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Anaesthetic efficacy of periodontal ligament injection of 2% lidocaine with 1:80,000 adrenaline

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ABSTRACT

Aim: To evaluate the effectiveness of periodontal ligament injection of 2% lidocaine with 1:80,000 adrenaline in producing profound pulp anaesthesia and soft tissue anaesthesia. **Materials and Methods:** The sample of this study included 120 dental students, 72 males and 48 females, ranging in age from 18 to 23 years. The periodontal injection was administered to the periodontal space on the mesial and distal aspects of the central incisor, first premolar and first molar of both arches. The injection was administered by a standard dental syringe using 0.2 ml of 2% lidocaine with 1:80,000 adrenaline. The pulp anaesthesia was evaluated by electric pulp tester and soft tissue anaesthesia was evaluated by probing. **Results:** The success rate of pulp anaesthesia in this study was 57.5% (60% in the maxilla and 55% in the mandible). In both arches, first premolar and first molar teeth showed a significantly higher success rate than that of central incisor ($p<0.05$). The mesial and distal teeth, adjacent to the injected tooth, were anaesthetized in 29.7% and 40.8% respectively. No significant difference was noted in the success rate of pulp anaesthesia between mesial and distal teeth ($p>0.05$). The duration of pulp anaesthesia was 18.34 minutes. The duration of pulp anaesthesia was significantly longer in the mandibular than maxillary teeth ($p<0.05$). The extent of associated soft tissue anaesthesia was 14.77mm on the labial (buccal) aspect and 11.18 mm on the lingual (palatal) aspect. No significant difference was noted, in both arches, in the extension of soft tissue anaesthesia on both aspects ($p>0.05$). **Conclusion:** The periodontal ligament injection anaesthesia has a higher success rate in premolars and molars as compared to incisors. The duration of pulp anaesthesia was 18.34 minutes. The extent of soft tissue anaesthesia was 14.77 mm on the labial aspect and 11.18 mm on the lingual aspect.

Key Words: Periodontal ligament injection, local anaesthesia, lidocaine 2%, adrenaline 1:80,000.

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INTRODUCTION

Routine local anaesthetic techniques such as infiltration and the mandibular block provide, in most cases, satisfactory results. However, occasionally, when presented with a "hot" tooth with pulpal inflammation, these techniques may fail to provide good anaesthesia.[1] Adjunctive local anaesthetic techniques and their armamentaria are often marketed to clinicians as a panacea, but they are no without their own disadvantages and complications. Such techniques and equipment include intraosseous injection systems, computer–controlled systems for delivery of local anaesthesia, periodontal ligament (PDL) injection and needleless jet injection system.[2]

The PDL injections were originally described in 1924 by Cassamani, but they were not popular because the risk of blood borne infection and septicaemia was too great for the patients.[3] During the 1980s, the majority of articles pertaining to PDL injections began to appear, due to a resurgence of interest in the technique.[4] With this technique the needle is inserted through the gingival sulcus into the PDL space between the tooth and the alveolar crest.[5,6] Although special syringes and needles are available, the technique is equally effective when a standard gauge–27 needle is used.[7] The route by which the anaesthetic solution reaches the periapical tissue with a PDL injection is into and through the marrow spaces surrounding the tooth and not apically through the PDL membrane, thus making this injection comparable to the intraosseous injection.[8, 9]

The PDL injection is useful when conventional anaesthesia is not fully effective,[2] for procedures that require short anaesthesia, and when highly localized anaesthesia is necessary to diagnose the source of pain.[3] The PDL injection is also beneficial for children, hemophiliacs, immunocompromised, and pregnant women. This technique is contraindicated when infection exists at the injection site, as well as with primary teeth.[3]

The success rate of pulp anaesthesia by PDL injection is linked most closely with the use of a vasoconstrictor. Kim[1] achieved profound anaesthesia 88% of the time with 2% lidocaine with 1:50,000 adrenaline and 81% of the time with 2% lidocaine with 1:100,000 adrenaline. White *et al*.[10] found that the success rate of primary PDL injection was 79% in mandibular and 75% in maxillary first molars, and 18% in mandibular and 39% in maxillary lateral incisors. Childers *et al*.[11] reported that when PDL injection was used as a supplemental to conventional inferior alveolar nerve block, the success rate was 78%. Nusstein *et al*.[12] demonstrated that the anaesthetic success of PDL injection in lower posterior teeth with acute pulpitis was 56%.

