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Sexual dimorphism by measuring the mesiodistal width of the permanent maxillary and mandibular canine in a sample of the South African population in the Northern Suburb of Cape Town.

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A mini thesis submitted in partial fulfilment of the requirements for the degree of MSc (Dentistry) in the Department of Forensic Dentistry, Faculty of Dentistry, University of Western Cape.

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Abstract

Human identification is one of the major responsibilities in the field of Forensic Odontology as it plays a role in identifying deceased individuals using their oral and dental structures. Furthermore, human identification could be a challenging procedure in catastrophic disasters and mass fatality incidents in terms of decomposed and skeletonized human remains. Identification process can be applied using different methods such as fingerprint, DNA and detention. Gender-determination of the victim facilitates reconstruction and rebuilding in the profiling of a medico-legal case investigation. Gender-determination facilitates the procedure up to 50% for positive identification. Anthropology studies have shown that the sexual dimorphism of skeletal remains and teeth can facilitate the identification process. However, teeth are the hardest structures in the human body and virtually immortal as they can withstand diverse circumstances

This study aimed to investigate sexual dimorphism of teeth by measuring the mesiodistal width of the maxillary and mandibular permanent canines in a sample of the South African population living in Cape Town. Two hundred orthodontic study models were used, 50 males and 50 females, between 13-30 years of age.

The results of this study indicated sexual dimorphism when measuring the mesiodistal width of the permanent maxillary and mandibular canines. The left mandibular canine (33) showed the most significant feature of dimorphism with 72% gender determination probability, followed by the right mandibular canine (43) with 69% gender determination probability. The left maxillary canine (23) showed 66% gender determination probability followed by the right maxillary canine (13) with 60% gender determination probability.

Key words: **Sexual dimorphism, gender-determination, dental identification, mesiodistal dimensions of canines.**

DECLARATION

I declare that *Sexual dimorphism by measuring the mesiodistal width of the permanent maxillary and mandibular canine in a sample of the South African population in Cape Town* is my own work, that it has not been submitted for any degree of examination to any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Abdelhadi. Abdellatif August 2019

Signed:.....

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I'm sincerely grateful for the people who helped, guided and gave me from their precious time, as without them, this thesis wouldn't be completed.

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Chapter 1

Introduction

An unidentified deceased body poses a dilemma for forensic investigators pertaining to 3 major questions which should be answered; who is he or she? How did he die? And when did he die? The answers to these 3 questions will reflect on the whole process of the forensic investigation (Walton, 2006).

Gender-determination of the victim facilitates reconstruction and rebuilding in the profiling of a medico-legal case investigation. Human identification is a major task during forensic investigations. Gender-determination facilitates the procedure up to 50% for positive identification. In cases of fresh bodies, visual identification can be applied as differences between males and females are much easier to identify, but more complicated in decomposed and skeletonized bodies (Pretty *et al*., 2001).

The identification process utilizes data such as; age, height, weight, eye colour, hair colour, race and gender which all play a significant role in positive identification. In cases of skeletonized or decomposed human remains, using the human pelvis is one of the methods of gender determination that can be detected visually, as the female pelvis is more distinguishable as it is usually larger to accommodate the birth canal. The skull may also be used for gender-determination as the male skull is robust and muscle attachment is larger than in females, brow ridges are more pronounced, lower jaw looks square, while female skull is smooth and light (Lundy, 1998).

For decades scientists studied the link between the human skeleton and gender-determination. Odontometric analysis, which measures the size of teeth, was one of the methods used to guide and facilitate identification. In the case of mutilation or fragmentation of human remains, gender-determination through dental structure may be crucial and Odontometric analysis may be used as one of the methods (Krishan *et al*., 2015).

Over time teeth have proved to be one of the hardest and stable structures in the human remains, as they can withstand physical, chemical and thermal conditions that aid in the identification process. Investigation of sexual dimorphism was conducted using several

methods in studies on different populations. One of these is odontometric analysis of maxillary and mandibular teeth. The odontometric parameters can be used in cases where remains are fragmentary, especially maxillary odontometric parameters, as the maxilla is attached directly to the base of the skull, which makes it stable in addition to its anatomical landmarks that can provide significant results (Kaushal*et al.*, 2003).

