CHAPTER 4

Results

4.1 General information

Sixty four permanent mandibular molars were originally recruited in this study. Two teeth from two patients were excluded from this study due to uncooperative behavior and two teeth from two patients were also excluded due to negative response to Endo-Ice® cold test indicating high probability of non-vital pulp. This study finally consisted of 60 permanent mandibular molars (58 first permanent molars, 2 second permanent molars) from 53 healthy patients (27 males, 26 females), who were between 7-20 years old (mean 131.27± 34.55 months).

Table 4.1 presents the general information including age, gender, diagnosis, anxiety level, stage of root development and operators.

To diagnose the pulpal status of deep carious teeth studied, both clinical symptom and Endo-Ice® cold test were incorporate. Twenty-seven teeth were diagnosed as normal pulp. Twenty teeth were diagnosed as reversible pulpitis and thirteen were diagnosed as irreversible pulpitis. Percentage agreement between the clinical symptom and Endo-Ice® cold test was only 51.67% (31/60). The diagnosis determined by clinical symptom was more severe than by the one with Endo-Ice® cold test.

Before beginning the dental procedure, Facial image scale (FIS) (Appendix C) was used to evaluate the anxiety levels of the patients. Most patients 84.48% (49/58) scored 1-3, which mean that the majority of participants had none to mild anxiety before the dental procedure.

Stage of root development was evaluated from periapical radiograph following Demirjian et al. (117), 36.70% (22/60) and 63.30% (38/60) of our samples were in the G and H stages of root development respectively.

There were four operators participating in this study. Operator No.1, 2, 3 and 4 operated 47 (78.30%), 9 (15.00%), 2 (3.00%), 2 (3.00%) cases, respectively.

Table 4.2 presents the general information of three groups with different pulpal diagnoses. Age, gender and stage of root development of the subjects in each group were not statistically significant different.

Table 4.1 General information

General information	Total (N=60)
Age (Months)	131.27±34.55
Gender % (n/N)	
Male	46.70% (28/60)
Female	53.30% (32/60)
Diagnosis % (n/N)	
Normal pulp	45.00% (27/60)
Reversible pulpitis	33.33% (20/60)
Irreversible pulpitis	21.67% (13/60)
Anxiety levels*(FIS) % (n/N)	
1	20.69% (12/58)
2	29.31% (17/58)
3	34.48% (20/58)
4	10.34% (6/58)
5	5.17% (3/58)
Stage of root development % (n/N)	
G	36.70% (22/60)
H	63.30% (38/60)
Operators	
No. 1	47 (78.30%)
No. 2	9 (15.00%)
No. 3	2 (3.00%)
No. 4	2 (3.00%)

*Missing data: 2 cases

Table 4.2 General information of three groups with different pulpal diagnoses

Diagnosis / General Information	Normal pulp (n=27)	Reversible pulpitis (n=20)	Irreversible pulpitis (n=13)	*p* value	Statistic test
Age (Months) Median (Min:Max)	116.0 (84:219)	133.5 (90:219)	116.0 (105:244)	0.235 NS	Kruskal-Wallis
Gender % (n/N)					
Male	14 (51.9%)	8 (40%)	6 (46.2%)	0.722 NS	Pearson Chi-square
Female	13 (48.1%)	12 (60%)	7 (53.8%)		
Anxiety levels (FIS) % (n/N)	No data:1	No data:1			
1	7	3	2		
2	7	6	4		
3	9	8	3		
4	1	2	3		
5	2	0	1		
Stage of root development % (n/N)					
G	14 (51.9%)	6 (30%)	2 (15.4%)	0.260 NS	Pearson Chi-square
H	13 (48.1%)	14 (70%)	11 (84.6%)	0.535 NS	

