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ORIGINAL ARTICLE / ARAŞTIRMA MAKALESİ

Comparison of Inferior Alveolar Nerve Block and Infiltration Anesthesia Techniques for Pain Control in Primary Mandibular Molar Extractions in pediatric patients

Türkçe başlık: Çok Hastalarda Süt Mandibular Molar Diş Çekimlerinde Ağrı Kontrolü İçin İnferior Alveolar Sinir Bloğu ve İnfiltrasyon Anestezisi Tekniklerinin Karşılaştırılması

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ÖZ

Amaç: Bu çalışma, çocuk hastalarda süt mandibular molar diş çekimleri sırasında ağrıyı yönetmede inferior alveolar sinir bloğu (IASB) ve bukkal infiltrasyon anestezisinin etkinliğini karşılaştırmayı amaçladı.
Gereç ve Yöntemler: Bu prospektif gözlemsel çalışma Marmara Üniversitesi Diş Hekimliği Fakültesi'nde, rutin süt molar diş çekimi için sevk edilen çocukları kapsıyordu. Katılımcılar IASB ve infiltrasyon anestezi gruplarına ayrıldı. Çalışmanın birincil sonuç ölçütü, görsel analog skala (VAS) kullanılarak ölçülen ağrı şiddetiydi. Bu çalışmanın kovaryantları anestezi grubu, kalan diş kökü uzunluğu ve rezorpsiyon evresiydi. Tanımlayıcı istatistikler demografik ve klinik özellikleri özetledi. Mann-Whitney ve Kruskal-Wallis testleri, gruplar ve rezorpsiyon evreleri arasındaki VAS skorlarını karşılaştırırken, Pearson korelasyon ve çoklu doğrusal regresyon analizleri, ağrı şiddetinin ilişkilerini ve belirleyicilerini değerlendirdi.
Sonuçlar: Katılımcıların ortalama yaşı 8.3 yıl (SD = 1.8) idi. Cinsiyetler, anestezi grupları veya rezorpsiyon evreleri arasında VAS skorlarında anlamlı bir fark bulunmadı. Korelasyon analizi, ağrı şiddeti ile kalan diş köklerinin yüzdesi arasında anlamlı bir ilişki göstermedi. Çoklu doğrusal regresyon analizi, hiçbir belirleyicinin ağrı şiddetini anlamlı şekilde açıklayamadığını gösterdi.
Sonuç: İnfiltrasyon anestezisi, çocuklarda süt mandibular molar diş çekimleri sırasında ağrıyı yönetmede en az IASB kadar etkilidir. Bulgular, daha basit uygulanabilirliği ve daha az komplikasyonları göz önüne alındığında, bukkal infiltrasyon anestezisinin IASB'na geçerli bir alternatif olarak kullanılabileceğini desteklemektedir.
Anahtar Kelimeler: İnfiltrasyon anestezisi, rejyonal anestezi, mandibular sinir, süt dişi

ABSTRACT

Objectives: This study aimed to compare the effectiveness of inferior alveolar nerve block (IANB) and infiltration anesthesia in managing pain during primary mandibular molar extractions in pediatric patients.
Materials and Methods: This prospective observational study at the Marmara University Faculty of Dentistry included children referred for routine primary molar tooth extraction. Participants were divided into two groups: the IANB group and the infiltration anesthesia group. The primary outcome measure was pain severity, which was measured using the visual analog scale (VAS). The covariates for this study were anesthesia group, remaining tooth root length, and the stage of resorption. Descriptive statistics summarized demographic and clinical characteristics. Mann–Whitney and Kruskal–Wallis tests compared VAS scores between groups and resorption stages, while Pearson correlation and multiple linear regression analyses evaluated relationships and predictors of pain severity.
Results: The mean age of participants was 8.3 years (SD = 1.8). No significant differences in VAS scores were found between genders, anesthesia groups, or resorption stages. Correlation analysis showed no significant relationship between pain severity and the percentage of remaining tooth roots. Multiple linear regression indicated that none of the predictors significantly affected pain severity.
Conclusions: Infiltration anesthesia is at least as effective as IANB for managing pain during primary mandibular molar extraction in children. The findings support the potential use of infiltration anesthesia as a viable alternative to IANB, given its simpler application and fewer complications.
Keywords: Infiltration anesthesia, regional anesthesia, mandibular nerve, primary tooth

