.[4,5] However, when the mandibular posterior teeth are treated with 2% mepivacaine for inferior alveolar nerve block anaesthesia, nearly 50% of patients report intra-operative pain.[6] Classical inferior alveolar nerve block anaesthesia cannot sufficiently ensure painless treatment. Therefore, it is important to improve the efficacy of anaesthesia used during tooth extraction. In recent years, with the emergence of new types of local anaesthetic

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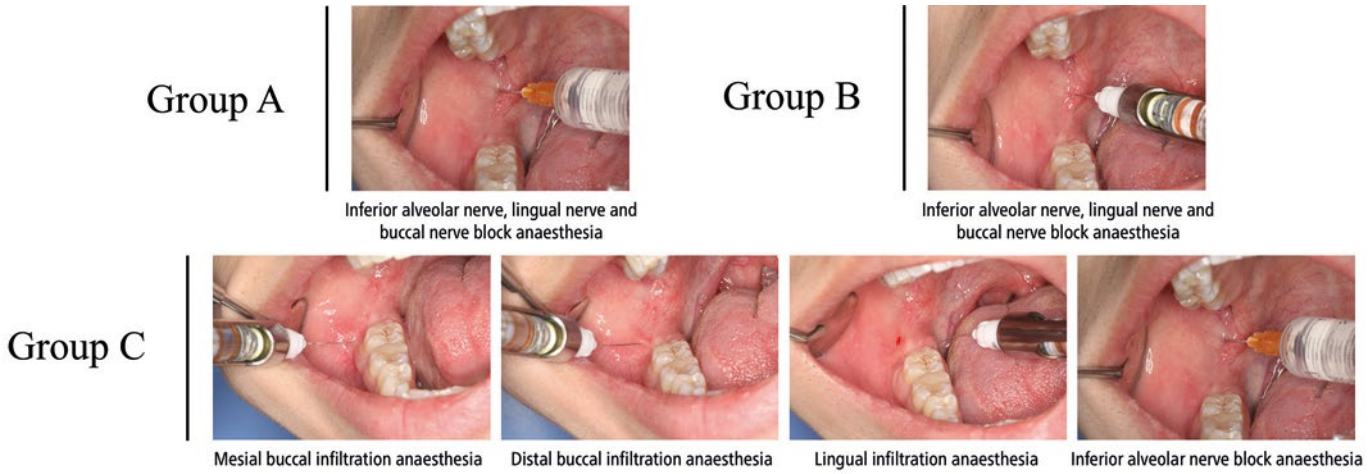


Fig. 1 This is shown as a schematic of three groups of local anaesthesia. Group A received 2% lidocaine (4 ml) without adrenaline in the inferior alveolar nerve, lingual nerve and buccal nerve block anaesthesia. Group B received 2% mepivacaine (1.8 ml) with 1:100,000 adrenaline in the inferior alveolar nerve, lingual nerve and buccal nerve block anaesthesia. Group C received a combination of 2% mepivacaine (1.8 ml) with 1:100,000 adrenaline for local mucosal infiltration anaesthesia and 2% lidocaine (2 ml) without adrenaline for inferior alveolar nerve block anaesthesia

agents, oral surgeons have gradually explored new types of injections for local anaesthesia to further improve the efficacy of analgesia and reduce the pain of treatment. This study proposed a combination of 2% lidocaine for inferior alveolar nerve block anaesthesia and 2% mepivacaine for local mucosal infiltration anaesthesia, which achieved better anaesthetic efficacy than classic inferior alveolar nerve block anaesthesia in a clinical setting. The purpose of this research was to compare the anaesthetic efficacy of two different local anaesthesia protocols in the extraction of mandibular third molars.

Materials and methods

Clinical data

This study was approved by Stomatology Hospital of Guangzhou Medical University IRB and all participants signed an informed consent agreement. From March 2019 to September 2019, 150 patients who were diagnosed with an 'impacted mandibular third molar' and needed it extracted were selected from the Department of Maxillofacial Surgery at the Stomatological Hospital affiliated with Guangzhou Medical University. The conditions of the impacted teeth included horizontal impaction, mesioangular impaction and vertical impaction. These teeth must be removed by incising the gingiva, withdrawing the gingival flap, separating the teeth and extracting the impacted tooth. All patients were between 18 and 30 years old. The patients were healthy at the beginning of the study and had never previously had a tooth extracted. None of the subjects had any contraindication to tooth extraction, and they were able to correctly judge and describe the intensity of their pain. There were 57 males with an average age of 24.88 ± 3.45 years and 93 females with an average age of 29.94 ± 3.54 years. Before surgery, all patients signed informed consent for tooth extraction. A randomised controlled trial design was employed.

