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Assessment of Pulpal Anesthesia in Primary Molars with Reversible and Irreversible Pulpitis using Electric Pulp Tester

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Abstract

Background: Achieving predictable pulpal anesthesia in primary teeth is essential for successful pediatric dental procedures. However, subjective indicators such as numbness are unreliable in children, especially in cases of pulpal inflammation. Electric Pulp Testing (EPT) has shown promise as an objective method for assessing pulpal anesthesia in permanent teeth, but its reliability in primary molars—particularly those with reversible or irreversible pulpitis—remains insufficiently explored.

Aim: To evaluate the reliability of the Electric Pulp Tester as an indicator of pulpal anesthesia in primary maxillary and mandibular molars diagnosed with reversible and irreversible pulpitis.

Materials and Methods: Forty children aged 4–9 years requiring pulp therapy for primary molars were included. After standardized supraperiosteal administration of 4% articaine, soft-tissue anesthesia was verified, followed by assessment of pulpal anesthesia using a digital EPT. Responses were categorized as "pain" (positive response before 80) or "no pain" (80/80). During access opening and pulp therapy, pain behaviour was evaluated using the FLACC scale by a blinded observer. Associations between EPT scores and FLACC scores were analysed using the Chi-square test.

Results: A statistically significant correlation was found between EPT responses and FLACC scores in both maxillary and mandibular molars ($P < 0.001$). In maxillary teeth, 92.3% of children with no EPT response showed complete comfort, while 71.4% of those with positive EPT responses exhibited severe discomfort. In mandibular teeth, all children with no EPT response demonstrated comfort, whereas 50% with positive EPT responses exhibited severe pain. Teeth with irreversible pulpitis showed higher EPT responsiveness and greater discomfort during procedures.

Conclusion: EPT is a reliable, objective indicator of the adequacy of pulpal anesthesia in primary molars with reversible and irreversible pulpitis. Its use can help clinicians predict anesthetic success and determine the need for supplemental injections before initiating treatment, enhancing comfort and behaviour management in pediatric patients.

Keywords: Electric pulp tester; pulpal anesthesia; primary molars; reversible pulpitis; irreversible pulpitis; FLACC scale; pediatric dentistry; articaine; sensibility testing

Introduction

Ensuring a painless dental experience is crucial for successful management of children in a dental office. A pain – free procedure benefits not only the child but also the operator as treatment can be done in a relaxed manner and local anaesthesia plays a key role in this matter.[1] Supraperiosteal injections are effective in

anesthetising primary maxillary molars and inferior alveolar nerve block (IANB) remains the mainstay in achieving anesthesia for primary mandibular molars. Despite administering the buccal supraperiosteal injection, primary maxillary molars may sometimes still exhibit sensitivity during operative procedures. This incomplete anesthesia might be attributed to the extensively flared palatal roots, which receive additional innervation from the palatal nerves.[2] Failure of IANB to achieve anesthesia of pulp has also been reported to be approximately 10%.[1] This is clinically detected when child complaints of pain during the procedure, potentially leading to uncooperative behaviour.

Achieving adequate depth of pulpal anaesthesia is a critical component in the management of dental pain, particularly during endodontic procedures of primary molars. Subjective symptoms like numbness in the area of administration cannot be used as a reliable predictor of adequate anesthesia in children as they can be complicated by patient interpretation of pain, anxiety of the child and previous unpleasant experiences.[3]

Electric pulp testing (EPT) has been established as a valuable tool in assessment of pulp status in primary teeth with high accuracy when compared to other pulp sensibility testing methods.[4] Stimulation of intact A delta nerves in the pulp – dentine complex takes places by application of an electric current on the tooth surface which causes generation of an action potential. When the nerves are not completely anesthetized it results in a positive response.[5]

Various studies have established the role of pulp sensibility tests as an indicator for local anesthesia in permanent teeth.[6–8] However, there are limited studies on primary teeth and no studies done in teeth with irreversible pulpitis. Hence this study was aimed to evaluate the reliability of the EPT as an indicator for the adequacy of pulpal anesthesia in primary maxillary and mandibular molars diagnosed with reversible and irreversible pulpitis.