NS: No significant difference (p>0.05) between group

4.2 Pre-operative phase

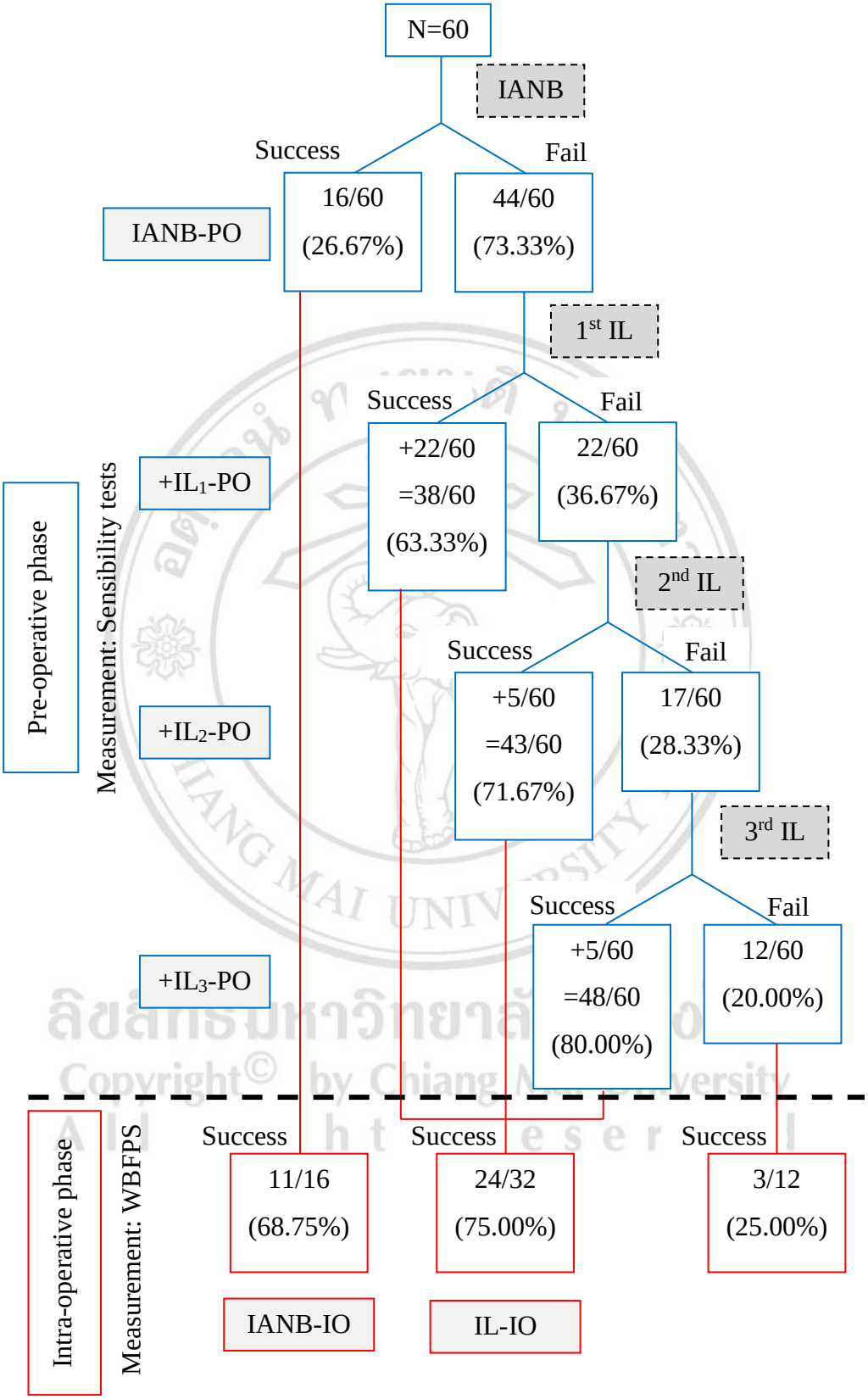

Figure 4.1 The cumulative success and failure rates of pulpal anesthesia in pre-operative and intra-operative phases

4.2.1 After the IANB administration

After ten minutes of the IANB administration, sign of soft tissue anesthesia including lip and tongue numbness were evaluated. We found the success rate of soft tissue anesthesia by the IANB technique after 10 minutes to be 90.00% (54/60). After waiting for another five minutes, the success rate of soft tissue anesthesia by IANB was increased to 93.33% (56/60). Then, IANB was re-administered in four cases, 6.67% (4/60), that soft tissue numbness did not occur after the first IANB administration. Soft tissue numbness was then re-evaluated and all four cases had soft tissue numbness after the second IANB administration.

After the success of soft tissue anesthesia by IANB was reassured in all cases, the pulpal anesthesia was evaluated using the sensibility tests including Endo-Ice® cold test and EPT. Overall success rate of pulpal anesthesia by IANB pre-operatively (IANB-PO) was 26.67% (16/60) (Figure 4.1 and Table 4.3). Success rates of pulpal anesthesia by IANB in the teeth diagnosed as normal pulp, reversible pulpitis and irreversible pulpitis were 40.70% (11/27), 15.00% (3/20) and 15.38% (2/13), respectively (Table 4.3). There were no significant differences of the success rates of pulpal anesthesia by IANB between different pulpal diagnoses.

