CHAPTER FOUR: RESULTS AND ANALYSES

4.1. Introduction

In general all the data were first collectively analyzed (Table 4.1).

Table 4.1 The mean dimensional measurement of the incisive canal and related structures

Structure	n	Mean (SD) (mm)
Incisive foramen (Labiopalatal)	94	2.80 (0.81)
Incisive foramen (Mesiodistal)	94	3.49 (0.98)
Nasal foramen (Labiopalatal)	94	6.03 (2.96)
Incisive canal length	94	16.24 (4.38)
Incisive canal width	94	3.84 (1.32)
Anterior maxillary bone thickness	94	7.54 (1.65)
Incisive foramen location	94	11.92 (3.09)

From Table 4.2 shows that there was a significant difference observed in the incisive canal length optional between right and left side (*P*=0.024); the difference between the two sides was only 0.67 mm. For this reason, the incisive canal length was taken from both right and left side individually for our analysis.

Table 4.2 Comparison of the incisive canal length between right and left sides

Incisive canal length	Right side Mean(SD)	Left side Mean(SD)	Mean different (95%CI)	*P* value[a]
	16.65 (4.46)	15.98 (4.71)	0.67 (0.09,1.26)	0.024

a. Paired t-test was used

4.2. According to gender

To know the anatomical variations between the gender the following comparisons were done.

4.2. 1. Comparison of the dimensions of the incisive canal and related structures between males and females

The assumption of outcomes being normally distributed and equality of variances was checked. Independent t-test was used when the assumption was met and in cases where the assumption was violated Mann-Whitney test was performed.

The results in Table 4.3 showed that there was a significant difference in the labiopalatal diameter of the incisive foramen (*P* =0.004). Males show higher mean values than females, which means they have a larger diameter of incisive foramen than females.

However, there was no significant difference between males and females when mesiodistal diameters of incisive foramen, nasal foramen and the incisive foramen location were compared (*P* = 0.942, *P* =0.097 and *P* = 0.520 respectively).

Significant difference was observed when the incisive canal length was compared between males and females from both sides (*P* value for right side=0.001 while *P* value for left side=.002). The incisive canal was longer in males than females on both sides, with a mean difference of 3.59 mm in the right side and 2.99 mm in the left side. In general the right side of the incisive canal was longer in males and females than the left side. The mean difference between the two sides was 0.97 mm in males and 0.37mm in females. In addition the mean width value of the incisive canal of males was higher (4.14 mm) when compared to females (3.52 mm).The *P* value attained was 0.22. With regards to the anterior maxillary bone thickness, the *P* value was 0.002 indicating that

there was significant difference between males (mean=8.05 mm) and females (mean = 7.00 mm).

Table 4.3 Comparison the dimensions of the incisive canal and related structures between males and females

Dependent variable	Males n=48 Mean (SD) mm	Females n=46 Mean (SD) mm	*Mean diff. (95% CI)*	*P* value[a]
Incisive foramen (Labiopalatal)	3.03 (0.76)	2.56(.79)	0.46 (0.15,0.78)	0.004
Incisive foramen (Mesiodistal)	3.30 (1.30)[c]	3.3(1.0)[c]	_	0.942[b]
Nasal foramen (Labiopalatal)	5.81(3.20)[c]	5.16(3.0)[c]	_	0.097[b]
Right incisive canal length	18.41 (4.05)	14.82 (4.15)	3.58 (1.91,5.26)	0.001
Left incisive canal length	17.44 (4.10)	14.45 (4.85)	2.99 (1.16,4.84)	0.002
Incisive canal width	4.14 (1.44)	3.52(1.1)	.618 (0.09,1.15)	0.022
Bone thickness	8.05 (1.75)	7.00(1.35)	1.05 (0.41,1.70)	0.002
Incisive foramen location	11.71(2.89)	12.13(3.31)	-0.42 (-1.68,0.85)	0.520

a. Independent t-test was used
b. Mann-Whitney test was used
c. Median (IQR)
Level of significant was set at 0.05.

Table 4.4 shows that there was no significant difference between male and female in the incisive canal direction (*P*=0.470). The slanted-curve canal was slightly more common in females (70%) than males (62.5%). This type of course and direction of the canal was more common than the slanted- straight type.

Table 4.4 Association between incisive canal course and direction and gender

Variable	n	Incisive canal course and direction		*P* value[a]
		Slanted-curve Freq (%)	Slanted-straight Freq (%)	
Sex				
Males	48	30(62.5)	18(37.5)	0.470
Females	46	32(70)	14(30)	

a. Chi Square was used
Level of significant was set at 0.05

Table 4.5 shows no significant difference in the number of the channels in the middle portion of the incisive canal when comparison was made between males and females (*P*=0.218). Furthermore, most of the cases have one channel at the middle portion (71% in male and 59% in female).

Table 4.5 Comparison of number of channel at the middle portion between males and females

Variable	n	No. of channel at the middle portion		*P* value[a]
		1 channel Freq (%)	2 channel Freq (%)	
Sex				
Males	48	34(71)	14(29)	0.218
Females	46	27(59)	19(41)	

a. Chi Square was used
Level of significant was set at 0.05

Note: Only one case (Chinese male) showed 3 channels at the middle portion of the incisive canal. This finding was omitted for the statistic test.

4.2. 1. 1. Comparison of the incisive canal length and the nasal foramen diameter (labiopalatal) between right and left side in males

The assumption of outcomes being normally distributed and equality of variances were met thus paired *t*-test was used. Additionally comparisons were done within the same

gender to determine if there is any variation between the left and right side. Although there is a clear significant difference between right and left incisive canal length in males (P = 0.009) (Table 4.6), the right incisive canal mean was (18.4 mm) while the left incisive canal mean was (17.44 mm). However no significant difference was observed between the right and left nasal foramen (labiopalatal) diameter (P=0.261).

Table 4.6 Comparison of the incisive canal length and the nasal foramen diameter (labiopalatal) between right and left side in males

Variable	Right IC length Mean (SD) mm	Left IC length Mean (SD) mm	Mean of length different (95%CI)	*P* value[a]
Incisive canal length	18.40 (2.45)	17.44 (2.45)	0.96 (0.25,1.67)	0.009
Nasal foramen (Labiopalatal)	6.70 (1.90)	6.38 (1.90)	0.31 (-0.24,0.86)	0.261

a. Paired t-test was used
Level of significant was set at 0.05

4.2. 1. 2. Comparison of the incisive canal length and the nasal foramen diameter (labiopalatal) between right and left side in females

The assumption of outcomes being normally distributed and equality of variances were not met thus Wilcoxon Signed Rank test was used instead of paired t-test. According to Table 4.7 there is a significant difference between the right and left incisive canal length (P = 0.006) while the nasal foramen did not show any significant difference between the right and left diameter (P=0.764).