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INTRODUCTION

Pain-free dentistry is crucial for treating children, and local anesthesia plays a vital role (Chopra et al., 2016). Controlling pain during dental procedures is essential, and every dentist prioritizes optimal pain control and discomfort reduction (Moaddabi et al., 2023). While the injection of local anesthesia can cause anxiety in both children and adults, it is necessary to ensure comfort during subsequent dental treatments. In children, the injection process is a major source of fear, especially when combined with tooth extraction, making tooth extraction one of their most dreaded dental procedures (Tirupathi & Rajasekhar, 2020). Providing less painful local anesthesia has significant benefits, as it reduces the need for surgery under general anesthesia (Tirupathi & Rajasekhar, 2020).

In adults, the bone anatomy of the posterior mandible restricts effective diffusion of the anesthetic solution. Inferior alveolar nerve block (IANB) is commonly used for anesthesia in treating mandibular primary or permanent molar teeth, particularly in mixed dentition cases (Foster et al., 2007; Klingberg et al., 2017; Shabazfar et al., 2014). Although IANB provides broad-area anesthesia, it is often painful and has a relatively high failure rate (Kaufman et al., 1984). There are specific risks associated with this technique, including potential damage to the lingual and/or inferior alveolar nerves (Pogrel, 2007). Other drawbacks include intravascular injections, hematoma, muscle injury and trismus (Peedikayil & Vijayan, 2013; Shabazfar et al., 2014; Wright, 2011). Soft tissue anesthesia following IANB often exceeds treatment timeframes, which can increase the risk of burns and bite injuries, especially in children and mentally disabled patients (Chi et al., 2008).

Since its adoption in dentistry, articaine has been noted for its high lipid solubility attributed to the presence of a thiophene ring that increases its ability to penetrate bone and soft tissue (Arrow, 2012). Several studies with adult subjects have reported reduced procedural pain during maxillary molar extractions using a single buccal infiltration of 4% articaine without requiring an additional palatal injection (Bataineh & Al-Sabri, 2017; Lima-Junior et al., 2009; Uckan et al., 2006). Research by Corbett et al. showed higher anesthesia success rates for first permanent molars with a buccal infiltration of articaine (70.4%) than for those with an IANB with lidocaine (55.6%) in adult volunteers, suggesting that a buccal infiltration may be sufficient instead of an IANB (Corbett et al., 2008). Although subsequent similar findings have been published in adults, there is insufficient evidence in the pediatric population, and further research is necessary (Jung et al., 2008; Poorni et al., 2011). To the best of the authors' knowledge, no studies have evaluated root resorption in this context. Tirupathi et al.'s systematic review concluded that more evidence is needed regarding the analgesic efficacy of 4% articaine for primary molar extraction in children before justifying its use (Tirupathi & Rajasekhar, 2020).

Clinical guidelines for local analgesia in pediatric dentistry prioritize safe and comfortable application tailored to the needs of children and adolescents (Kuhnisch et al., 2017). This study aimed to demonstrate an IANB technique and infiltration anesthesia technique for primary mandibular molar extraction in children. The effectiveness of IANB versus infiltration anesthesia in managing pain during primary mandibular molar extraction was compared, with the null hypothesis stating no significant difference in pain severity during extraction as measured by the visual analog scale (VAS) between the two methods.

MATERIALS AND METHODS

Study Design

This prospective observational study was conducted at the Marmara University School of Dentistry, Department of Oral and Maxillofacial Surgery. Ethical approval was obtained from the Marmara University School of Medicine Ethics Committee, ethical approval number 9.2024.126, and the study adhered to the principles outlined in the Declaration of Helsinki. Children referred to the Oral and Maxillofacial Surgery Department for routine primary molar tooth extraction were incuded in the study. Children who continued to visit this clinic and met the inclusion criteria were invited to participate in the study. The parents and the children were thoroughly informed about the entire procedure, and written consent was obtained from the parents, while verbal assent was obtained from the children.