Methodology

Forty children aged 4-9 years were selected from the outpatient department of Govt Dental College and Hospital, Kadapa. The study was carried out after obtaining ethical clearance from the Institutional Ethics Committee. Informed consent was obtained from the parents before the start of the study.

The inclusion criteria were children,

1. Categorized as the American Society of Anesthesiologists 1
2. With carious lesions diagnosed with reversible pulpitis or irreversible pulpitis requiring pulp therapy for maxillary or mandibular primary molar
3. Frankl rating 3 – 4
4. No history of allergy to local anesthetic solutions

The exclusion criteria were,

1. Children who had taken analgesics 24 h before the procedure
2. Necrosed teeth
3. Teeth with more than one-third root resorption or furcal radiolucency
4. Teeth indicated for extraction.

The clinical protocol employed was as follows:

The prospective teeth were clinically and radiographically examined to confirm the diagnosis. 10% lignocaine (Lox 10%, Neon Laboratories Ltd, Mumbai, India) topical anesthetic spray was applied at the site of injection using a sterile cotton applicator tip for 30 s. 0.8 ml of 4% Articaine (Vishal Dentocare Pvt. Ltd, Ahmedabad, India) with 1:100000 epinephrine was injected supraperiosteally for maxillary and mandibular molar.[3,9] A single researcher injected the local anesthetic for all the patients. A 30-gauge needle (GDC Fine Crafted Dental Pvt. Ltd, Hoshiarpur, India) with a cartridge and syringe system were used to deliver the injections after loading with the corresponding amount of local anesthetic agent.

Five minutes after the administration of local anesthesia, gingiva surrounding the tooth was examined for soft tissue anesthesia using a blunt end probe. If the soft tissue anesthesia was deemed unreliable, an additional dose of local anesthetic solution was administered and reassessed after another five minutes. If soft tissue anesthesia remained unsatisfactory, the child was excluded from the study. If soft tissue anesthesia was found to be adequate, pulpal anesthesia was evaluated using EPT.

The tooth to be examined was dried with cotton gauze and isolated using cotton rolls. A digital Electric Pulp Tester (Waldent, New Delhi, India) with a reading range of 0-80 was used for this study. The conducting

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medium used was toothpaste (Colgate-Palmolive India Ltd, Mumbai, India). The child's thumb and forefinger were placed on the EPT lip clip to complete the circuit. The readout on the EPT digital display was recorded, when the children raised their hand on feeling an uncomfortable sensation. The EPT probe was placed on the mesiobuccal cusp tip or middle third of buccal aspect (if the mesiobuccal cusp tip was not intact) of the tooth to be tested and readings were recorded.[3] If the tooth responded to the EPT (non 80/80), it was considered as "Pain." If the tooth did not respond to EPT at 80 (80/80)it was tabulated as "No Pain Response".

On completion of the test an interval of 2 min was allowed so that the pulp could return back to their normal condition. The rubber dam was applied and the endodontic procedure for the tooth was carried out. Pulp status was confirmed on direct visual inspection of presence of bleeding and ability to control bleeding on access opening after local anesthesia. If the bleeding was hyperemic or pale red colored the diagnosis of reversible pulpitis was confirmed and pulpotomy procedure was carried out after controlling bleeding. If the bleeding was cyanotic or dark red colored, the diagnosis of irreversible pulpitis was confirmed and pulpectomy procedure was carried out.[5] During the procedure, a precalibrated observer who was blinded to the purpose of the study evaluated the intensity of pain using an observational pain rating scale – Face Legs Activity Cry Consolability scale (FLACC) [Table 1].

A supplemental palatal injection was given if pain was reported during the procedure.

Statistical Analysis

The data were compiled and subjected to statistical analysis using SPSS version 26. The level of significance was set at 5% (i.e., $P < 0.05$). The association between EPT readings and FLACC score were analyzed using Chi square test.