Table 4.7 Comparison of the incisive canal length and the nasal foramen diameter (labiopalatal) between right and left side in females

	Depended variable	Right side Median (IQR) mm	Left side Median (IQR) Mm	*P* value[a]
Female	Left IC length-Right IC length	15.07 (5.4)	14.35 (5.8)	0.006
	Left nasal foramen-Right nasal foramen	4.97 (3.1)	5.22 (3.2)	0.764

a. Wilcoxon test was used
Level of significant was set at 0.05

4.3. Comparison of the dimensions of the incisive canal and related structures between the Malays and Chinese

Comparison was done between ethnicity (Malays and Chinese) to determine any variation amongst them. The assumption of outcomes being normally distributed and equality of variances was checked. Independent t-test was used when the assumption was met and in cases where the assumption was violated Mann-Whitney test was performed. Although the results showed no significant differences in most of the measurements between Malays and Chinese, (Table 4.8) the nasal foramen diameter showed a slight significant difference ($P = 0.028$). The mean value of the Malays was (5.06 mm) while for the Chinese was (6.48 mm). This difference in the mean between the two ethnicity indicated that the nasal foramen diameter in the Chinese was the only feature that was larger than in the Malays.

Table 4.8 Comparison of the dimensions of the incisive canal and related structures between the Malays and Chinese

Dependent variable	Malays n=47 Mean (SD) mm	Chinese n=47 Mean (SD) mm	*Mean diff. (95% CI)*	*P* value[a]
Incisive foramen (Labiopalatal)	2.92 (0.79)	2.67 (0.81)	0.25 (-0.07,0.58)	0.125
Incisive foramen (Mesiodistal)	3.57 (1.01)	3.42 (0.96)	0.15 (-0.25,0.55)	0.459
Nasal foramen (Labiopalatal)	5.06 (2.6)[c]	6.48 (5.0)[c]	–	0.028[b]
Right incisive canal length	15.83 (4.76)	17.47(4.01)	-1.64 (-3.44,0.16)	0.075
Left incisive canal length	15.15 (4.47)	16.80 (4.84)	-1.65 (-3.56,0.26)	0.089
Incisive canal width	3.36 (1.5)[c]	4.0 (2.2)[c]	–	0.054[b]
Bone thickness	7.49 (2.3)[c]	7.54 (2.6)[c]	–	0.788[b]
Incisive foramen location	12.55 (3.7)[c]	12.2 (5.1)[c]	–	0.268[b]

a. Independent T-test was used *level of significant was set at 0.05.
b. Mann-Whitney test was used
c. Median (IQR)

In addition, the incisive canal course and direction showed significant difference with a *(P* =0.030) (Table 4.9). Although the slanted-curved canal is prevailing in both races, the Malays have shown a higher percentage than the Chinese, where the percentage for Malays was 77% and for Chinese was 55%.

Table 4.9. Comparison of the incisive canal course direction between the Malays and the Chinese

Variable	n	Incisive canal course and direction		*P* value
		Slanted-curve Freq (%)	Slanted-straight Freq (%)	
Ethnicity				
Malays	47	36(77)	11(23)	0.030
Chinese	47	26(55)	21(45)	

a. Chi Square was used.
Level of significant was set at 0.05

The number of the channels at the middle portion of the incisive canal was compared between Malays and Chinese in Table 4.10. This comparison showed no significant difference between the two ethnicity groups (*P*=0.130). Although 72% of the Malays (n=36) showed 1 channel at the middle portion of the incisive canal, in 28% (n=13) of the Malays there were 2 channels at the middle portion. The increased presence of one channel was also noticed in Chinese (57%; n=27) while the 2 channel structure was seen in 20 subjects (43%).

Table 4.10. Comparison of the number of channels at the middle portion between the Malays and Chinese

Variable	n	No. of channel at middle portion		*P* value
		1 channel Freq (%)	2 channels Freq (%)	
Ethnicity				
Malays	47	34(72)	13(28)	0.130
Chinese	47	27(57)	20(43)	

a. Chi Square was used
Level of significant was set at 0.05.

4.3. 1. Comparison of the dimensions of the incisive canal and related structures between gender amongst Malays

Further comparisons were done between genders of each ethnicity group**.** The assumption of outcomes being normally distributed and equality of variances was checked. Independent t-test was used when the assumption was met and in cases where the assumption was violated Mann-Whitney test was performed. According to Table 4.11 there were many differences between values of Malay males and Malay females. This comparison showed a significant difference in the incisive foramen labiopalatal diameter (*P*=0.026). The difference in the mean indicates larger incisive foramen diameter in males.

Also, the nasal foramen diameter was larger in males and the comparison showed a significant difference (*P*=0.024) with a mean of (6.28 mm) for Malay males while for females was (4.48 mm).The right incisive canal was longer than the left incisive canal in males and females with a difference of (0.86 mm) in males and (0.47 mm) in females. There was a significant difference noted between males and females in the right and the left canal *(P* = 0.001) for the right side with a difference of (4.97 mm), while for the left side (*P* = 0.001) and the difference in the length of the left incisive canal was 4.58 mm. Another significant difference was noticed in the incisive canal width (*P* =0.019) and Malay males (mean=4.05 mm) had a bigger width canal than females (mean =3.16 mm).

Table 4.11 Comparison of the dimensions of the incisive canal and related structures between gender amongst Malays

Dependent variable	Malay Males n=25 Mean (SD) mm	Malay Females n=22 Mean (SD) mm	*Mean diff. (95% CI)*	*P* value[a]
Incisive foramen (Labiopalatal)	3.17 (0.71)	2.66 (0.81)	0.51 (.0654,.956)	0.026
Incisive foramen (Mesiodistal)	3.66 (1.15)	3.48 (0.85)	0.17 (-.425,.772)	0.562
Nasal foramen (Labiopalatal)	6.28 (3.41)	4.48 (1.29)	1.80 (.247,3.359)	0.024
Right incisive canal length	18.16 (3.79)	13.19 (4.41)	4.98 (2.57,7.4)	0.001
Left incisive canal length	17.30 (3.72)	12.72 (4.01)	4.59 (2.31,6.9)	0.001
Incisive canal width	4.05 (1.57)	3.16 (0.77)	0.89 (.153,1.64)	0.019
Bone thickness	7.69 (2.9)[c]	7.37 (1.6)[c]	-	0.24[b]
Incisive foramen location	11.79 (2.82)	12.95 (2.88)	-1.16 (-2.85,0.51)	0.168

a. Independent t-test was used.
b. Mann-Whitney test was used.
c. Median (IQR)
Level of significant set at 0.05.