The purpose of this study was to evaluate the effectiveness of PDL injection in attaining anaesthesia in maxillary and mandibular teeth, to determine the duration of pulp anaesthesia and the extent of associated soft tissue anaesthesia.

MATERIALS AND METHODS

The sample of this study was 120 healthy dental student volunteers, 72 males and 48 females, ranging in age from 18–23 years. Based on written clinical history and oral questioning, the subjects were judged to be in a good health, were currently taking no medication, and never had an allergic or toxic reaction to local anaesthetic agent. The sample was randomly divided into six groups, each of 20 subjects. Each group received a PDL injection for a particular tooth type. They included: Maxillary central incisor, first premolar, and first molar and mandibular central incisor, first premolar, and first molar.

Upon clinical examination, all experimental and adjacent mesial and distal teeth (which must be present) should be free of calculus, caries, restorations, root canal treatment, and exposed dentine. Periodontal probing was done on the mesial and distal aspects of each tooth. Teeth with periodontal pockets greater than 3 mm were eliminated from the study. Mobility was tested with horizontal pressure using two mirror handles positioned on the buccal and lingual aspects of the tooth. All teeth included in the study had a mobility index of M1 (less than 0.5 mm in any direction).

The experimental tooth and its adjacent mesial and distal teeth were tested for vitality by electric pulp tester (Dentotest TB09, Germany). Since the criterion of pulp anaesthesia was the response of the tooth to electric pulp tester, teeth with doubtful response were not included.

The PDL injections were administered by using a standard dental cartridge syringe and gauge–30 ultrashort dental needles. The anaesthetic agent used was 2% lidocaine with 1:80,000 adrenaline (Septodont, France). With the subject in a semisupine position, the needle was placed through the mesial gingival sulcus at 30–degree angle to the long axis of the tooth, with the bevel facing away from the tooth (Figure 1). To improve access to the posterior aspect of the first molar, the needle was bent at the hub. With the thumb and index finger of the left hand supporting the needle to prevent buckling, the needle was wedged with force into the PDL space between the tooth and the alveolar crest of the bone. The handle of the syringe was squeezed firmly until backpressure was achieved and this pressure was maintained for approximately 20 seconds, injecting at least 0.2 ml, but no more than 0.3 ml. If no strong resistance (backpressure) to the passage of solution was felt during injection, the needle was repositioned and the injection repeated. The injection was repeated on the distal interproximal space.

Immediately following completing the injections, the experimental tooth and its adjacent mesial and distal teeth were tested, every minute, for pulp anaesthesia by electric pulp tester. Complete anaesthsia was defined as the absence of subject response at the maximum output of the pulp tester. After complete anaesthesia was confi-

rmed, an automatic timer was started to measure the duration of anaesthesia. Recovery from anaesthesia was recorded when the tooth starts to respond to electric pulp testing.

Figure (1): Direction of the needle during periodontal ligament injection

The extent of soft tissue anaesthesia was determined in the following way: A periodontal probe was intermittently pressed against the gingiva as it was moved in three directions: Mesially parallel to the free gingival margin; distally, parallel to the free gingival margin; and mid–axially, toward the apex of the tooth. This pricking test was done on the labial (buccal) and lingual (palatal) aspects until the first reported sensation. The extent of soft tissue anaesthesia for each surface was found by averaging the extent of the anaesthesia in each of the three directions.

Data were statistically analyzed by Statistical Package for Social Science (SPSS) and Stat–exact programs on Pentium IV computer. For comparison of the duration of pulp anaesthesia and extent of soft tissue anaesthesia between particular tooth types, within each arch, and between total maxillary and mandibular teeth, Z–test was used. For the success rate of pulp anaesthesia, Fisher's exact test was used for comparison between teeth of the same arch and between total maxillary and mandibular teeth. A p–value less than 0.05 was considered to be significant.

RESULTS

The success rate of pulp anaesthsia after PDL injection for the experimental teeth and their adjacent mesial and distal teeth was shown in Table (1) and Figure (2). The overall success rate of pulp anaesthesia of the experimental teeth was 57.5%. The success rate was 60% in the maxillary and 55% in the mandibular teeth. This difference was not statistically significant ($p>0.05$).