Inclusion and Exclusion

Children aged 6-12 years with medically healthy conditions, without allergies to medications or local anesthetic solutions, and who were able to communicate in Turkish were included. Those requiring local anesthesia for the extraction of one or more mandibular posterior teeth due to irreversible pulpitis, failed pulp therapy, recurrent caries, or orthodontic reasons were also included. Each tooth requiring simple extraction under infiltration anesthesia was considered independently because it needed its own anesthesia. If multiple teeth on one side required extraction under the IANB, only the tooth that best met the inclusion criteria was considered.

Teeth with acute apical infection, purulent drainage from the gingival sulcus or surrounding tissues, or excessive mobility were excluded. Patients with acute dentoalveolar infection, multiple decayed teeth, allergies to anesthetics, who had medical conditions endangering general health, who refused to participate and who had taken analgesics within 12 hours before the dental appointment were also excluded from the study.

Sample Size Calculation

The sample size was calculated based on the study by Jorgenson et al. (2020). The effect size was determined as $d = (24 - 14.62)/8 \approx 1.1725$. Using an alpha error probability (α) of 0.05 and a power (1-β error probability) of 0.8, the required sample size was calculated using a two-tailed t test for the difference between two independent means. The final sample size for each group was adjusted to 30, considering potential dropouts.

Anesthesia Procedure

The anesthesia technique was performed as follows: Initially, a topical anesthetic was applied to reduce discomfort associated with needle insertion into the mucosal membrane. Lidocaine 10% pump spray (AstraZeneca AB, Södertalje, Sweden) was applied to the area to be anesthetized with a sterile swab and left in place for two minutes. For local anesthesia, 80 mg/2 ml articaine hydrochloride and 0.01 mg/2 ml epinephrine (Maxicaine, Vem İlaç, İstanbul, Turkey) were used for either buccal infiltration or IANB. The choice of anesthesia was decided by performing radiographic examination of the patients and also the mobility of the tooth was examined during the intraoral examination. Accordingly, infiltration anesthesia was preferred in teeth with a resorption degree greater than the middle third of the root as estimated from the radiograph, and inferior alveolar block anesthesia was preferred in teeth with less remove one. In both groups, the anesthetic solution was administered using a 2.5 cc syringe with a 27-gauge needle (Bahrololoomi & Rezaei, 2021). The injection rate was approximately 1 ml/min for both techniques. IANB was performed using the conventional direct method previously described (Kammerer et al., 2012). If the child reported any pain or discomfort during anesthesia control, an additional injection was given and treatment was done but excluded from the study. Behavioral guidance techniques such as positive reinforcement, and nonverbal behavior guidance were used before anesthesia and during tooth extraction. And the VAS scale applied by the treating physician.

Fourth – or fifth-year dental students who had previously undergone training in extraction and anesthesia carried out the procedures.

Outcome Measures

The data collected in this study included descriptive variables such as age, gender, systemic condition, and the number of extracted teeth. The primary outcome measure was pain severity during tooth extraction, which was assessed using the colored visual analog scale (VAS) with facial expressions. Pain was evaluated immediately after the procedure by asking the children to rate their pain on the VAS, which is a 10 cm scale ranging from 0 (no pain) to 10 (worst pain possible) (Fig. 1). The covariates for this study were anesthesia group (infiltration vs. IANB), the length of remaining tooth root (metric), the percentage of the remaining tooth root (%), and the stage of resorption (stage I, II, or III). The length of the remaining tooth root was measured using a ruler, as shown in Fig. 2.

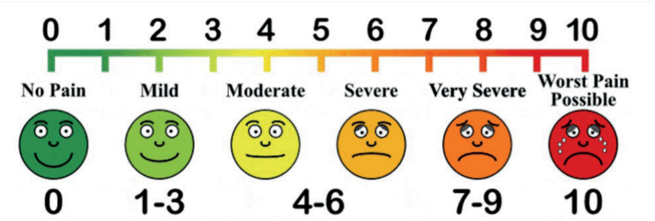

Figure 1: The visual analog scale (VAS) used for pain assessment, ranging from 0 (no pain) to 10 (worst pain possible). The scale includes descriptors and facial expressions to help children rate their pain levels more effectively.