Experimental groups and types of anaesthesia

We used IBM SPSS Statistics 23.0 software to establish a randomisation table. The patients were randomly divided into groups A, B and C; each group contained 50 people. The three groups were treated with different types of local anaesthesia before tooth extraction. Group A received 2% lidocaine (4 ml) without adrenaline in the inferior alveolar nerve, lingual nerve and buccal nerve block anaesthesia. Group B received 2% mepivacaine (1.8 ml) with 1:100,000 adrenaline in the inferior alveolar nerve, lingual nerve and buccal nerve block anaesthesia. Group C received a combination of 2% lidocaine (2 ml) without adrenaline for inferior alveolar nerve block anaesthesia and 2% mepivacaine (1.8 ml) with 1:100,000 adrenaline for local mucosal infiltration anaesthesia. The operation is illustrated in Figure 1. n this study, the local anaesthetic agents were 2% lidocaine hydrochloride (without adrenaline, Shanghai, 5 ml/tube) and 2% mepivacaine hydrochloride (1:100,000 adrenaline, Septodont, 1.8 ml/tube).

Characteristics of the surgeon and the tooth extraction operations

The doctor in this study worked in the Department of Maxillofacial Surgery at the Stomatological Hospital affiliated with Guangzhou Medical University. He was associate chief physician and had more than five years of experience. He was proficient in the two types of local anaesthesia as well as extraction of the mandibular third molars. Each tooth extraction operation consisted of incising the gingiva, withdrawing the gingival flap, separating the teeth, extracting the impacted tooth and suturing the incision after debridement. We administered a painkiller only after the operation.

Evaluation indicators

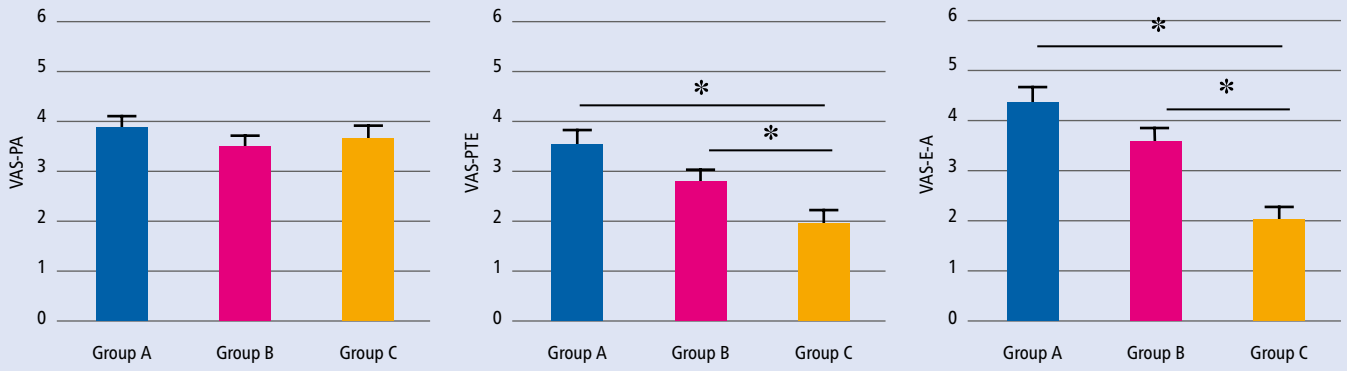
This study used questionnaires to collect information. The evaluation indicators were the visual analogue scale (VAS), the intra-operative time, the score for anaesthetic effect, the score for intra-operative bleeding and status at post-operative evaluation. The specific contents were as follows.

VAS

The patients rated their pain on the VAS. On this scale, 0 means no pain and 10 means unbearable pain. The patients were asked to report pain scores after local anaesthesia and tooth extraction, herein designated VAS-PA (visual analogue scale-pain of anaesthesia) and VAS-PTE (visual analogue scale-pain of tooth extraction).

In the clinic, some patients complained of obvious pain during tooth extraction and

Fig. 2 Comparisons were performed using one-way ANOVA. P value of <0.05 was considered statistically significant. VAS-PA = visual analogue scale-pain of anaesthesia, VAS-PTE = visual analogue scale-pain of tooth extraction, VAS-PTE-A = visual analogue scale-pain of tooth extraction-adjusted



needed additional local anaesthesia due to poor efficacy of the anaesthetics before tooth extraction. After additional local anaesthesia, the pain was reduced and sometimes even eliminated. Therefore, the patients tended to report lower VAS-PTE scores than those who needed only the initial anaesthesia. However, it is important to note that a second round of anaesthesia was administered only if patients felt obvious pain after the first round. Therefore, if additional anaesthesia was given, we considered the first round to have been unsuccessful and ineffective.