Table (1): Success rate of pulp anaesthesia of the experimental teeth and adjacent mesial and distal teeth

Tooth Type	Experimental Tooth %(No.)	Mesial Tooth %(No.)	Distal Tooth %(No.)
Maxillary			
Central Incisor	35(7/20)*	30(6/20)	20(4/20)***
First Premolar	70(14/20)	20(4/20)**	35(7/20)
First Molar	75(15/20)	50(10/20)	60(12/20)
Combined	60(36/60)	33.3(20/60)	38.3(23/60)
Mandibular			
Central Incisor	20(4/20)+	5(1/20)	10(2/20)+++
First Premolar	60(12/20)	20(4/20)	50(10/20)
First Molar	85(17/20)	50(10/20)++	70(14/20)
Combined	55(33/60)	25(15/60)	43.3(26/60)
Total Sample	57.5%(69/120)	29.7(35/120)	40.8(49/120)

*Significantly difference when compared with maxillary first premolar and first molar (Fisher's exact test, $p<0.05$).

+Highly significantly difference when compared with mandibular first premolar and first molar (Fisher's exact test, $p<0.01$).

**Significantly difference when compared with maxillary first molar (Fisher's exact test, $p<0.05$).

++Significantly difference when compared with mandibular first premolar ($p<0.05$) and highly significantly difference when compared with mandibular central incisor (Fisher's exact test, $p<0.01$).

***Significantly difference when compared with maxillary first molar (Fisher's exact test, $p<0.05$).

+++Highly significantly difference when compared with mandibular first premolar and first molar (Fisher's exact test, $p<0.01$).

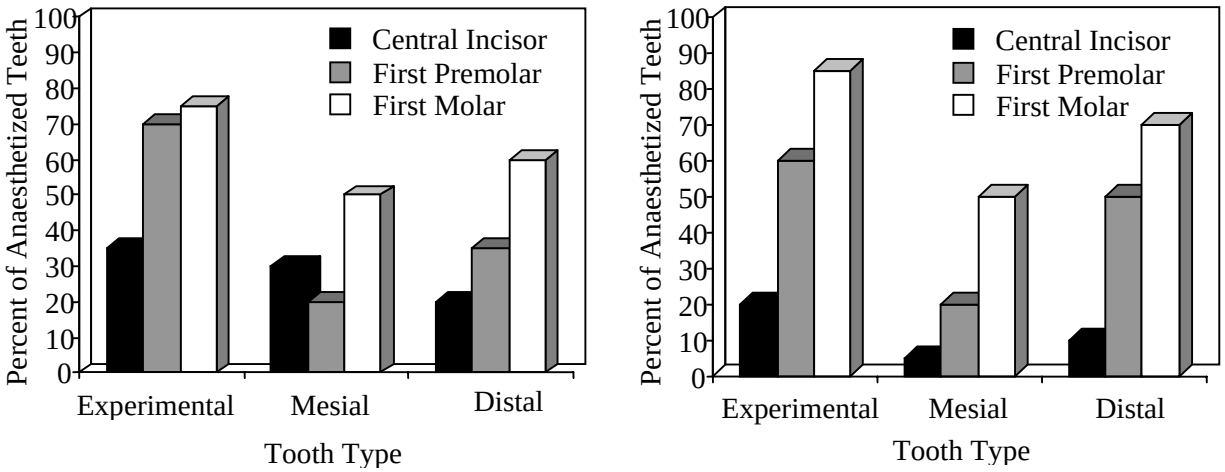

Figure (2): Success rate of pulp anaesthesia for experimental, mesial and distal teeth (Left: Maxillary teeth; right: Mandibular teeth)

The success rate of pulp anaesthesia for each maxillary tooth type was 35% for the central incisor, 70% for the first premolar, and 75% for the first molar. For each mandibular tooth type, the success rate was 20% for the central incisor, 60% for the first premolar, and 85% for the first molar. No significant difference was noted in the success rate of pulp anaesthesia between maxillary first premolar and first molar ($p>0.05$), but their success rate was significantly more than that of maxillary central incisor ($p<0.05$). No significant difference in the success rate of pulp anaesthesia was noted between mandibular first molar and mandibular first premolar ($p>0.05$). Highly significant difference was noted between mandibular central incisor and both mandibular first premolar and first molar ($p<0.01$).

The success rate of pulp anaesthesia for the adjacent mesial and distal teeth was significantly less than that for the experimental teeth ($p<0.05$). The overall success rate for the mesial teeth was 29.7% (33.3% in the maxilla and 25% in the mandible). The distal teeth showed a success rate of 40.8% (38.3% in the maxilla and 43.3% in the mandible). There was no significant difference between mesial and distal teeth ($p>0.05$).