Although no significant difference was seen in the incisive canal course and direction (*P*=0.918) (Table 4.12) the majority of cases showed slanted-curve direction with a percentage of 76% for Malay males and 77% for Malay females.

Table 4.12 Comparison of incisive canal course and direction between gender amongst Malays

Variable	n	Incisive canal course and direction		*P* value[a]
		Slanted-curve Freq (%)	Slanted-straight Freq (%)	
Ethnicity				
Malay Males	25	19(76)	6(24)	0.918
Malay Females	22	17(77)	5(23)	

a. Chi Square was used.
Level of significant set at 0.05

As shown in Table 4.13 there is no significant difference in the number of channels at the middle portion (*P* =0.478). The percentage of the presence of 1 channel at the middle portion was 68% for Malays males and 77% for Malays females while the presence of 2 channels was with percentage 32% for Malays males and 23% for Malays females.

Table 4.13 Comparison of the number of channels at the middle portion of incisive canal between gender amongst Malays

Variable	n	No. of channels at middle portion		*P* value[a]
		1 channel Freq (%)	2 channels Freq (%)	
Ethnicity				
Malay Males	25	17 (68)	8 (32)	0.478
Malay Females	22	17 (77)	5 (23)	

a. Chi Square was used.
Level of significant set at 0.05.

4.3. 2. Comparison of the dimensions of the incisive canal and the related structures between genders amongst Chinese

The assumption of outcomes being normally distributed and equality of variances was checked. Independent t-test was used when the assumption was met and in cases where the assumption was violated Mann-Whitney test was performed. According to Table 4.14, no significant difference was shown in almost all the measurements except in the incisive canal length and the anterior maxillary bone thickness. Similar to the results of the other comparisons between males and females in the incisive canal length, the Chinese males showed a longer right and left incisive canal than the females with a difference of (2.39 mm) for the right incisive canal and (1.56 mm) for the left incisive canal. The right incisive canal is still longer than the left incisive canal in the Chinese males and females. The anterior maxillary bone shows a significant difference *(P* = 0.004) and the difference in the mean indicated that the Chinese males have a high anterior bone thickness than Chinese females (mean for male=8.21mm and for female =6.76 mm).

Table 4.14 Comparison the dimensions of the incisive canal and the related structures between gender amongst Chinese

Dependent Variable	Chinese Males n=23 Mean (SD) mm	Chinese Females n=24 Mean (SD) mm	*Mean diff. (95% CI)*	*P* value[a]
Incisive foramen (Labiopalatal)	2.88 (0.81)	2.48 (0.78)	0.40 (-0.06,0.87)	0.088
Incisive foramen (Mesiodistal)	3.42 (0.91)	3.43 (1.04)	-0.01 (-0.58,0.56)	0.967
Nasal foramen (Labiopalatal)	6.92 (3.6)[d]	5.99 (5.40)[d]	_	0.766[c]
Right incisive canal length	18.71 (4.39)	16.32 (3.31)	2.35 (.073,4.63)	0.009
Left incisive canal length	17.6 (4.57)	16.04 (5.09)	1.57 (-1.28,4.41)	0.019
Incisive canal width	4.25 (1.33)	3.87 (1.26)	0.38 (0.37,1.14)	0.319
Bone thickness	8.21(1.82)	6.76 (1.41)	1.45 (0.49,2.41)	0.004
Incisive foramen location	12.48 (5.5)[d]	10.97 (4.8)[d]	-	0.890[c]

a. Independent t-test was used.
b.Mann-Whitney test was used.
c. Median (IQR)
Level of significant was set at 0.05.

There was no significant difference in the canal direction between the Chinese males and the Chinese females (*P*=0.312) (Table 4.15). In Chinese males 52% of the cases showed a slanted-straight direction and the other 48% was slanted-curve. On the contrast, 62.5% of females showed a slanted-curve and 37.5% for the slanted-straight.

Table 4.15.Comparison of incisive canal course and direction between gender amongst Chinese

Variable	n	Incisive canal course and direction		*P* value[a]
		Slanted-curve Freq (%)	Slanted-straight Freq (%)	
Ethnicity				
Chinese Males	23	11 (48)	12 (52)	0.312
Chinese Females	24	15 (62.5)	9 (37.5)	

a. Chi Square was used.

Level of significant was set at 0.05.

The following table shows (Table 4.16) that there is a significant difference in the number of the channels at the middle portion of the incisive canal (*P*=0.025). Although most of the Chinese males have 1 channel with a percentage of 74%, but more Chinese females (58%) have 2 channels at the middle portion of the canal.

Table 4.16 Comparison of the number of channels at the middle portion of incisive canal between gender amongst Chinese

Variable	n	No. of channels at middle portion		*P* value[a]
		1 channel Freq (%)	2 channels Freq (%)	
Ethnicity				
Chinese Males	23	17 (74)	6 (26)	0.025
Chinese Females	24	10 (42)	14 (58)	

a. Chi Square was used.

Level of significant was set at 0.05.

4.4. Comparison the dimensions of the incisive canal and the related structures between the ethnicities amongst the same gender

The assumption of outcomes being normally distributed and equality of variances was checked. Independent t-test was used when the assumption was met and in cases where the assumption was violated Mann-Whitney test was performed.

4.4. 1. Comparison the dimensions of the incisive canal and the related structures between Malay and Chinese amongst males

According to the data that are shown in Table 4.17 there is no significant difference in all the measurements.