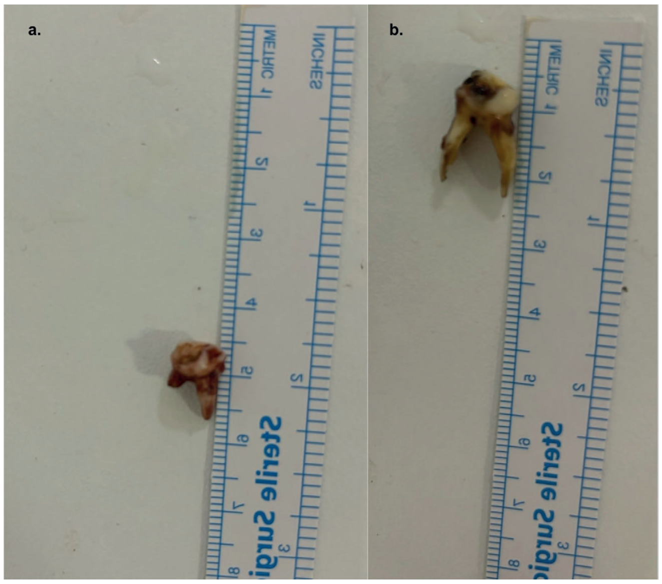

Figure 2: Measurement of the remaining tooth root length using a ruler. (a) Example of a primary molar with minimal remaining root. (b) Example of a primary molar with substantial remaining root.

Statistics

Categorical data were analyzed for frequencies and percentages. The distribution of the data was tested using the Kolmogorov–Smirnov test. Descriptive statistics were calculated based on the normality of the data, including the mean and standard deviation for normally distributed data and the median with 95% confidence intervals for nonnormally distributed data. Various statistical tests, such as the Mann–Whitney test, Kruskal–Wallis test, Pearson's correlation test, and multiple linear regression analysis, were applied to examine specific relationships and factors affecting VAS scores. For statistical reasons, each tooth was considered a separate unit. Statistical analyses were performed using Prism 10 software (GraphPad Inc., Boston, USA), with a significance level set at $p<0.05$.

RESULTS

The demographic and clinical characteristics of the study participants are summarized in Table 1. The mean age of the participants was 8.3 years, with a standard deviation (SD) of 1.8 years. Of the total participants, 33.3% were female (n=10), and 66.7% were male (n=20). Regarding tooth number, 23.3% of the teeth were identified as tooth number 74 (n=7), 26.7% as tooth number 75 (n=8), 16.7% as tooth number 84 (n=5), and 33.3% as tooth number 85 (n=10). Participants were divided into two groups based on the anesthetic technique used: 40.0% received IANB anesthesia (n=12), while 60.0% received an infiltration (n=18). The remaining root length had a mean of 6.4 mm with an SD of 2.5 mm, and the percentage of the remaining root length was 58.6% with an SD of 22.7%. Resorption stages were categorized as follows: 46.7% in Stage I (n=14), 40.0% in Stage II (n=12), and 13.3% in Stage III (n=4).

Table 1. Descriptive statistics of the study population.

	n	%	Mean	SD
Age			8.3	1.8
Systemic status				
Healthy	30	100		
Gender				
Female	10	33.3		
Male	20	66.7		
Tooth number				
74	7	23.3		
75	8	26.7		
84	5	16.7		
85	10	33.3		
Group				
Infiltration	18	60.0		
IANB	12	40.0		
The remaining root length			6.4	2.5
Percentage of remaining root length (%)			58.6	22.7
Resorption stage				
Stage I	14	46.7		
Stage II	12	40.0		
Stage III	4	13.3		

IANB, Inferior alveolar nerve block; SD, Standard deviation

The Mann–Whitney test showed no significant difference in the VAS score between genders (P = 0.520). The median VAS score was 4.00 for females (n=10) and 4.50 for males (n=20), with a median difference of – 0.500 (Fig. 3a). Similarly, no significant difference was found in the VAS score between the IANB group and the infiltration group (p = 0.100). The median VAS score was 5.00 for the IANB group (n=12), and 4.00 for the infiltration group (n=18) with a median difference of – 1.00 (Fig. 3b). The Kruskal–Wallis test comparing VAS scores across the three stages also revealed no significant differences (p = 0.285). These results indicate no statistically significant variation in medians among the stages (p > 0.05) (Fig. 3c).