Other aspects of dental identification involve the use of dental records for identification purposes, including oral pathological lesions and tumours, as well as prosthetic appliances and congenital abnormalities of teeth (Adams *et al*., 2013).

The most common teeth used to investigate gender dimorphism are the canines. Canines are the most resilient teeth in the mouth. However, they also display a minimal effect of attrition during mastication and tooth brushing as they are minimally loaded compared to the molars and premolars. Moreover, canines are usually less affected by dental diseases such as caries and periodontal disease, therefore canines are considered as a key tooth for dental identification (Dempsey & Townsend GC, 2001).

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Chapter 2

Literature Review

Osteometry is the study of gender determination using human skeletons. Gender determination can also be determined by Odontometric parameters. However, the most accurate method thus far is the polymerase chain reaction (PCR) for DNA extraction (Hasegawa *et al.*, 2009). Although tooth pulp can be a good source of DNA, especially canines and molars, external factors such as contamination and moisture may lead to destruction during the extraction procedure (Shanbhag, 2017).

Sexual dimorphism using human dentition has been used and proven effective in different studies with different measurements, using tooth size by measuring the mesiodistal and bucco-lingual dimensions. Results showed significant features between males and females in crown dimensions of deciduous and permanent teeth (Rajendran, 2009). Garn *et al*., (1967) investigated sexual dimorphism among different ethnic groups by measuring the mesiodistal width of the maxillary and mandibular permanent canines. They concluded that mandibular canines showed more significant features than maxillary canines. However, their measurement showed different results for different ethnic groups.

Thompson and Anderson's investigation of sexual dimorphism, by measuring the permanent mandibular canine width and inter-canine distance, revealed that males showed significant features with a 74% correction rate classification (Nagare *et al*., 2018).

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In Japan investigations on sexual dimorphism in a sample of the Japanese population were conducted by two researchers (Kuwana, 1983, and Mizuno, 1990). Comparisons between the maxillary and mandibular canines revealed that permanent maxillary canines showed the most significant identification features.

Odontometric parameters used in India by Grewal (2017), to evaluate sexual dimorphism comprised four different parameters such as; the inter-canine width, the arch length, intermolar width, and combined width of the six maxillary anterior teeth. Results revealed that the four parameters were found highly significant for males and females, and concluded

that gender determination may be done using odontometric methods for simplicity, reliability and financial affordability (Grewal *et al.*, 2017).

In 2012, a study investigated sexual dimorphism among the Uruguayan population between the ages of 21 and 60 years, using odontometric analysis. This study measured the mesiodistal widths and the gingivo-incisal length of the mandibular canines and found that their results were statistically significant with a reliability of 72.3%. They concluded that the method can be used as an auxiliary tool in forensic anthropology for human identification (Sassi *et al.*, 2016).

A recent study in India used the maxillary and mandibular permanent canines for gender-determination. The study revealed that males show significant features regarding the mean dimension when compared to female maxillary right canines (Pandey & Ma, 2016).

In Turkey, Işcan and Kedici investigated sexual variations by using the bucco-lingual dimensions of the permanent maxillary and mandibular canines and mandibular second molars among the Turkish population. Based on their results, they identified sex with a 77% correction rate (Işcan & Kedici, 2003).

In Nigeria (2012) a study was performed on 300 patients to investigate sexual dimorphism using the mandibular canine width and inter-canine distance, in the age group 18-30 years. Measurements were performed by using a Digital Vernier Caliper. The study results were significant as the mesiodistal width of males was found to be greater when compared to females and in addition the inter-canine distance showed a higher degree in males and was highly significant (Ibeachu *et al.*, 2012).

Naikoo *et al.*, (2017) investigated sexual dimorphism in a sample of the Kashmiri population in India by measuring the mesiodistal canine width of the permanent mandibular canine, a significant feature of males, with a success rate of 95% if the width of the canine was greater than 7.85mm.