The duration of pulp anaesthesia of the experimental teeth was shown in Table (2) and Figure (3). The duration of pulp anaesthesia for the overall sample was 18.34 $\pm$ 10.20 minutes. The mean duration for the maxillary teeth was 15.93 $\pm$ 7.68 minutes. For the mandibular teeth, the mean duration was 20.75 $\pm$ 11.80 minutes. The difference between maxillary and mandibular teeth was statistically significant ($p<0.05$). The duration of pulp anaesthesia in the maxillary central incisor was very highly significantly less than that of the first premolar and first molar ($p<0.001$). No significant difference was registered between the latter two teeth ($p>0.05$). The same results were also found in the corresponding mandibular teeth.

The extent of soft tissue anaesthesia produced by PDL injection was shown in Table (3) and Figure (4). The extent of associated soft tissue anaesthesia for the total sample was 14.77 $\pm$ 4.47 mm on the labial (buccal) aspect and 11.18 $\pm$ 3.48 mm on the palatal (lingual) aspect. The mean extension of soft tissue anaesthesia for the maxillary teeth was 14.13 $\pm$ 4.47 mm on the labial (buccal) aspect and 11.50 $\pm$ 3.86 mm on the palatal (lingual) aspect. The extension of soft tissue anaesthesia for the mandibular teeth was 15.40 $\pm$ 4.42 mm on the labial (buccal) aspect and 10.67 $\pm$ 3.05 mm on the palatal (lingual) aspect. No significant difference was present between maxillary and mandibular teeth on both aspects ($p>0.05$). The extension of soft tissue anaesthesia on the labial aspect of maxillary central incisor was significantly less than that of maxillary first molar ($p<0.05$). No significant difference was noted between maxillary first premolar and first molar regarding the extension of buccal soft tissue anaesthesia ($p>0.05$). The extension of

soft tissue anaesthesia on the palatal aspect of maxillary central incisor was significantly less than that for maxillary first premolar ($p<0.05$), and very highly significantly less than that of maxillary first molar ($p<0.001$). Significant difference was found between maxillary first premolar and first molar in the extension of soft tissue anaesthesia on the palatal aspect ($p<0.05$). Very highly significant difference was noted in the extension of labial soft tissue anaesthesia between mandibular central incisor and both mandibular first premolar and first molar ($p<0.001$). No significant difference was noted between the latter two teeth in the extension of buccal soft tissue anaesthesia ($p>0.05$). The lingual soft tissue anaesthesia showed no significant difference among mandibular teeth ($p>0.05$).

Table (2): Duration of pulp anaesthesia produced by periodontal ligament injection

Tooth Type	Duration of Pulp Anaesthesia (Minutes)			
	Minimum	Maximum	Mean	± SD
Maxillary				
Central Incisor	2.00	19.00	10.20*	4.60
First Premolar	10.00	30.00	18.40	5.70
First Molar	2.00	32.00	19.20	8.79
Combined	2.00	32.00	15.93**	7.68
Mandibular				
Central Incisor	3.00	15.00	9.90***	3.68
First Premolar	4.00	45.00	26.50	11.71
First Molar	6.00	57.00	25.85	9.78
Combined	3.00	57.00	20.75	11.80
Total Sample	2.00	57.00	18.34	10.20

*Very highly significantly difference when compared with maxillary first premolar and first molar (Z-test, $p<0.001$).

**Significantly difference when compared with combined mandibular teeth (Z-test, $p<0.05$).

***Very highly significantly difference when compared with mandibular first premolar and first molar (Z-test, $p<0.001$).

SD: Standard deviation.

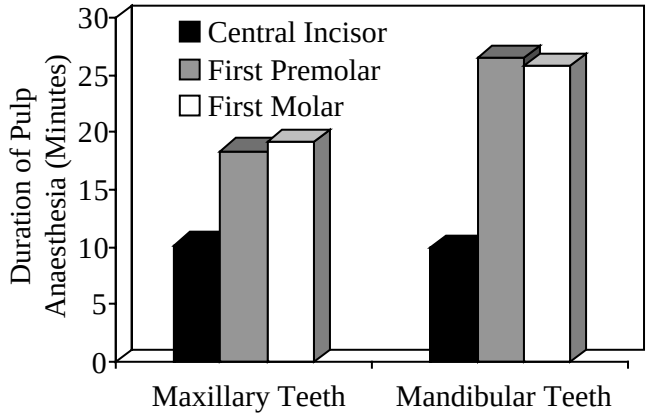

Figure (3): Duration of pulp anaesthesia after periodontal ligament injection

Table (3): Extent of soft tissue anaesthesia produced by periodontal ligament injection