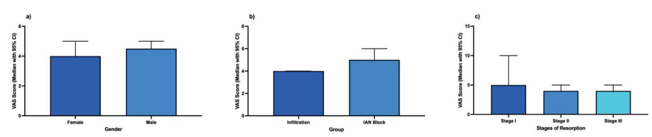

Figure 3. Comparison of visual analog scale (VAS) scores. (a) VAS scores by sex, showing the median and 95% confidence intervals (CIs) for females and males. (b) VAS scores by anesthesia group (Infiltration vs. IANB), showing the median and 95% CI. (c) VAS scores by stage of resorption (stage I, II, and III), showing the median and 95% CI.

The Pearson correlation coefficient (r) between pain severity and the percentage of remaining tooth roots was 0.31, with a 95% confidence interval ranging from – 0.052 to 0.61. The R squared value was 0.099. The two-tailed p value was 0.091, indicating no significant correlation (Fig. 4).

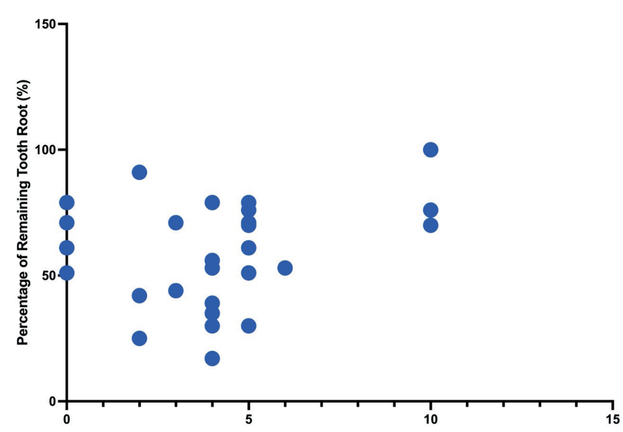

Figure 4. Scatter plot showing the correlation between pain severity (VAS score) and the percentage of the remaining tooth root.

The multiple linear regression analysis for pain severity, using the least squares method, yielded an R-squared value of 0.2864, indicating that 28.64% of the variance in pain severity is explained by the model. The ANOVA results showed that the overall model was not statistically significant (F(8, 21) = 1.053, P=0.4301). None of the individual predictors, including age, sex, extracted tooth number, group, the longest remaining tooth root, or the percentage of remaining tooth root, were significantly different (all P>0.05). The parameter estimates showed the following results: intercept (Estimate = 17.86, SE = 9.97, 95% CI = - 2.873 to 38.59, t = 1.791), age (95% CI = - 1.164 to 0.5404, t = 0.7612), sex (female) (95% CI = - 3.284 to 2.445, t = 0.3044), number of extracted teeth (95% CI = - 0.3717 to 0.1048, t = 1.165), group (IANB) (95% CI = - 2.538 to 3.523, t = 0.3381), longest remaining tooth roots (95% CI = - 1.059 to 3.801, t = 1.173), and percentage of remaining tooth roots (95% CI = - 0.4255 to 0.1341, t = 1.083). The residuals passed normality tests, confirming that the model's residuals followed a normal distribution (Table 2).