Ayoub *et al.*, (2014) investigated sexual dimorphism among the Lebanese population by measuring the mesiodistal width of the permanent mandibular canines. Participants were in

the 18-25 age group and results showed significant features in males with a 95% success rate when the mandibular canine width was greater than 7.104 mm.

Hunter & Priest, (1960) investigated the discrepancy and errors of measuring mesiodistal width intraorally and in dental casts. They concluded that measuring mesiodistal width in the dental cast was more accurate than intraoral measurements. Results of a study by Kaushal *et al.*, (2003) showed no significant differences in demonstrating and measuring the mesiodistal width of mandibular canines intraorally or in dental casts.

Chapter 3

Aim and Objectives

3.1 Aim

The aim of this study was to evaluate gender dimorphism between males and females by measuring the mesiodistal width of the permanent maxillary and mandibular canines in a sample of the South African population in Cape Town.

3.2 Objectives

To measure the maximum mesiodistal width of the permanent right and left maxillary and mandibular canines and evaluate the sexual dimorphism.

To compare the size of left and right permanent maxillary and mandibular canines.

To analyse the results of this study statistically.

Chapter 4

Methodology

Two hundred archival study models (50 males – 50 females) were collected for this study by measuring the mesiodistal width of the permanent maxillary and mandibular canines, using a digital calliper to evaluate the sexual dimorphism (Figure:1). The archival orthodontic study models were collected from the Department of Orthodontics at the Tygerberg Oral Health Centre, University of the Western Cape, as archival data belongs to patients who attended the orthodontic dental clinic at Tygerberg hospital.

Data was collected using a digital calliper (Neiko 01407A 6"Stainless Steel Digital Calliper) by measuring the maximum distance of the mesiodistal width of the left and right permanent maxillary and mandibular canines.

4.1 Inclusion criteria for collecting data were:

Age range 18 to 30 years.

Only fully erupted teeth were included in this study.

Dental records of the orthodontic study casts were used.

4.2 Exclusion criteria:

Any defects in the orthodontic study models, excluding carious canines, dental anomalies and trauma.

Figure 1: Digital Calliper in millimetres (mm).

A digital calliper (Figure 1) was used to measure the maximum mesiodistal width of the permanent maxillary and mandibular left and right canines. Measurement of the plaster of Paris study models was recorded in millimetres (mm).

The sexual dimorphism of the permanent left and right maxillary canines and the left and right mandibular canines was calculated according to the Garn formula: Sexual Dimorphism in mesiodistal width = [{XM/XF} - 1] x 100; where XM represented the mean mesiodistal width in males and XF represented the mean mesiodistal width in females (Garn, S.M., 1967).

Inter-Observer Reliability

The first observer was a postgraduate student from the Forensic Dentistry Department while the second investigator was a postgraduate student from the Department of Oral Medicine at the Tygerberg Oral Health Centre.

The measurements taken by the "first observer" and repeated blindly by the second observer and compared.

According to the Federation Dentaire Internationale (FDI) or the World Dental Federation the (two digits system) Figure 2, notation of dental charting of the permanent maxillary and mandibular canines are as follows (Yadav, 2013).