Tooth Type	Extent of Soft Tissue Anaesthesia (mm)							
	Labial (Buccal) Aspect				Lingual (Palatal) Aspect			
	Minimum	Maximum	Mean	±SD	Minimum	Maximum	Mean	±SD
Maxillary								
Central incisor	4.00	24.00	12.10*	5.78	4.00	17.00	9.20**	3.24
First premolar	9.00	20.00	14.60	3.12	6.00	17.00	11.25+	3.06
First molar	10.00	22.00	15.70	3.44	10.00	24.00	14.05	3.75
Combined	4.00	24.00	14.13	4.47	4.00	24.00	11.50	3.86
Mandibular								
Central incisor	6.00	17.00	12.00++	3.11	6.00	18.00	10.45	3.66
First premolar	12.00	26.00	17.00	3.80	12.00	17.00	11.10	2.67
First molar	11.00	27.00	17.20	4.27	11.00	17.00	11.05	2.84
Combined	6.00	27.00	15.40	4.42	6.00	18.00	10.67	3.05
Total sample	4.00	27.00	14.77	4.47	4.00	24.00	11.18	3.48

*Significantly difference when compared with maxillary first molar (Z-test, $p<0.05$).
**Significantly difference when compared with maxillary first premolar (Z-test, $p<0.05$) and very highly significantly difference when compared with maxillary first molar (Z-test, $p<0.001$).
+Significantly difference when compared with maxillary first molar (Z-test, $p<0.05$).
++Very highly significantly difference when compared with both mandibular first premolar and first molar (Z-test, $p<0.001$).
SD: Standard deviation.

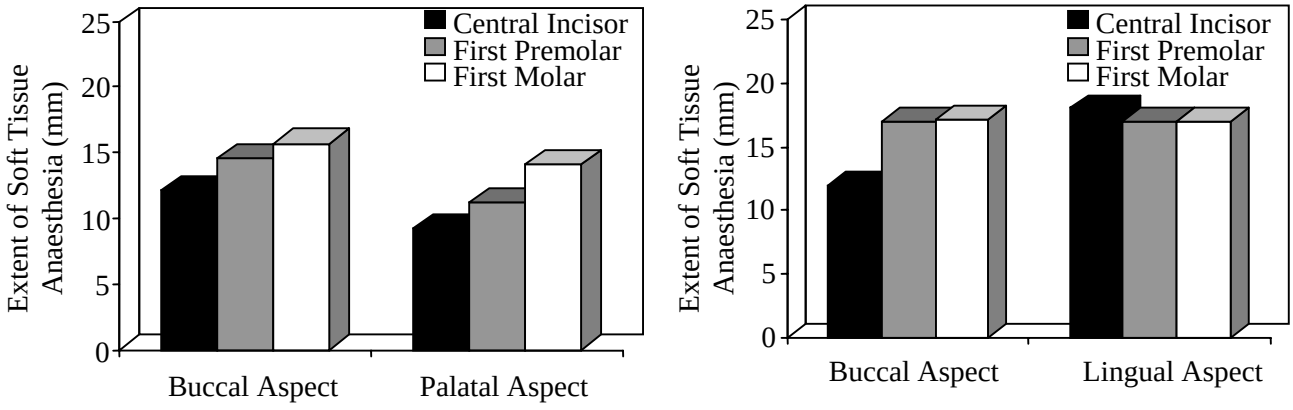

Figure (4): Extent of soft tissue anaesthesia (mm) after periodontal ligament injection
(Left: Maxillary teeth; right: Mandibular teeth)

DISCUSSION

The overall success rate of PDL injections in the present study was 57.5%. The results closely resembled those of White *et al.*[10] and Nusstein *et al.*,[13] who reported a success rate of 56.3% and 56% respectively. However, many authors have described a higher success rate for PDL injections ranging from 74%[14] to 91.6%.[15] These variations in the success rate of PDL injections may be attributed to the variations in the method of assessing success, the type of the anaesthetic agent used, the concentration of the vasoconstrictor, and the operator experience. Many of the clinical studies have relied on the dentist's evaluation of the patient's pain felt during operative or surgical procedures. These clinical evaluations are more variable when compared with the objective measurement of anaesthesia provided by the electric pulp tester. Dreven *et al.*[16] has shown that an 80 reading in normal and asymptomatic teeth resulted in complete anaesthesia. Therefore, although successful anaesthesia is almost assured if the patient does not respond to the maximum output of the pulp tester in asymptomatic teeth, a reading of less than 80 but greater than baseline may or may not correlate with success. The results

of this study indicated that success is lower when measured objectively with the electric pulp tester.