Table 4.17 Comparison the dimensions of the incisive canal and the related structures between the Malay and Chinese amongst males

Dependent variable	Malay Males n=25 Mean (SD) mm	Chinese Males n=23 Mean (SD) Mm	*Mean diff. (95% CI)*	*P* value[a]
Incisive foramen (Labiopalatal)	3.16 (0.71)	2.88 (0.80)	2.88 (-0.15,0.72)	0.194
Incisive foramen (Mesiodistal)	3.66 (1.15)	3.42 (0.91)	0.24 (-0.36,0.84)	0.43
Nasal foramen (Labiopalatal)	6.28 (3.41)	6.72 (2.96)	-0.43 (-2.29,1.43)	0.642
Right incisive canal length	18.16 (3.79)	18.67 (4.39)	-0.51 (-2.88,1.87)	0.670
Left incisive canal length	17.3 (3.72)	17.6 (4.57)	-0.31 (-2.72,2.10)	0.799
Incisive canal width	4.05 (1.57)	4.25 (1.33)	-0.19 (-1.04,0.65)	0.645
Bone thickness	7.69 (2.9)[c]	8.73 (2.2)[c]	-	0.403[b]
Incisive foramen location	11.78 (2.82)	11.64 (3.04)	0.14 (-1.56,1.84)	0.87

a. Independent t-test was used.
b. Mann-Whitney test was used.
c. Median (IQR)
Level of significant set at 0.05.

The comparison of the incisive canal course and direction showed a significant difference (*P* =0 .044) (Table 4.18). During this comparison the slanted-curve canal was most common in the Malay males with 76% and 24% for slanted-straight while in the Chinese males 52% of the cases were found to have slanted-straight canal and 48% have slanted-curve canal.

Table 4.18.Comparison of canal course and direction between Malay males and Chinese males

Variable	n	Incisive canal course and direction		*P* value[a]
		Slanted-curve Freq (%)	Slanted-straight Freq (%)	
Ethnicity				
Malay Males	25	19(76)	6(24)	0.044
Chinese Males	23	11(48)	12(52)	

a. Chi –square was used.
Level of significant set at 0.05.

No significant difference between Malay males and Chinese males appeared in Table 4.19 in the number of the channels at the middle portion of the incisive canal (P=0.653) where in both of them the common number of channels at the middle portion was 1 channel with a percentage of 68% in Malay males and 74% in Chinese males.

Table 4.19 Comparison of the number of channels at the middle portion of incisive canal between Malay males and Chinese males

Variable	n	No. of channel at middle portion		*P* value[a]
		1 channel Freq (%)	2 channels Freq (%)	
Ethnicity				
Malay Males	25	17(68)	8(32)	0.653
Chinese Males	23	17(74)	6(26)	

a. Chi Square was used.
Level of significant was set at 0.05.

4.4. 2. Comparison of the dimensions of the incisive canal and the related structures between the Malay and Chinese amongst females

There were a lot of significant differences between the Malay females and Chinese females as seen in table overleaf (Table 4.20). Nasal foramen diameter has a significant difference between them (*P* =0.045) and the mean for Malay females - 3.94 mm and for Chinese females - 5.99 mm. The incisive canal length appeared to have a significant difference in the right side with a difference of 3.13mm and *(P*= 0.009). The left incisive canal length shows a significant difference (*P* = 0.018) and with difference of (3.33 mm). The last significant difference in this table was in the incisive canal width (*P* = 0.027) and a mean- 3.16 mm for Malay females and a mean - 3.87 mm for Chinese females. All the values indicate a longer and wider incisive canal in the Chinese female than Malay females with a larger diameter for the nasal foramen.

Table 4.20 Comparison the dimensions of the incisive canal and the related structures between the Malay and Chinese amongst females

Dependent variable	Malay Females n=22 Mean (SD) mm	Chinese Females n=24 Mean (SD) mm	*Mean diff. (95% CI)*	*P* value[a]
Incisive foramen (Labiopalatal)	2.66 (0.81)	2.48 (0.78)	0.18 (-0.29,0.65)	0.442
Incisive foramen (Mesiodistal)	3.48 (0.85)	3.43 (1.05)	0.05 (-0.52,0.62)	0.850
Nasal foramen (Labiopalatal)	3.94 (2.2)[c]	5.99 (5.4)[c]	-	0.045[b]
Right incisive canal length	13.19 (4.41)	16.32 (3.31)	-3.14 (-5.44,-8.31)	0.009
Left incisive canal length	12.71 (4.01)	16.04 (5.09)	-3.33 (-6.10,-0.59)	0.018
Incisive canal width	3.16 (0.767)	3.87 (1.26)	-0.71 (-1.34,0.08)	0.027
Bone thickness	7.27 (1.26)	6.76 (1.41)	0.51 (-.29,1.31)	0.203
Incisive foramen location	13.09 (3.6)[c]	10.97 (4.8)[c]	-	0.113[b]

a. Independent t-test was used.
b. Mann-Whitney test was used.
c. Median (IQR)
Level of significant was set at 0.05.

Although the comparison between Malay females and Chinese females in the incisive canal course and direction did not show any significant difference (*P*=0.277) (Table 4.21) but it can be seen that the slanted-curve canal is more wide spread than the slanted-straight canal in both ethnicity with a percentage of 77% in Malay females and 62.5% in Chinese females.

Table 4.21 Comparison of incisive canal course and direction between Malay females and Chinese females

Variable	n	Incisive canal course and direction		*P* value[a]
		Slanted-curve Freq (%)	Slanted-straight Freq (%)	
Ethnicity				
Malay females	22	17 (77)	5 (23)	0.277
Chinese females	24	15 (62.5)	9 (37.5)	

a. Chi Square was used.
Level of significant was set at 0.05.

The number of the channels at the middle portion of the incisive canal showed a significant difference between Malay females and Chinese females (*P*=0.014) (Table 4.22) where 77% of the Malay females have 1 channel at the middle portion and only 23% have 2 channels while in Chinese females only 42% have 1 channel and the other 58% have 2 channels.

Table 4.22 Comparison of the number of the channels at the middle portion of incisive canal between Malay females and Chinese females

Variable	n	No. of channel at middle portion		*P* value[a]
		1 channel Freq (%)	2 channels Freq (%)	
Ethnicity				
Malay females	22	17 (77)	5 (23)	.014
Chinese females	24	10 (42)	14 (58)	

a. Chi Square was used.
Level of significant set at 0.05.