Table 2. Multiple linear regression analysis of pain severity

	Estimate	SE	95% CI	t
Intercept	17.86	9.97	-2.873 to 38.59	1.791
Age			-1.164 to 0.5404	0.7612
Gender (female)			-3.284 to 2.445	0.3044
Extracted tooth number			-0.3717 to 0.1048	1.165
Group (IANB)			-2.538 to 3.523	0.3381
The longest part of the remaining tooth root			-1.059 to 3.801	1.173
Percentage of remaining tooth root			-0.4255 to 0.1341	1.083

SE, Standard error; CI, Confidence interval; IANB, Inferior alveolar nerve block

DISCUSSION

In this prospective, observational clinical study, IANB anesthesia and infiltration anesthesia were compared in a routine clinical setting for the extraction of primary mandibular posterior teeth. Notably, to the best of the authors' knowledge, this study is the first to evaluate root resorption in the context of these anesthesia techniques. According to our results, infiltration anesthesia is at least as effective as IANB for this purpose. Consequently, we cannot reject the null hypothesis, as our findings indicate no significant differences in pain severity between the two anesthesia techniques under the conditions of this study. Our results are consistent with those of studies by Corbett et al. (2008) and Poorni et al. (2011) in adult populations, who reported similar findings. These findings are also consistent with those of Jorgenson et al.'s study (2020) in the pediatric population, which did not evaluate the degree of root resorption.

IANB remains the most commonly used anesthesia technique for surgical and restorative treatments in the posterior mandible (Foster et al., 2007; Shabazfar et al., 2014). However, it involves more complications than does buccal infiltration anesthesia (Choi et al., 2009; Jung et al., 2008; Takasugi et al., 2000). Buccal infiltration anesthesia is relatively less technique-sensitive in its application, highlighting the need for further studies to explore its use as an alternative to IANB anesthesia. In this context, our findings contribute to the ongoing discussion about optimizing local anesthesia techniques in pediatric dentistry.

Articaine is frequently preferred as an anesthetic due to its low allergic and toxic potential (Kammerer et al., 2014; Santos et al., 2007). Compared to other local anesthetic agents, it has high lipid solubility due to the thiophene ring, allowing it to penetrate bone and soft tissue more effectively, making it more efficient for infiltration injections (Arrow, 2012). It is also possible for the anesthetic agent to diffuse through the medullary bone via the accessory foramina of the mandible (Etoz et al., 2011; Madeira et al., 1978; Stein et al., 2007). These properties suggest that buccal infiltration anesthesia with articaine can be a viable option considering the thick cortical bone in the posterior mandible. The lack of difference in VAS scores between the two types of anesthesia observed in this study may be related to these properties of articaine. Furthermore, the multiple linear regression results, where root resorption was controlled as a covariate, did not seem to affect this outcome. Pearson analysis also revealed no significant correlation between the remaining root length and pain score.

In pediatric patients, one of the techniques used for pain assessment involves scales ranging from 0 to 10 (Bijur et al., 2001; Cohen et al., 2008). While this method can be influenced by patients' fear and pain expectations, it remains a reliable and widely used method (Ezoddini Ardakani et al., 2010; Kammerer et al., 2017). However, it should be noted that self-reported pain perception is subjective and can be confounded by various factors, such as the sensation of pressure, patient anxiety, and the effectiveness of the operator's behavioral management skills. This subjectivity is a limitation of this study.

The authors acknowledge that a crossover study design, including appropriate randomization and blinding, would be the ideal choice to increase internal validity (variability among patients). However, the research team decided against this approach, considering that it would further reduce participation in the study. Anesthetics were administered by a school of dentistry students with similar clinical experience rather than by a single dentist, and the study was not a split-mouth study.

In our study, the first primary molar and second primary molar teeth were examined without considering the group difference. What was important for us was the amount of resorption. However, due to their different positions in the jaw, the relationship of the teeth to the inferior alveolar nerve may be different, and the amount of numbness may also be different. For this reason, it would be more accurate to examine the results in separate groups as the first primary molar and second primary molar teeth.

These factors are considered significant limitations.

CONCLUSIONS

The findings of this study indicate that the IANB and infiltration anesthesia techniques are effective, with no significant differences in pain severity between the two methods. The lack of a significant correlation between root resorption and pain severity further supports the robustness of these results. Given the possible complications associated with IANB and the relatively simple application of infiltration anesthesia, our results suggest that infiltration anesthesia could be a viable alternative in pediatric dentistry. However, it is essential to conduct further research to confirm these findings and address other important factors, such as patient comfort, anxiety levels, and long-term outcomes.

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