The results of this study showed that the highest success rates of pulp anaesthesia were obtained in the premolars and molars, and the lowest success rates were found in the central incisors. This variation in the success rate of PDL injections between anterior and posterior regions may be explained, anatomically, by the fact that the openings in the cribriform plate (lamina dura), through which the anaesthetic solution spread into the bone marrow spaces, increase gradually in size and number from anterior to posterior.[17] Additionally, the mandibular anterior region may limit the placement of solution due to the small interproximal spaces.

Clinically, the higher success rates in the posterior teeth, of both arches, would indicate that the PDL injections could be used, as a primary technique, to anaesthetize these teeth. The low success rates of PDL injections in the incisor region indicated that when this technique is used as a primary method, it will not provide profound anaesthesia, which is clinically predictable.

Anaesthesia of adjacent teeth was obtained in 30% of the mesial and 40% of the distal teeth. The results came in close resemblance to those of White *et al*.[10] As PDL injection is a form of intra–osseous injection,[8] anaesthesia is not limited to single tooth, because the solution is not confined to PDL alone; rather it is distributed widely by passing through the cribriform plate and the medullary bone spaces into the vasculature in and around the affected tooth and the adjacent teeth. Several other authors[18–20] have confirmed the widespread distribution of anaesthetic solution in and around the bone and the adjacent teeth. The results of the present study were not in agreement with those of Simon *et al*.[21] and Littner *et al*.[22] They both reported that single tooth anaesthesia could be obtained with the PDL injection and this technique could be used as an aid in endodontic diagnosis.

The success rates of pulp anaesthesia for the adjacent teeth were lower than the experimental teeth. This may indicate that perfusion of the anaesthetic solution to adjacent teeth is less than in the tooth injected. Generally, the distal teeth had a higher success rate than mesial teeth. This could be explained by the observations of Birn,[17] who found that perforations in the walls of the cribriform plate increased from the incisors toward the molars, thus allowing for injection of the solution distally more readily than mesially. From the results of this study, it was convinced that the PDL injections cannot anaesthetize a single tooth, without causing anaesthesia of adjacent teeth, and that the PDL injection technique for diagnosis of a problem tooth, therefore, has serious limitations.

The duration of pulp anaesthesia in the present study ranged between 2–57 minutes, with a mean of 18.34 minutes. The results came in agreement with many previous studies. Kaufman *et al*.[5] found that PDL injection of 2% lidocaine with 1:50,000 adrenaline produced a mean duration of profound anaesthesia of 27.05 minutes and a range of 0–67 minutes. In the report of Kaufman *et al*.,[5] anaesthesia by PDL injection of 2% lidocaine without adrenaline had a mean duration of 1.05 minutes and a range of 0–2.5 minutes. In that same report, a review of the literature indicated that most studies reported duration of anaesthesia concentrating on 20 minutes. A study by Johnson *et al*.[23] concluded that 2% lidocaine with 1:100,000 adrenaline produced effective anaesthesia for 17.3 minutes and reported that adrenaline concentration was more important than any other factor. Dower and Barniv[25] also reported that the duration of pulp anaesthesia was ~ 20 minutes. Therefore, from the results of this study and previously mentioned studies, the PDL injection as a primary technique is indicated for procedures of short duration. When using PDL injection as a supplemental technique, the clinician must be aware that profound anaesthesia is probably also of short duration.

Soft tissue anaesthesia occurred on both labial (buccal) and palatal (lingual) aspects. The mean extension of the former was 14.77mm and the later was 11.18mm. The results came in accordance with those of Kaufman *et al*.[5] As the soft tissue became anaesthetized, procedures that involve soft tissues, such as extraction, could be reformed without supplemental infiltration

or submucous injection. The explanation for greater buccal soft tissue anaesthesia than palatal soft tissue anaesthesia may be due to more buccally directed placement of the needle.

CONCLUSIONS

The periodontal ligament injection using 2% lidocaine with 1:80,000 adrenaline had a higher success rate in both maxillary and mandibular first premolar and first molar, as compared to central incisor. The adjacent mesial and distal teeth could be anaesthetized, although the success rate overall was lower than in the tooth injected. The duration of pulp anaesthesia was 18.34 minutes, with the duration being significantly longer in posterior as compared to anterior region. The soft tissue, on both labial (buccal) and lingual (palatal) aspects, became anaesthetized to an extent of 14.77 mm for the former and 11.18 mm for the latter.

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