4.5 According to age group

As shown in Tables 4.23 and 4.24 and by using Kruskal-Wallis test and Bonferroni post hoc test the significant differences between different age groups appeared only in the anterior maxillary bone thickness and incisive foramen location. Multiple comparisons were done using Bonferroni post hoc test to identify where this significant difference occurred between different age groups. As shown in Table 4.24 there was a significant difference *(P* value =0.001) between age groups in the bone thickness where the mean difference of 2.247 mm between 15-25year age group and 56-75year age group was observed. Another significant difference was also seen in between 15-25 year age group and 46-55 age group with a difference in the bone thickness of 1.49 mm. Both of 26-35year age group and 36-45 year age group showed a significant difference in the bone thickness with 46-55 year age group and 56-75 year age group. All these differences in the bone thickness indicate a reduction in the bone thickness with advanced age. Furthermore, incisive foramen location showed a significant difference with age, where the mean differences reduces as shown in Table 4.24.The age group 15-25years show a difference in the location of 3.85 mm with 56-75 year age group.

Table 4.23 Comparison of the nasal foramen and the incisive canal width between different age groups

variables	Age group					*P* value[a]
	15-25 years n=20 Median (IQR)	26-35 years n=17 Median (IQR)	36-45 years n=19 Median (IQR)	46-55 years n=19 Median (IQR)	56-75 years n=19 Median (IQR)	
Nasal foramen (Labiopalatal)	6.07 (5.3)	4.8 (2.8)	6.07 (3.9)	5.83 (2.2)	4.71 (4.7)	0.487
Incisive canal width	4.08 (1.8)	3.16 (1.6)	3.8 (2.1)	3.72 (1.6)	3.37 (2.0)	0.731

a. Kruskal-Wallis test
Level of significant was set at 0.05

Table 4.24 Comparison of the dimensions of the incisive canal and the related structures between different age groups (Bonferroni post hoc test)

	(I) Age group	(J) Age group	Mean difference (I – J)	*P* value*
Incisive foramen diameter (Labiopalatal)	15-25yr	26-35yrs	.0304	1.000
		36-45yrs	.1085	1.000
		46-55yrs	-.2115	1.000
		56-75yrs	-.4341	.939
	26-35yr	15-25yrs	-.0304	1.000
		36-45yrs	.0782	1.000
		46-55yrs	-.2418	1.000
		56-75yrs	-.4645	.856
	36-45yr	15-25yrs	-.1085	1.000
		26-35yrs	-.0782	1.000
		46-55yrs	-.3200	1.000
		56-75yrs	-.5426	.395
	46-55yr	15-25yrs	.2115	1.000
		26-35yrs	.2418	1.000
		36-45yrs	.3200	1.000
		56-75yrs	-.2226	1.000
	56-75yr	15-25yrs	.4341	1.000
		26-35yrs	.4645	1.000
		36-45yrs	.5426	.996
		46-55yrs	.2226	.711
Incisive foramen diameter (Mesiodistal)	15-25-yr	26-35yrs	-.2895	1.000
		36-45yrs	.0505	1.000
		46-55yrs	-.5490	.823
		56-75yrs	-.5227	.978
	26-35yr	15-25yrs	.2895	1.000
		36-45yrs	.3400	1.000
		46-55yrs	-.2595	1.000
		56-75yrs	-.2332	1.000
	36-45yr	15-25yrs	-.0505	1.000
		26-35yrs	-.3400	1.000
		46-55yrs	-.5995	.614
		56-75yrs	-.5732	.734
	46-55yr	15-25yrs	.5490	.823
		26-35yrs	.2595	1.000
		36-45yrs	.5995	.614
		56-75yrs	.0263	1.000
	56-75yr	15-25yrs	.5227	.978
		26-35yrs	.2332	1.000
		36-45yrs	.5732	.734
		46-55yrs	-.0263	1.000

Cont.Table 4.24 Comparison of the dimensions of the incisive canal and the related structures between different age groups (Bonferroni post hoc test)

	(I) Age group	(J) Age group	Mean difference (I – J)	*P* value*
Incisive canal length	15-25yr	26-35yrs	.3515	1.000
		36-45yrs	-.1531	1.000
		46-55yrs	.7869	1.000
		56-75yrs	.3601	1.000
	26-35yr	15-25yrs	-.3515	1.000
		36-45yrs	-.5046	1.000
		46-55yrs	.4354	1.000
		56-75yrs	.0086	1.000
	36-45yr	15-25yrs	.1531	1.000
		26-35yrs	.5046	1.000
		46-55yrs	.9400	1.000
		56-75yrs	.5132	1.000
	46-55yr	15-25yrs	-.7869	1.000
		26-35yrs	-.4354	1.000
		36-45yrs	-.9400	1.000
		56-75yrs	-.4268	1.000
	56-75yr	15-25yrs	-.3601	1.000
		26-35yrs	-.0086	1.000
		36-45yrs	-.5132	1.000
		46-55yrs	.4268	1.000
Bone thickness	15-25yr	26-35yrs	.5110	1.000
		36-45yrs	.7343	1.000
		46-55yrs	1.4901	.022
		56-75yrs	2.2470	.001
	26-35yr	15-25yrs	-.5110	1.000
		36-45yrs	.2233	1.000
		46-55yrs	.9791	.503
		56-75yrs	1.7359	.007
	36-45yr	15-25yrs	-.7343	1.000
		26-35yrs	-.2233	1.000
		46-55yrs	.7558	1.000
		56-75yrs	1.5126	.022
	46-55yr	15-25yrs	-1.4901	.022
		26-35yrs	-.9791	.503
		36-45yrs	-.7558	1.000
		56-75yrs	.7568	1.000
	56-75yr	15-25yrs	-2.2470	.001
		26-35yrs	-1.7359	.007
		36-45yrs	-1.5126	.022
		46-55yrs	-.7568	1.000

Cont.Table 4.24 Comparison of the dimensions of the incisive canal and the related structures between different age groups (Bonferroni post hoc test).

	(I) Age group	(J) Age group	Mean difference (I – J)	*P* value*
Incisive foramen location	15-25yr	26-35yrs	1.1293	1.000
		36-45yrs	2.1993	.191
		46-55yrs	1.9719	.351
		56-75yrs	3.8456	.001
	26-35yr	15-25yrs	-1.1293	1.000
		36-45yrs	1.0700	1.000
		46-55yrs	.8426	1.000
		56-75yrs	2.7163	.058
	36-45yr	15-25yrs	-2.1993	.191
		26-35yrs	-1.0700	1.000
		46-55yrs	-.2274	1.000
		56-75yrs	1.6463	.812
	46-55yr	15-25yrs	-1.9719	.351
		26-35yrs	-.8426	1.000
		36-45yrs	.2274	1.000
		56-75yrs	1.8737	.477
	56-75yr	15-25yrs	-3.8456	.001
		26-35yrs	-2.7163	.058
		36-45yrs	-1.6463	.812
		46-55yrs	-1.8737	.477

Table 4.25 and Table 4.26 did not show any significant difference in the incisive canal course and direction (*P*=0.228). However, it appeared that the slanted-curve canal direction was more common in all age groups than the slanted-straight canal direction.