To unify all patients' VAS-PTE scores for evaluation by the doctors, we adjusted the VAS-PTE of patients who had received a second round of local anaesthesia. For each patient who received additional local anaesthesia, three points were added to the original VAS-PTE, converting it to the VAS-PTE-A (visual analogue scale-pain of tooth extraction-adjusted). After this adjustment, VAS-PTE-A scores greater than or equal to ten points were recorded as ten points.

Intra-operative time

The intra-operative time was defined as the time from the incision and withdrawal of the gingiva to the successful extraction of the tooth and the suturing of the incision. This interval was recorded by the nurse.

Anaesthetic effect scores

The anaesthetic effect was evaluated on a three-level scale. Level I was defined as no pain during the operation. Level II was defined as mild intra-operative pain that could be tolerated without additional local anaesthesia. Level III was defined as intolerable intra-operative pain that necessitated additional local anaesthesia. These scores, determined from the patients' reported feelings during the operation, were recorded post-operatively by a doctor other than the one who performed the surgery. The doctor who performed the evaluations was unaware of the type of local anaesthesia.

Intra-operative bleeding scores

The severity of intra-operative bleeding was evaluated on a four-level scale. Level I was defined as mild oozing of blood from the soft tissue and bone surface, such that the surgical field was not affected and the operation could proceed smoothly. Level II was defined as moderate oozing of blood from the soft tissue and bone surface, affecting part of the surgical field; the operation could be continued after the blood was wiped away with a cotton ball or removed from the site by weak suction. Level III was defined as severe blood infiltration from the soft tissue and bone surface, affecting most of the surgical field; this level of bleeding required a cotton ball treated with an adrenergic agent to reduce blood flow or strong suction to remove blood before the operation could continue. Level IV was defined as extremely severe oozing of blood from the soft tissue and bone surface, such that the operation was terminated. These intra-operative bleeding scores were recorded post-operatively by a doctor other than the one who performed the surgery. The evaluating doctor was unaware of the type of local anaesthesia.

Post-operative evaluation

Each patient returned on the first day after the operation. The doctor observed and recorded whether post-operative bleeding and swelling had occurred. One week after the operation, the patient returned to have the sutures removed. The doctor recorded the status of wound healing (good/normal/poor), the occurrence of infection and/or dry socket (present/absent) and the degree of mouth opening (normal/limited mouth opening [degree I])/limited mouth opening [degree II]/limited mouth opening [degree III]).

Statistical analysis

The software package IBM SPSS Statistics 23.0 was used for statistical analysis. One-way ANOVA was used for measurement data. The Kruskal-Wallis test was used for rank data. The differences were considered significant if $P < 0.05$.

Results

Anaesthetic effect

There was no significant difference in VAS-PA among the three groups ($P = 0.562$). The order of VAS-PTE scores was group A>group B>group C and the difference among the three groups was statistically significant ($P = 0.001$). Additionally, the pairwise differences between groups C and A and between groups C and B were statistically significant (both $P = 0.001$). However, there was no statistically significant difference between group A and group B ($P = 0.067$). Substantial percentages of groups A and B required additional anaesthesia during tooth extraction (30% and 26%, respectively), whereas only one patient (2%) in group C did. These results show that the anaesthetic effects in group A and group B were inferior to the effect in group C ($P < 0.001$). Because most patients who needed additional anaesthesia were in group A or group B, the VAS-PTE-A scores of groups A and B were significantly higher than that of group C (Figure 2 and Table 1).

Table 1 Analysis of anaesthetic effect (comparisons were performed using Kruskal-Wallis test)

Groups	Total (n)			Mean rank
	Level I	Level II	Level III	
Group A	12	23	15	93.13
Group B	20	17	13	81.83
Group C	37	12	1	51.54
H = 28.70				
P <0.001*				

Key:
H = chi-square value in Kruskal-Wallis test
* = statistically significant

Table 2 Analysis of intra-operative time (comparisons were performed using one-way ANOVA)

Index	Time (x ± s)			F	P value
	Group A (n = 50)	Group B (n = 50)	Group C (n = 50)		
The operating time	14.49 ± 5.82	15.99 ± 6.51	15.94 ± 6.85	0.884	0.415

Key:
F = ANOVA coefficient

Table 3 Analysis of intra-operative bleeding (comparisons were performed using Kruskal-Wallis test)

Groups	Total (n)				Mean rank
	Level I	Level II	Level III	Level IV	
Group A	17	20	13	0	90.65
Group B	19	26	5	0	82.05
Group C	39	9	2	0	53.80
H = 23.91					
P <0.001*					

Key:
H = chi-square value in Kruskal-Wallis test
* = statistically significant

Intra-operative time

The intra-operative times of the three groups were 14.49 ± 5.82 minutes in group A, 15.99 ± 6.51 minutes in group B and 15.94 ± 6.85 minutes in group C. The mean intra-operative times were similar among the three groups and the difference was not statistically significant (P = 0.415, Table 2).