Results

Mean age of the recruited children was 7.27 ± 1.73. There were 20 males and 20 female among which groups 1 and 3 contained equal proportion of males and females. Group 2 contained 6 males and 4 females. Group 4 had 4 males and 6 females. The relationship between EPT values and FLACC Score in both maxillary and mandibular teeth were found to be statistically significant.

The distribution of FLACC scores and EPT scores in Maxillary molars with reversible and irreversible pulpitis is given in Fig1. In maxillary molars, 50% of children with irreversible pulpitis and 80% of children with reversible pulpitis had a FLACC score of 0 and were comfortable during procedure whereas 50% children with irreversible pulpitis and 20% children with reversible pulpitis showed some level of discomfort during the procedure. 60% of children with irreversible pulpitis did exhibit pain on EPT after administration of local anaesthesia whereas 40% children experiences pain on EPT after administration of LA.

Fig 2 shows the distribution of FLACC scores and EPT scores in mandibular molars with reversible and irreversible pulpitis. In mandibular molars with irreversible pulpitis, 80% children had FLACC score of zero whereas 20% showed severe discomfort during the procedure. Among children with reversible pulpitis, 90% children had FLACC score of zero and 10% showed moderate discomfort.

Table 2 shows the association between FLACC scores and EPT in maxilla. Among children without pain in EPT 92.3% of cases were relaxed during the procedure (no pain). Only 7.7% experienced mild pain, and none had severe pain. Among children who responded with pain on EPT only 14.3% reported being relaxed. Another 14.3% reported mild pain. A significant 71.4% reported severe pain, indicating a strong association between positive EPT findings and higher pain levels.

Table 3 shows the association between FLACC scores and EPT in mandible. 100% of cases with no pain on EPT reported being relaxed (no pain). None of the cases reported moderate or severe pain. Among children whose EPT indicated pain, only 25% reported being relaxed. Another 25% reported moderate pain. 50% reported severe discomfort, indicating a substantial shift toward higher pain perception. The results had strong statistical significance. EPT results strongly correlate with different levels of pain perception.

Discussion

This study aimed to evaluate the reliability of the Electric Pulp Tester (EPT) as an indicator for the

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adequacy of pulpal anesthesia in primary maxillary and mandibular molars diagnosed with reversible and irreversible pulpitis. The findings demonstrate a strong correlation between EPT values and clinical pain perception as measured by the FLACC scale, supporting the utility of EPT as an objective tool for assessing pulpal anesthesia in pediatric dentistry.

The role of the EPT to precisely and objectively measure the adequacy of pulpal anesthesia in permanent teeth is well established, as advocated by various researchers including Grossman, who recommended the use of pulp testers to determine whether a tooth is completely anesthetized after a local anesthetic injection before operative procedures.[3] The foundational work by Dreven et al.[6] in permanent teeth demonstrated that EPT could effectively measure analgesia in human vital teeth, finding that teeth with adequate anesthesia showed no response to EPT at maximum output. Similarly, Certosimo and Archer[10] evaluated EPT as an indicator of local anesthesia and concluded that if ineffective anesthesia could be predicted, supplemental injections could be administered to alleviate the anesthetic problem.

However, the use of EPT in primary teeth has been less extensively studied, with limited research available on its application in teeth with irreversible pulpitis. Our study addresses this knowledge gap by demonstrating that EPT can serve as a reliable predictor of anesthetic adequacy in both reversible and irreversible pulpitis cases in primary molars. The strong statistical significance ($p<0.001$) observed in both maxillary and mandibular teeth between EPT readings and FLACC scores validates the clinical utility of this diagnostic tool in pediatric practice.

Studies by Dhanaswari et al.[14] in 2021 and Chopra et al.[9] in 2022, concluded that buccal infiltration with articaine provides an effective alternative to IANB in children with minimal discomfort. Hence this study protocol employed a standardized approach using 4% Articaine with 1:100,000 epinephrine administered supraperiosteally for both maxillary and mandibular molars.

The results of this study revealed notable differences between maxillary and mandibular molars. In maxillary molars, 92.3% of children with negative EPT responses (indicating adequate anesthesia) were relaxed during the procedure, while only 14.3% of those with positive EPT responses remained comfortable. This pattern was even more pronounced in mandibular molars, where 100% of children with negative EPT responses were relaxed, compared to only 25% of those with positive EPT responses.