Table 4.25 Comparison of incisive canal course and direction between different age groups

Variable	n	Incisive canal course and direction		*P* value[a]
		Slanted-curve Freq (%)	Slanted-straight Freq (%)	
Age group				
15-25 years	20	11(55)	9(45)	0.228
26-35 years	17	14(82)	3(18)	
36-45 years	19	11(58)	8(42)	
46-55 years	19	15(79)	4(21)	
56-75 years	19	11(58)	8(42)	

a. Chi Square was used.
Level of significant was set at 0.05.

4.6. Limitation in the analysis

This study contains 94 cases, of which 4 of these cases were edentulous patients. A caution was expressed whether edentulousness in a person affected the morphology of the incisive canal. They were added to this study to increase the sample size after ensuring that they do not affect the results of the study. A separate descriptive analysis for 90 cases without the edentulous cases was undertaken. Subsequently a comparison with 94 cases was made, which included the measurements most affected by the loss of teeth- incisive canal length, anterior maxillary bone thickness and the incisive foramen location. The comparison of the two results did not show a remarkable difference from the clinical point of view. The following table (Table 4.26) shows the results of comparison of 94 cases and 90 cases (after omitting the 4 edentulous cases) which clearly showed that the findings were not significantly different.

Table 4.26 Descriptive analysis for the incisive canal length, incisive foramen location, bone thickness in 90 cases and 94 cases

Dependent variable	Right incisive canal length	Left incisive canal length	Bone thickness	Incisive foramen location
94 cases Mean (SD) mm	16.66 (4.46)	15.98 (4.71)	7.54 (1.65)	11.93 (3.09)
90 cases Mean (SD) mm	16.68 (4.51)	16.02 (4.78)	7.63 (1.61)	12.07 (3.06)

CHAPTER FIVE: DISCUSSION

5. 1. Introduction

Incisive canal and anterior maxillary bone resorption affect directly in reducing the possibility of placing an implant in an ideal position (Mecall *et al*., 1991; Rosenfeld *et al.*, 1996). Although the incisive canal is discussed frequently in the literature, there are not enough studies describing the morphology and measurement variations of this canal (Mraiwa *et al*., 2004). Most of the studies focus on incisive canal pathology and their mangements (Swanson *et al*., 1991; Kreidler *et al*., 1993; and Daley *et al*., 1996).

5. 2. Incisive foramen dimension and location

The incisive foramen diameter was measured in two directions, labiopalatal and mesiodistal direction. The mean diameter of the incisive foramen in the mesiodistal direction is 3.499 mm. There was no significant difference in the mesiodistal diameter when comparisons were made according to ethnicity, gender or age groups.

The diameter of incisive foramen measured in labiopalatal direction is usually below 6 mm; when the diameter goes beyond the 10 mm, a pathological condition should be considered (White *et al*., 2000; Swanson *et al*., 1991; Kreidler *et al*., 1993 and Daley *et al.*, 1996). In this study, incisive foramen diameter was still below this threshold (mean = 2.81 mm) and males showed a larger diameter than females, especially amongst Malays. Although there is no significant difference in the location of the incisive foramen between males and females, in general the males exhibit closer position to the most anterioinferior point of the cortical plate of the buccal bone of the maxilla. However, by ethnicity and gender Chinese females have the closest location of incisive foramen to the most anterioinferior point of the cortical plate.

There were many difficulties and anatomic limitations regarding the location of the incisive canal in relation to implant placement in the anterior maxilla (Kraut and Boyden, 1998). They reported that although 96% of the patients in their study had

volumetric relationships between the canal and the maxillary central incisor, this relationship would be advantageous for ideal placement of implant in the sockets of the maxillary central incisor. Caution must be expressed as the sample size in each age group was not enough to make a strong conclusion about the effect of aging on the incisive canal dimensions and its related structures, However, this study revealed a possible effect of the aging on the location of the incisive foramen where the distance between the incisive foramen and the most anterioinferior point of the cortical plate of the buccal bone of the maxilla reduced as a result to bone resorption. This change in the position of the foramen and the reduction in the distance make the procedure of dental implantation more complex with advancing age.

5.3. Nasal foramen

There was no possibility to get a clear and complete image for the incisive canal from a coronal-section slice due to the posterior curvature of the canal during its course. As a result of this limitation, the mesiodistal diameter was difficult to assess and the only way to determine the nasal foramen diameter was from sagittal cross-section slices - that is labiopalatal direction.

In this study the nasal foramen exhibit mean diameter of 6.03 mm labiopalataly. In general there was no significant difference in the nasal foramen diameter between males and females. The Chinese were however observed to have larger foramina than Malays with a difference of 1.42 mm. With regards to a comparison between right and left nasal foramina, the right nasal foramen is larger than the left in males and the opposite is true in females.

Mardinger *et al.* (2008) reported that there was the enlargement of the nasal foramen with age which could be similar to the tendency of the maxillary sinus to expand into surrounding bone after tooth loss. However in this study the aging did not show any

affect on the nasal foramen diameter. The differences in the finding of the two studies could be because there were only four edentulous patients included in this study.

5.4. Incisive canal length and width

According to the previous study by Kraut and Boyden (1998) they stated that in 4% of the cases the size of the canal hinders the placement of the implant. In such cases, this problem can be overcome by surgical intervention where the soft tissue contents are pushed back and the incisive foramen obturated by bone graft (Artzi *et al.*, 2000).