Intra-operative bleeding

The degrees of intra-operative bleeding in the three groups were as follows: in group A, 17 cases were level I, 20 cases were level II and 13 cases were level III; in group B, 19 cases were level I, 26 cases were level II and 5 cases were level III; in group C, 39 cases were level I, 9 cases were level II and 2 cases were level III. During the extraction of the mandibular third molar, group C had the least blood loss and the clearest surgical fields, followed by group B and group A. The difference was statistically significant (P <0.001, Table 3).

Post-operative evaluation

Regarding wound healing, group A contained one case rated as 'normal' and one case rated as 'poor'; group B contained one case rated as 'normal'. All other cases in all three groups were rated as 'good'. In group A, one patient developed post-operative wound infection. Regarding the degree of mouth opening, degree I limitation was present in three cases in group A, three cases in group B and two cases in group C; the rest were normal. There was no post-operative bleeding in any of the three groups (Table 4).

Discussion

Lidocaine and mepivacaine have been used in our institution's Department of Stomatology for more than half a century due to their efficacy and safety. Currently, the main local anaesthetic agent preparations commonly used in oral surgery are mainly 2% lidocaine hydrochloride and 2% mepivacaine hydrochloride (1:100,000 adrenaline). Lidocaine hydrochloride and mepivacaine hydrochloride are amide local anaesthetic agents. These agents share several advantages, such as good anaesthetic effect, rapid onset and a low risk of allergic reactions. These two anaesthetic agents can be used for nerve block anaesthesia or infiltration anaesthesia. Skin allergy tests are typically not performed before these compounds are used for injection anaesthesia because they seldom cause allergic reactions. Thus, lidocaine and mepivacaine were recognised as ideal local anaesthetic agents for use in the Department of Stomatology.

Before the extraction of the mandibular third molar, we often block the inferior alveolar nerve, lingual nerve and buccal nerve with one injection. However, this anaesthesia method has a certain risk of failure due to the anatomical variation in the position of the mandibular foramen, inferior alveolar nerve, buccal nerve and lingual nerve, as well as differences in surgeons' skill levels.[7,8] Due to the dense structure of the mandible, local anaesthetic agents are often blocked by the barrier formed by the thick cortical bone.[9] If infiltration anaesthesia is the only type used, the anaesthetic agents cannot penetrate the root apexes of the teeth and cannot provide sufficient anaesthesia for the extraction of mandibular third molars. In the clinic, we often add infiltration anaesthesia to control intra-operative pain when classical inferior alveolar nerve block anaesthesia fails. Added infiltration anaesthesia is one of the most widely used adjuvant injection techniques[10] and it can improve the success rate of classic inferior alveolar nerve block anaesthesia.[11,12,13] Therefore, the combination of inferior alveolar nerve block anaesthesia and infiltration anaesthesia may improve the anaesthetic effect during the extraction of the mandibular third molar.

The combined application of local anaesthetic agents can effectively increase

Table 4 Analysis of post-operative evaluations

Post-operative evaluation	Total (n)		
	Group A	Group B	Group C
Wound healing			
Good	48	49	50
Normal	1	1	0
Poor	1	0	0
Infection or dry socket			
Present	1	0	0
Absent	49	50	50
Degree of mouth opening			
Normal	47	47	48
Limited mouth opening (degree I)	3	3	2
Limited mouth opening (degree II)	0	0	0
Limited mouth opening (degree III)	0	0	0
Post-operative bleeding			
Present	0	0	0
Absent	50	50	50

the anaesthetic effect and extend its duration. However, this approach increases the use of local anaesthetic agents. Attention should be paid to preventing the absorption of local anaesthetic agents into the blood and assessing patients' tolerance to determine the appropriate dose before the anaesthetic agents are injected. When local anaesthetic agents are used in combination, clinicians should be vigilant for warning signs of toxic reactions, such as restlessness, excessive talking, trembling and vomiting. For adults, the total dose of lidocaine should not exceed 300 mg and the total dose of mepivacaine should not exceed 400 mg. In this study, the amount of lidocaine used in group A was 80 mg. In group B, the amount of mepivacaine used was 36 mg. In group C, the amount of lidocaine used was 40 mg and the amount of mepivacaine used was 36 mg. Although a combination of local anaesthetic agents was used in group C, the use of local anaesthetic agents did not increase substantially. In this study, we used different injection methods, different anaesthetic agents and different dosages in different groups. The comparability of the three groups were not ideal, thus it was not a standardised study. However, both the conventional injection methods in groups A and B are commonly used in our clinical work, plus our study discovered that the combined method in group C achieved a much more satisfactory anaesthetic effect.