Permanent ipsilateral teeth (incisors, canines and premolars) were used as the controls for pulpal anesthetic test after the confirmation of soft tissue anesthesia following IANB. Interestingly, we found that 28.33% (17/60) of control teeth still responded to the sensibility tests after the IANB administration that means that the success rate of pulpal anesthesia in the ipsilateral control group, the assumed normal pulp teeth, was 71.67% (43/60).

Interestingly, in the cases that the ipsilateral control teeth did not respond to both sensibility tests indicating the success of pulpal anesthesia by IANB, 48.33% (29/60) of the ipsilateral studied teeth in these cases still responded to at least one of both sensibility tests.

In this study, both Endo-Ice® cold test and EPT were used to evaluate pulpal anesthesia in the pre-operative phase. We found that the agreement between these two sensibility tests, where both Endo-Ice® cold test and EPT gave the same results, were 61.67%.

Long buccal nerve block technique, which was used to anesthetize buccal soft tissue, was necessary in this study because the operation surely invaded buccal gingival tissue. Pulpal anesthesia of eight cases in the pilot study was evaluated by both sensibility tests after the administration of the long buccal nerve block. We found that if there was a positive response to sensibility tests before long buccal nerve block, pulp responded in the same manner after the long buccal injection in all cases. Thus, it may be assumed that the long buccal nerve block technique did not affect pulpal anesthesia of studied teeth in our study.

4.2.2 After the supplemental IL administration

An IL injection was used as a supplemental technique after facing a failure of pulpal anesthesia following IANB. Success rates of pulpal anesthesia by the supplemental IL injection were presented in Table 4.3. Overall cumulative success rates of pulpal anesthesia following the first, second and third supplemental IL injections pre-operatively (+IL_1-PO, +IL_2-PO, +IL_3-PO) were 63.33% (38/60), 71.67% (43/60) and 80.00% (48/60), respectively (Figure 4.1 and Table 4.3). The first IL injection significantly increased the success rate of pulpal anesthesia ($p<0.001$) as shown in Table 4.5, while there were no significant differences between increased success rates of pulpal anesthesia by the second and third IL injections.

In the normal pulp group, success rates of pulpal anesthesia following the first, second and third supplemental IL injections pre-operatively (+IL_1-PO, +IL_2-PO, +IL_3-PO) were 62.96% (17/27), 74.07% (20/27) and 85.19% (23/27), respectively (Table 4.3). There was no significant difference of success rates between each supplemental IL injection (Table 4.5).

In the reversible pulpitis group, success rates of pulpal anesthesia following the first, second and third supplemental IL injections pre-operatively (+IL_1-PO, +IL_2-PO, +IL_3-PO) were 70.00% (14/20), 80.00% (16/20) and 85.00% (17/20), respectively (Table 4.3). The first IL injection significantly increased the success rates of pulpal anesthesia (p=0.001) as shown in Table 4.5, while there were no significant differences between increased success rates of pulpal anesthesia of the second and third IL injections.

In the irreversible pulpitis group, success rates of pulpal anesthesia following the first, second and third supplemental IL injection pre-operatively (+IL_1-PO, +IL_2-PO, +IL_3-PO) were 53.85% (7/13), 53.85% (7/13) and 61.54% (8/13), respectively (Table 4.3). There was no significant difference between success rates of pulpal anesthesia by each supplemental IL injection (Table 4.5).

The higher the number of IL injections, the more cumulative success rates of pulpal anesthesia as shown in Table 4.3. However, although the success rates were not statistically significant, the irreversible pulpitis group seemed to have lower pulpal anesthetic success in all steps compared to the other two diagnoses.