Liang *et al.* (2009) reported the mean length of the incisive canal as 10.6 mm while in Mraiwa *et al*. (2004) reported the incisive canal was having a mean length of 8.1mm. The incisive canal in this research had a mean length of 16.32 mm which was clearly longer than the previous studies. Whereas, the mean width recorded in this study for the incisive canal was 3.84 mm. This width was quite similar to the previous study reported by Mraiwa *et al.* (2004) and by Liang *et al.* (2009) where the mean widths were 4.6 mm and 3.6 mm respectively. This study followed Liang *et al*. (2009) method to measure the incisive canal width but actually this method is inappropriate in some cases due to the greater variations at the three levels of measurement of the canal (Figure 5.1). For example in incisive canal with funnel-like shape the nasal foramen may have larger dimension while in the banana-like shape the greater width is at the midpoint of the canal.

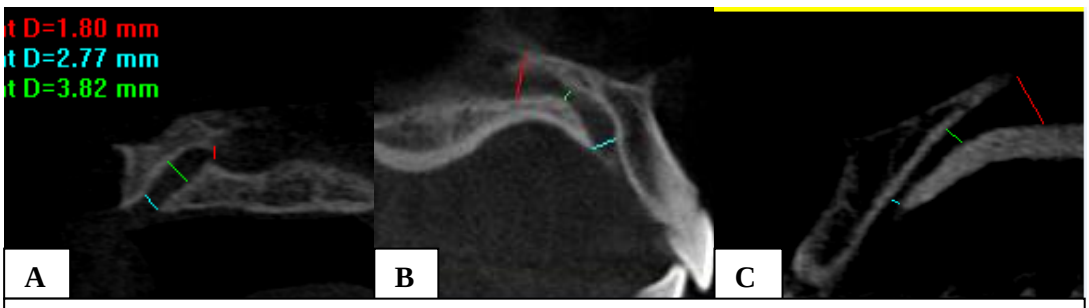

Figure 5.1: Different shapes of the incisive canal **A.** Banana- shape, **B.** Hour-glass shape and **C.** Funnel-shape

The relationship between gender and incisive canal dimensions was discussed by Liang *et al*. (2009), Iordarishvilli (1991) and Güler *et al*. (2005). All of them agreed that the males have longer and wider canal than the females and this was also confirmed by this study.

Several authors described the effect of the age on the incisive canal dimensions (length and width). Mardinger *et al*. (2008), Liang *et al*. (2009) and Iordarishvilli (1991) found that with age, the incisive canal diameter increased due to the bone resorption. In addition, Iordarishvilli (1991) also stated about the decrease of incisive canal length with age. However, this study did not find any significant difference in the canal dimensions. This difference in the results could be because the sample size was not enough in each age group and did not have a significant number of edentulous patients. The loss of teeth leads to increased degree of bone resorption in the disused area leading to decrease in the length of the bone at that particular area. As a consequence the incisive canal length gradually decreases.

As the incisive canal has a Y-shape, comparisons were done to get more information about the length and if this division will affect or make a difference between the two sides of the canal. As a result of this comparison, we can safely say that the right canal is longer than the left canal in both males and females.

5.6. Anterior maxillary bone thickness

Equally important for implant placement is the anterior maxillary bone width anterior to the canal. This bone width was determined previously in several studies. Cheng *et al*. (1997) determined the bone thickness as the distance between the anterior wall of incisive canal and the cortical plate of the anterior maxillary bone. The mean width reported was 7.8 mm. Barkin *et al*. (2002) measured the same distance of the anterior maxillary bone and the mean width was 5.9 mm. In this study the mean width of the

anterior maxillary bone thickness was still in the same range - 7.54 mm. In general this bone is thicker in males than females indicating females need more precautions during surgical procedures. Furthermore, advancing aging showed a possible effect the anterior maxillary bone thickness leading to reduction in the width of the bone. This makes the surgical intervention in this area more challenging. This reduction in bone thickness due to aging was reported previously by Mardinger *et al*. (2008) and Artzi *et al*. (2000) and this was confirmed in this study.

5.7. The incisive canal course and direction

Song *et al*. (2009) found four patterns for incisive canal direction slanted-curve, slanted-straight, vertical-curve and vertical-straight. The most common type was slanted-curve and this was followed by slanted-straight. This study is in complete agreement with the previous study where the slanted-curve canal is the most common followed by the slanted-straight canal variety. Other types were not noticed in this group of Mongoloids. Although all the measurements in this study were measured by using i-Cat vision software, the incisive canal direction was assessed by different software, namely SimPlant software. This change in the software programs was necessary as the SimPlant program permitted angular measurements of the canal.

5.8. The number of the channels at the middle portion of the incisive canal

In the same study reported by Song *et al*. (2009), it was possible to determine the number of the channels at the middle portion of the incisive canal. The majority of the cases had one channel at their middle portion. This is in full agreement with the present observation in this research (Figure 5.2)

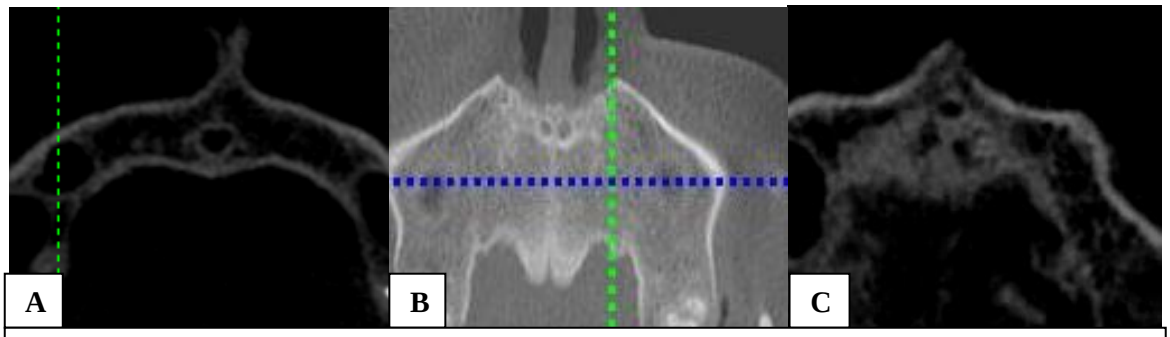

Fig.5.2. The number of the channels at the middle portion of the incisive canal **A.** one channel, **B.** two channels, **C**. three channels

5.9. Effect of ethnicity on the incisive canal dimensions and related structures

There was no study that discussed the variations in the incisive canal and incisive foramen dimensions within the same ethnicity and between ethnicity (Malays and Chinese). This study describes the variations as following:

In general there was no significant difference between the Malays and Chinese except in the diameter of the nasal foramen where the Chinese demonstrated larger dimension than Malays. Although most of the canal directions in Malays and Chinese have the slanted-curve pattern the appearance of the slanted-straight pattern was higher in Chinese than the Malays.