In this study, we found that both VAS-PTE and VAS-PTE-A were lower in group C than in group A or group B ($P = 0.001$). The ranking of groups by anaesthetic effect was group C>group B>group A ($P < 0.001$). In group C, intra-operative bleeding was decreased ($P < 0.001$). These results suggest that the combination of inferior alveolar nerve block anaesthesia and infiltration anaesthesia can effectively improve the anaesthetic effect. The idea of combining inferior alveolar nerve block anaesthesia and infiltration anaesthesia was based on the observation that added infiltration anaesthesia could improve the anaesthetic effect after the failure of inferior alveolar nerve block anaesthesia.[14,15,16] Infiltration anaesthesia replaced lingual and buccal nerve block anaesthesia, simplifying the process of local anaesthesia administration. At the same time, the anaesthesia success rate was improved while still maintaining the local anaesthetic dosage in a safe range. This combined approach prevented the problem of insufficient anaesthesia that often occurs when infiltration anaesthesia or inferior alveolar nerve block anaesthesia is used alone. Lidocaine was injected into the mandibular nerve for nerve block anaesthesia, while mepivacaine infiltrated the alveolar bone from the mucosa. Block anaesthesia, as applied in this study, acted on the inferior alveolar nerve by blocking the afferent stimulation of nerve endings. Infiltration anaesthesia directly acted on the nerve endings around the mucosa and alveolar bone around the third molar. This combination can improve the effect of anaesthesia and control intra-operative pain. Because of the 1:100,000 adrenaline in the 2% mepivacaine hydrochloride, this preparation can control bleeding during surgery and maintain a clear surgical field, and the vasoconstrictor effect can reduce the absorption rate of local anaesthetic agents in the human body, thereby increasing the duration of local anaesthesia. However, VAS-PTE and VAS-PTE-A scores indicated group A>group B ($P = 0.067$). This difference may be caused by different anaesthetic agents. The anaesthetic effect of mepivacaine is similar to lidocaine.[17] Because of the weak vasodilation ability of mepivacaine, it can maintain anaesthesia for a long time without vasoconstriction.[18] Commercialised 2% mepivacaine hydrochloride contains 1:100,000 adrenaline, which increases the anaesthetic effect. There was no significant difference in VAS-PA among the three groups ($P = 0.562$). This result suggests that a greater number of injections did not cause the patients to feel more pain, although group C needed more injections than groups A or B to complete their local anaesthesia protocol. The lack of difference in injection pain may have occurred because the infiltration anaesthesia was injected first in group C. The infiltration anaesthesia quickly anaesthetised the mucosa in the operation area, mitigating the pain that the patients felt as the inferior alveolar nerve block anaesthesia was applied. The results of the post-operative evaluations showed that no more post-operative complications occurred in group C.

In general, group C experienced an increased anaesthetic effect. In addition, the decrease in intra-operative bleeding provided a clear surgical field with unobstructed views for the surgeon. Thus, the anaesthesia protocol of group C can further shorten the operation time and reduce the operation wound. Therefore, mild post-operative reaction and smooth recovery is predictable. Finally, the protocol improved the efficiency of treatment and the comfort of the patients.

Conclusion

Overall, the combination of inferior alveolar nerve block anaesthesia and infiltration anaesthesia used in the extraction of mandibular third molars was superior to classical inferior alveolar nerve block alone in terms of the patients' reported pain, the anaesthetic effect and the severity of intra-operative bleeding. This method not only simplified the process of local anaesthesia, but also improved its success rate. The combined anaesthesia protocol can greatly reduce intra-operative pain, which is consistent with the concept of modern minimally invasive treatment. This protocol is worth promoting for the extraction of mandibular third molars in the clinic.

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Conflict of interest

The authors have no potential conflicts of interest to declare.

Author contributions

ZCL organised and conducted this study. MY, TL, YZ, HQY and ZGP assisted with this study (collected the study data). LBZ conceived the idea, designed the experiments and analysed the data. All authors read and approved the final manuscript.

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