These findings support the clinical observation that incomplete anesthesia in primary maxillary molars might be attributed to the extensively flared palatal roots, which receive additional innervation from the palatal nerves.[2] Renuka et al.[3] in 2023**,** evaluated the reliability of the EPT as an indicator of pulpal anesthesia in primary maxillary molars and concluded that concluded that the EPT is a reliable tool as an indicator of pulpal anesthesia in primary first maxillary molars but not in second molars probably due to more flaring of palatal roots in 2nd molars. Our study contained more second molars in maxillary arch which could be the reason for more pain perception in maxilla than mandible.

Our findings are consistent with research in permanent teeth, where EPT has been validated as an effective measure of anesthetic adequacy. Recent studies by Kalantri et al.[7] and El Sayed and Gaballah[8] have demonstrated the utility of sensibility tests in assessing anesthetic efficacy in mandibular molars with symptomatic irreversible pulpitis, showing significant correlation between postanesthetic sensibility tests and clinical pain during endodontic procedures. The consistency of our results with these studies suggests that the physiological principles underlying EPT effectiveness for anesthetic assessment are similar in primary teeth, despite anatomical and developmental differences.

The failure of buccal infiltration to achieve adequate anesthesia, in primary mandibular molars was also reflected in our study. Local anesthesia in dentistry can fail for a number of reasons including ineffective anesthetic solution, complex oral anatomy, and improper technique.[1] The ability to predict ineffective anesthesia could enable clinicians to administer supplemental injections to alleviate the anesthetic problem, thereby improving treatment outcomes and patient comfort. Our findings suggest that EPT can help identify these failures before beginning the operative procedure.

An important finding of this study was the consistent reliability of EPT across both reversible and irreversible pulpitis cases. In maxillary molars, 60% of children with irreversible pulpitis exhibited pain on

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EPT after local anesthesia administration, compared to 40% with reversible pulpitis. This difference suggests that irreversible pulpitis may be associated with greater challenges in achieving adequate anesthesia, possibly due to altered neural pathways and increased inflammatory mediators that can affect anesthetic efficacy. Our findings align with the study by Modaresi et al.[11] who compared the quality of anaesthesia in intact and inflamed mandibular teeth by using an electric pulp tester and concluded that there is a resistance of inflamed pulps to local anaesthesia and recommend using the electric pulp tester as a clinical approach in evaluating the depth of anaesthesia during endodontic procedures.

The distribution of FLACC scores showed that 50% of children with irreversible pulpitis in maxillary molars had a FLACC score of 0 (comfortable), compared to 80% with reversible pulpitis. In mandibular molars, the pattern was different, with 80% of children with irreversible pulpitis achieving comfort (FLACC score 0) compared to 90% with reversible pulpitis. These findings align with clinical observations that pulp inflammation can influence the effectiveness of local anesthesia.

The use of EPT addresses the limitation of relying solely on subjective symptoms like numbness in the area of administration, which cannot be used as a reliable predictor of adequate anesthesia in children due to complications arising from patient interpretation of pain, anxiety, and previous unpleasant experiences.[3] This advantage aligns with findings from comprehensive reviews by Lin and Chandler[12] and Jafarzadeh and Abbott[13], who emphasized that EPT provides objective, quantifiable data that can guide clinical decision-making.

While EPT is valuable, no single pulp testing technique can reliably diagnose all pulp conditions, but when used as an indicator of anesthetic adequacy rather than pulp diagnosis, it provides objective, quantifiable data that can guide clinical decision-making. The ability to objectively assess anesthetic adequacy before beginning the procedure allows clinicians to administer supplemental injections when needed, potentially including palatal injections for maxillary teeth or alternative techniques for mandibular teeth. The FLACC scale used in this study provided an objective assessment of pain behavior, eliminating the subjectivity associated with self-reported pain scores in children.