Table 4.3 Cumulative success rates of pulpal anesthesia in different pulpal diagnoses in pre-operative phase (IANB-PO and +IL-PO)

	Normal pulp (N=27) % (n/N)	Reversible pulpitis (N=20) % (n/N)	Irreversible pulpitis (N=13) % (n/N)	Total (N=60) % (n/N)	*p* value	Statistic test
IANB-PO	40.70% (11/27) (a)	15.00% (3/20) (b)	15.38% (2/13) (c)	26.67% (16/60)	0.214[ab] (NS) 0.305[ac] (NS) 1.000[bc] (NS)	Fisher's Exact
+IL_1-PO	62.96% (17/27)	70.00% (14/20)	53.85% (7/13)	63.33% (38/60)	0.903 (NS)	Chi-square
+IL_2-PO	74.07% (20/27)	80.00% (16/20)	53.85% (7/13)	71.67% (43/60)	0.781(NS)	Chi-square
+IL_3-PO	85.19% (23/27)	85.00% (17/20)	61.54% (8/13)	80.00% (48/60)	0.808 (NS)	Chi-square

a: normal pulp, b: reversible pulpitis, c: irreversible pulpitis

Table 4.4 Increased success rates following supplemental IL injection in different pulpal diagnoses

	Normal pulp	Reversible pulpitis	Irreversible pulpitis	Overall
+1st IL	22.22%	55.00%	38.46%	36.67%
+2nd IL	11.11%	10.00%	0.00%	8.33%
+3rd IL	11.11%	5.00%	7.69%	8.33%

Table 4.5 The statistic value (*p* value) of increased success rate of pulpal anesthesia after supplemental IL injection

	Normal pulp	Reversible pulpitis	Irreversible pulpitis	Overall
1st IL	0.102	*0.001	0.097	†<0.001
2nd IL	0.379	0.716	1.000	0.330
3rd IL	0.501	1.000	0.691	0.286

* There was significant difference ($p<0.05$), Fisher's exact test

†There was significant difference ($p<0.05$), Pearson Chi-square

4.3 Intra-operative phase

After the pulpal anesthesia was confirmed by the sensibility tests in the pre-operative phase, the operative procedure was started. The WBFPS (Appendix D) was used to evaluate the success of pulpal anesthesia during the intra-operative phase. Success of intra-operative pulpal anesthesia was determined when patients scored 4 or less.

Overall success rate of intra-operative pulpal anesthesia following success of IANB alone (IANB-IO) and with supplemental IL injection (+IL-IO) were 68.75% (11/16) and 75% (14/32), respectively (Table 4.6).

When consider each diagnosis separately, success rates of intra-operative pulpal anesthesia by IANB (IANB-IO) and IL injections (+IL-IO) were shown in Table 4.6. Success rates of intra-operative pulpal anesthesia by IANB alone (IANB-IO) and supplemental with IL injection (+IL-IO) in the normal pulp group were 81.82% (9/11) and 83.33% (10/12), respectively.

Success rates of intra-operative pulpal anesthesia by IANB alone (IANB-IO) and supplemental with IL injections (+IL-IO) in the reversible pulpitis group were 33.33% (1/3) and 78.57% (11/14), respectively.

Success rates of intra-operative pulpal anesthesia by IANB alone (IANB-IO) and supplemental with IL injection (+IL-IO) in the irreversible pulpitis group were 50% (1/2) and 50% (3/6), respectively.

After the third IL administration, there were 20.00% (12/60) of teeth that still responded to the sensibility tests in the pre-operative phase, interestingly, 25% (3/12) of them had pulpal anesthetic success in the intra-operative phase (Figure 4.1).

Table 4.6 Success rates of pulpal anesthesia during intra-operative phase

Diagnosis	Normal pulp	Reversible pulpitis	Irreversible pulpitis	Overall
IANB-IO	81.82% (9/11)	33.33% (1/3)	50.00% (1/2)	68.75% (11/16)
+IL-IO	83.33% (10/12)	78.57% (11/14)	50.00% (3/6)	75.00% (24/32)

4.4 Failure rate of IANB technique and success rate of pulpal anesthesia in different operators

There were four operators participating in this study. The failure rates of blocked techniques, which soft tissue anesthesia was not presented after IANB within 15 minutes, and the success rates of pulpal anesthesia in pre-operative and intra-operative phase of each operator were shown in Table 4.7.

Table 4.7 Failure rate of IANB technique and success rate of pulpal anesthesia in different operators

Operators	No. 1 (N=47)	No.2 (N=9)	No.3 (N=2)	No.4 (N=2)
Failure of IANB technique	6.38% (3/47)	11.11% (1/9)	0.00% (0/2)	0.00% (0/2)
IANB-PO	27.70% (13/47)	22.22% (2/9)	0.00% (0/2)	50.00% (1/2)
+IL-PO	73.53% (25/34)	71.43% (5/7)	50.00% (1/2)	100.00% (1/1)
IANB-IO	84.60% (11/13)	0.00% (0/2)	-	0.00% (0/1)
+IL-IO	72.00% (18/25)	60.00% (3/5)	100.00% (1/1)	100.00% (1/1)