(13): Maxillary right canine

(23): Maxillary left canine

(33): Mandibular left canine

(43): Mandibular right canine

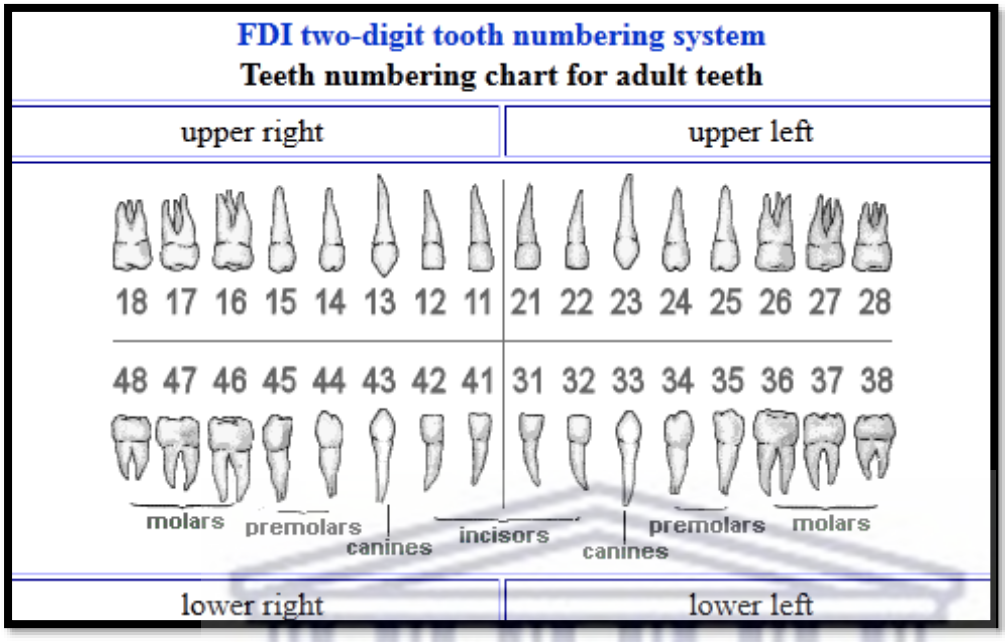


Figure 2: Description and illustration of FDI notation two-digit system, for permanent teeth notation as divided into four quadrants, showing the canine notations (13), (23), (33), (43).

Chapter 5

Results

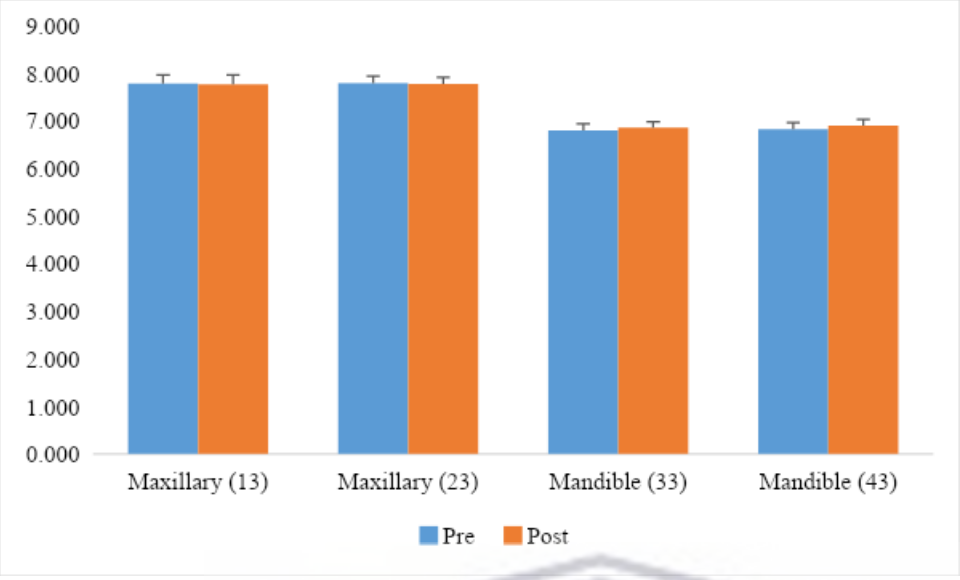
The inter-examiner results.

Paired Samples Test was used to analyse the results statistically.