While Dental Traumatology guidelines recommend against the use of sensibility tests in primary teeth, due to their lack of reliability for pulp diagnosis, our study demonstrates that EPT can be reliable when used specifically for assessing anesthetic adequacy rather than pulp vitality. However, electric pulp tests are known to be unreliable in many instances, producing false results in healthy immature teeth with incompletely formed roots. This limitation should be considered when interpreting EPT results in primary teeth with significant root development variations.

Future research should focus on comparing EPT with other objective methods of assessing anesthetic adequacy and exploring its application across different age groups and tooth types. Additionally, studies investigating the optimal EPT threshold values for different clinical scenarios in primary teeth would be valuable.

Conclusion

This study demonstrates that EPT serves as a reliable, objective indicator of pulpal anesthesia adequacy in primary molars with both reversible and irreversible pulpitis. The strong correlation between EPT values and clinical pain assessment provides clinicians with a valuable tool for predicting procedural comfort and determining the need for supplemental anesthesia. The implementation of EPT in routine pediatric dental practice could significantly improve treatment outcomes by ensuring adequate anesthesia before beginning operative procedures, thereby reducing patient discomfort and improving behavioral management during dental treatments.

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Tables

Table 1: Face Legs Activity Cry Consolability scale

Table 1. Face Legs Activity Cry Consolability scale			
	0	**1**	**2**
Face	No particular expression, Smile	Occasional Grimace or frown, withdrawn	Frequent to constant frown, clenched jaw
Legs	Normal position or Relaxed	Uneasy, Restless, Tense	Kicking, legs drawn up
Activity	Lying quietly, Normal position, Moves easily	Squirming, Shifting back and forth, Tense	Arches, rigid, jerking

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Cry	No cry (Asleep or Awake)	Moans or Whimpers, Occasional Complaint	Crying steadily, screams or sobs, frequent complaints
Consolability	Content, relaxed	Reassured by occasional touching, hugging or talking to, Distractible	Difficult to console or comfort
Interpretation of the behavioural scale			
Each category is scored on the 0–2 scale which results in the total score of 0–10 0=Relaxed and comfortable 1-3=Mild discomfort 4–6=Moderate pain 7–10=Severe discomfort pain or both			

Table 2: Association between FLACC and EPT in maxilla

EPT	FLACC (maxilla)			P value
	Relaxed	Mild pain	Severe pain	
No pain	12 (92.3%)	1 (7.7%)	0 (0%)	<0.001*
Pain	1 (14.3%)	1 (14.3%)	5 (71.4%)	
P<0.05* is considered statistically significant				

Table 3: Association between FLACC and EPT in mandible

EPT	FLACC (mandible)			P value
	Relaxed	Moderate pain	Severe pain	
No pain	16 (100%)	0 (0%)	0 (0%)	<0.001*
Pain	1 (25%)	1 (25%)	2 (50%)	
P<0.05* is considered statistically significant				