4.5 Agreement and sensitivity of sensibility tests

Although the Endo-Ice® cold test was the main sensibility test used in this study to determine both vitality and diagnosis of all sixty studied teeth, EPT was also tested in 58 studied teeth to evaluate the agreement between both tests. The agreement between both tests was 89.66% (52/58). The number of true positive (TP) and false negative (FN) in each test was calculated. Then the sensitivity was calculated according to the formula TP/ (TP+FN). The sensitivities of Endo-Ice® cold test and EPT in these 58 deep carious molars teeth were 0.97 and 0.93 respectively.

In 108 control teeth, including contralateral and ipsilateral teeth in this study, the agreement between these two sensibility tests was 80.56% (87/108). The sensitivity of Endo-Ice® cold test and EPT were 0.91 and 0.84, respectively, as shown in Table 4.8 and Table 4.9.

Table 4.8 Sensitivity of Endo-Ice® cold test in different teeth position

	Endo-Ice® cold test		Total	Sensitivity
	Positive	Negative		
Central incisors	5	0	5	1.00
Lateral incisors	30	1	31	0.97
Canine	2	0	2	1.00
First premolars	13	2	15	0.87
Second premolars	18	2	20	0.90
First molars	27	5	32	0.84
Second molars	3	0	3	1.00
Total	98	10	108	0.91

Table 4.9 Sensitivity of EPT in different teeth position

	EPT		Total	Sensitivity
	Positive	Negative		
Central incisors	4	1	5	0.80
Lateral incisors	27	4	31	0.87
Canine	2	0	2	1.00
First premolars	10	5	15	0.67
Second premolars	15	5	20	0.75
First molars	30	2	32	0.9
Second molars	3	0	3	1.00
Total	91	17	108	0.84

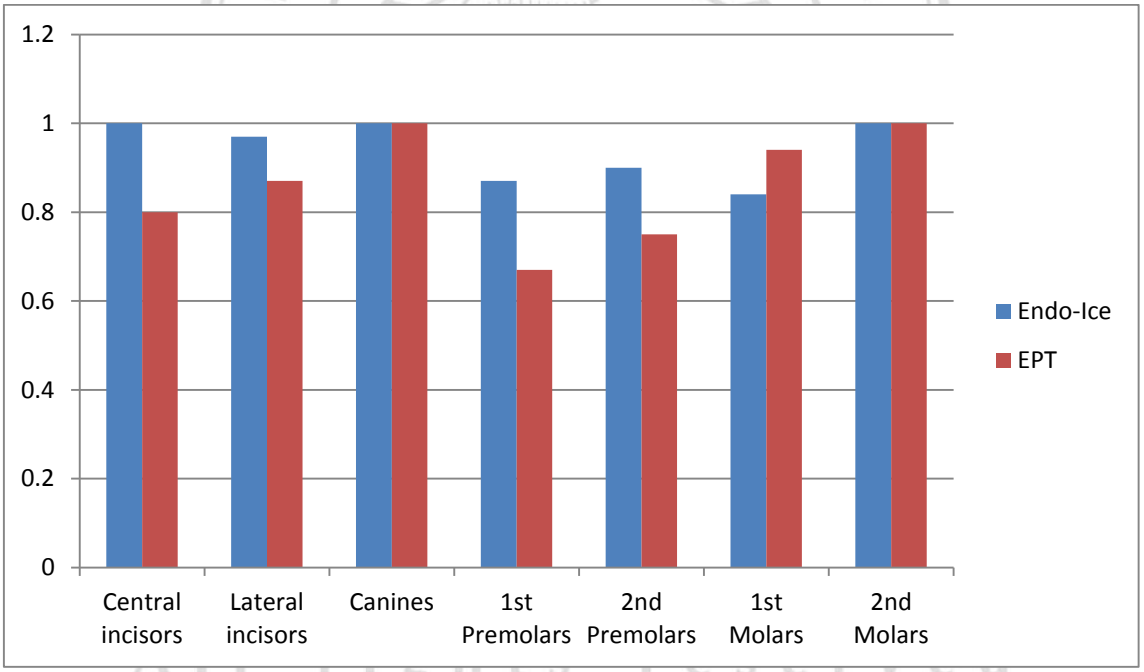

Figure 4.2 Sensitivity of Endo-Ice® cold test and EPT in different teeth position