During the comparison of the incisive canal dimensions within the Malays, the males have larger measurement values with regards to the incisive foramen diameter, incisive canal length, incisive canal width and anterior maxillary bone thickness. These findings about the influence of the gender on the canal dimensions were supported by the previous studies (Liang *et al*., 2009; Iordarishvilli, 1991 and Güler *et al*., 2005).

In the Chinese, the anterior maxillary bone is wider in Chinese males than Chinese females. In addition the incisive canal length is longer in males than females. With

regards to the number of the channels in the middle portion of the incisive canal, males have one channel in most cases whilst on the contrary, the majority of females have two channels.

When comparisons were done between the males in the two ethnicities there was no clear difference in the canal dimensions.

When the same comparison was done between the Malay females and Chinese females, the Chinese females appeared to have a bigger canal with longer and wider dimensions than Malay females. The nasal foramen was also larger in Chinese females. On the other hand the anterior maxillary bone is wider in the Malay females than the Chinese females. Interestingly, the majority of the Malay females canals have one channel at their middle portion of the canal whereas more than 50% of the Chinese females have two channels at their middle portion of the canal.

This demonstrates that although Chinese and Malays belong to the Mongoloid group, there are some differences in the morphology and the location of the incisive canal structures and foramen.

According to Mraiwa et al. (2004), data about anatomical variations, dimensions and typical morphology of the incisive canal are scarce in the literature. Although the present study is in complete agreement with the previous studies with regard to the effect of gender on the incisive canal dimensions, this study did not show any affect of aging on this dimensions as recorded in the other studies.

Thus so far there were no studies discussing the effect of the Y- shape in the incisive canal length. According to this study we can see clearly that the right incisive canal is indeed longer always than the left canal regardless of gender, ethnicity and age group.

This study also highlights the needs to more precautions during the implant procedure in Chinese females due to their thin anterior maxillary bone.

The majority of the Mongoloid population in Malaysia have slanted-curve canal with one channel at the middle portion of the incisive canal. Although studies by Song et al. (2009) reported agreement in the number of the channel, their Mongoloid population however had the vertical-straight canal as the most common canal course and direction (46.4%).

In this study CBCT and the SimPlant interactive software were used to visualize the anterior maxilla for cross-sectional imaging. This technique appears to have the potential to replace CT scans for accurate diagnosis and evaluation of structures in this area. Furthermore, it is evident that CBCT generate less radiation with high-quality images sufficient for invasive procedures such as implant insertion and bone grafting (Bornstein *et al.,* 2011; Liang *et al.,* 2009).

CHAPTER SIX: CONCLUSION

6.1 Introduction

The determination and the comparison of the dimensions of the incisive canal length, width, incisive foramen diameter, nasal foramen diameter, anterior maxillary bone thickness, and incisive foramen location amongst the Malays and Chinese was the goal of this study.

6.2 Summary of findings

This research was specifically focused to study six objectives from which the following results were attained:

According to gender

1. In general the males have a longer and wider incisive canal than the females.

2. The anterior maxillary bone thickness is wider in males than females.

3. Right incisive canal is longer than the left incisive canal in both genders.

4. The right nasal foramen is larger than the left one in males, and the opposite is true in females.

According to ethnicity

1. In general the only difference between the Malays and Chinese was in the nasal foramen diameter where the Chinese have a larger foramen than the Malays.

2. the most common pattern of canal direction is a slanted-curve in both ethnicities.

3. Most of the Malays and Chinese have one channel at the middle portion of the incisive canal.

4. Malay males have significantly larger dimensions than females in each of the following: incisive foramen, incisive canal length, incisive canal width, and nasal foramen.

5. In Malay males the canal has a slanted-curve direction in most of the cases while in the Chinese males a slanted-straight is most common.

6. There are no differences between Malays males and Chinese males in all the measured dimensions.

7. Most of the Chinese females have 2 channels at the middle portion of the incisive canal .while the majority of Chinese males have only 1 channel.

8. Chinese females have larger incisive canal dimensions (longer and wider) and larger nasal foramen than Malay females.

9. The majority of the Malay females have 1 channel at the middle portion of the incisive canal while most of the Chinese females have 2 channels at the middle portion of the incisive canal.

According to age

The effect of the aging may be cause reduction of the bone thickness and decrease in the distance between the incisive foramen and the most anterioinferior point of the buccal bone of the maxilla.

6.3 Implications of the study

This study clearly showed variations in the incisive canal dimensions and anterior bone thickness. This anatomical variability in the dimensions may be clinically important during surgical procedures such as implant placement. When dealing with Malay males, they have wide and long incisive canal and thin maxillary bone comparing with Chinese males. Chinese females who have the thinnest maxillary bone. In general males exhibited thicker anterior maxillary bone than females. Another challenge is the need to

rehabilitate this area with advanced age where a high rate of bone resorption takes place leading to reduction in the anterior bone thickness and making the incisive foramen to be located closer to buccal bone of the anterior maxilla.

Thus, it is highly recommended that the surgeons familiarize themselves with the anatomic variations at the anterior maxillary region prior to any surgical procedures in order to avoid neurosensory disturbances and potential complications. For that reason, a careful assessment of this area during the pre-operative planning procedures is important. CBCT cross-sectional imaging may serve this purpose.

6.4 Recommendation for future research

The long-term success of a dental implant will be highly dependent upon the bone in which it is placed. For this reason the assessment of the bone quality and quantity is very important in this area. This assessment involves evaluating the shape of the bone (both width and height). This study revealed many variations in the anterior maxillary bone thickness amongst gender, ethnicity and different age groups. As such, it is recommended that future studies assess the association between bone height and the degree of bone resorption of patients who have lost their upper anterior teeth or even if they are totally edentulous in maxilla.

6.5 Limitations of the study

1. There were a limited number of cases at the Division of Oral and Maxillofacial Radiology, which caused insufficient sample size to cover the categorical variables, i.e. incisive canal course and direction and the number of channels at the middle portion of the incisive canal.

2. Impact of the teeth loss on the dimensions of the incisive canal and the anterior maxillary bone thickness could not be studied due to insufficient numbers of edentulous case.

3. When doing literature search, it was found that there was also a lack of articles that discuss on the incisive canal morphology and location.