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Figures

Figure 1: EPT Score and FLACC Score in Maxillary Molars

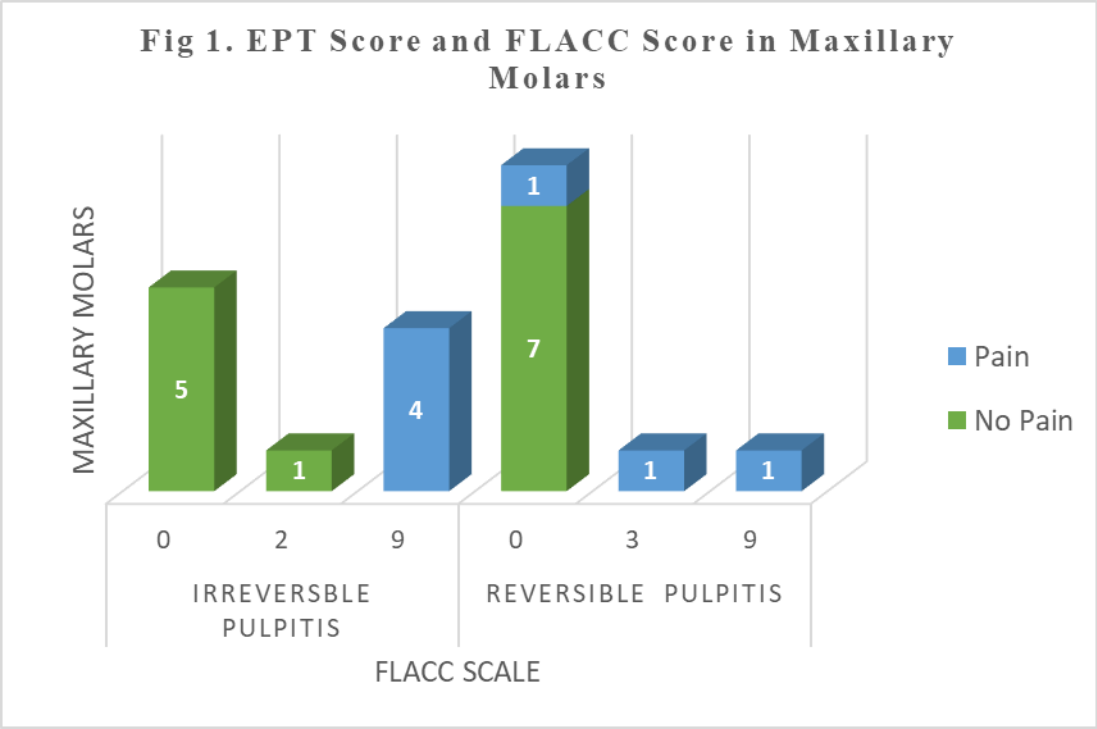
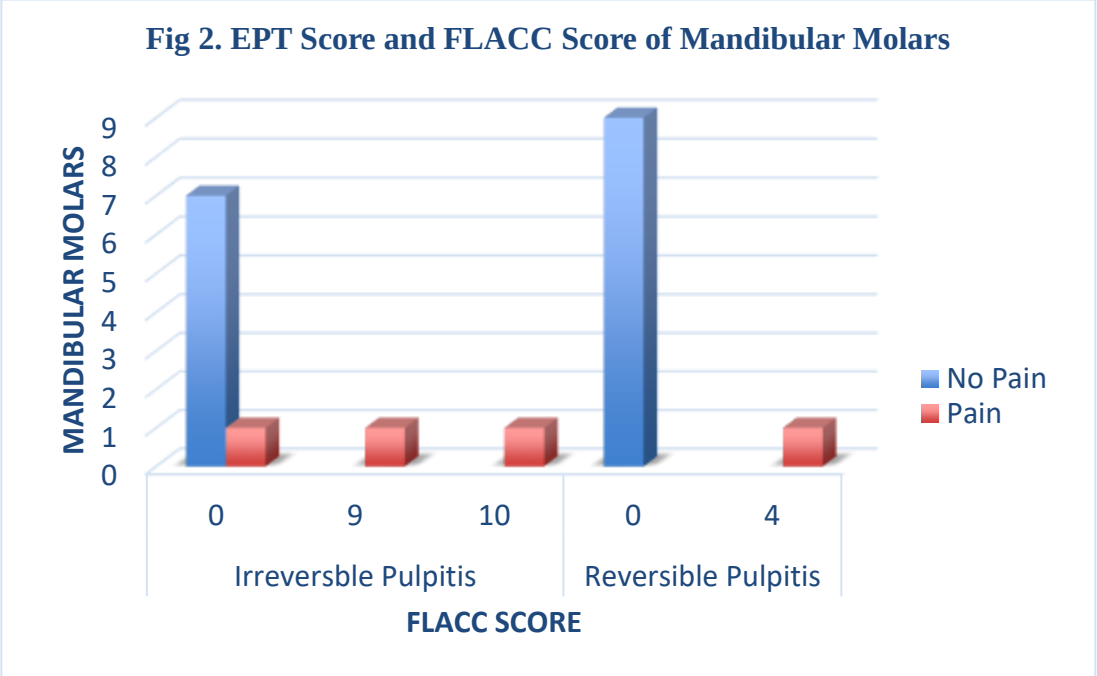


Figure 2. EPT Score and FLACC Score of Mandibular Molars



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