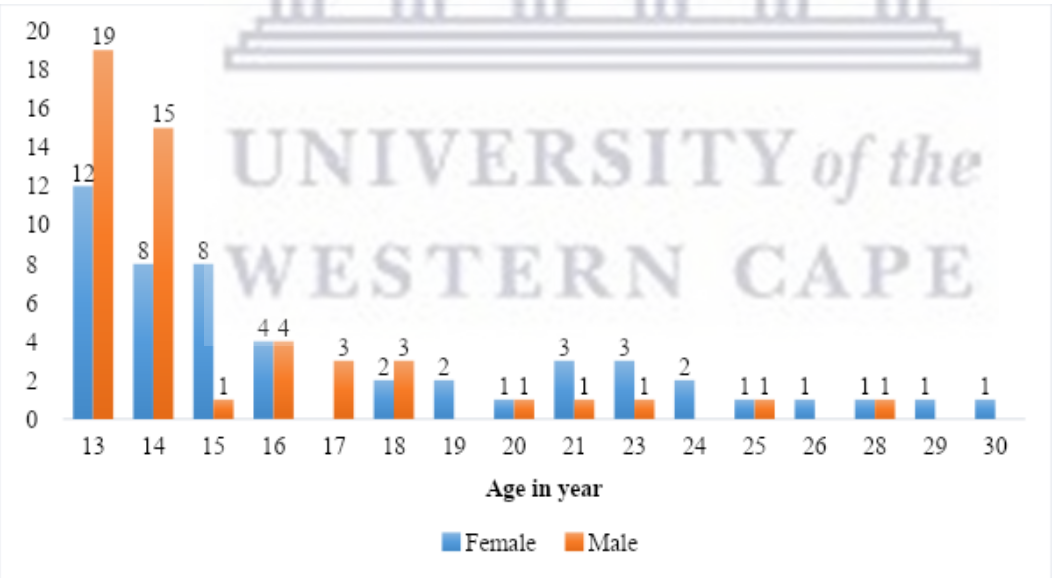
Table 1. The inter-examiner results as the P-value of the inter-examiner results based on the 1th observer and the 2nd observer indicated that there was no significant difference.

Column 1	N	Mean	Std. Error	P value
Maxillary (13) Pre	12	7,783	0,1813	0,658
Maxillary (13) Post	12	7,767	0,2024	
Maxillary (23) Pre	12	7,792	0,1474	0,586
Maxillary (23) Post	12	7,775	0,1382	
Mandible (33) Pre	12	6,8	0,1371	0,189
Mandible (33) Post	12	6,858	0,1177	
Mandible (43) Pre	12	6,825	0,1415	0,032
Mandible R (43) Post	12	6,9	0,1348	

The P-value of the inter-examiner results based on Pre and Post tests indicated that there was no significant difference between participants.



Graph 1: Mean width measurement results by the 1st observer and 2nd observer.



Graph 2: Graph shows the number of individuals according to age group and their number in each age group.

Table 2: Showed the descriptive statistics of age, mean age of the 100 participants, aged between 13 and 30 years old was 16.22 years, also, the mean age for females was 17.25 years and for mean 15.16 years.

Gender	N	Mean	Std. Error Mean	Column1
Female	**50**	**17.28**	**0.685**	
Male	**50**	**15.16**	**0.464**	
Total	**100**	**16,22**	**0,425**	

It is important to mention that it was not easy to collect two sets of data for all the ages concerned in this study. In keeping with the above-stated table 3 showed that there were 33 non-Paired Participants and 67 Paired Participants. The 67 Paired Participants included 33 males and 34 females and non-paired participants included 9 males and 24 females. The Paired Participants comprise ages 13, 14, 16 and 18 and non-paired participants comprise ages 15, 17, 19, … and 30.

Before the presentation of the global table comprising all the participants and all the ages. Participants were grouped not only based on the number of participants but also on the acceptability of the generated results.

Table 3: Age and sex group including paired participants and non-paired participants in age group.

Column1		Paired Participants		Non-Paired Participants	Total
Age	Male	Female	Male	Female	
13	19	12	0	0	31
14	8	15	0	0	23
15	0	0	1	8	9
16	4	4	0	0	8
17	0	0	3	0	3
18	2	3	0	0	5
19	0	0	0	2	2
20	0	0	1	1	2
21	0	0	1	3	4
22	0	0	0	0	0
23	0	0	1	3	4
24	0	0	0	2	2
25	0	0	1	1	2
26	0	0	0	1	1
27	0	0	0	0	0
28	0	0	1	1	2
29	0	0	0	1	1
30	0	0	0	1	1
Total	33	34	9	24	100

Comparison within the years:

5.1 The results of mesiodistal width for 13 years' old

Table 4,5,6,7 presents the comparison of mesiodistal width of the permanent maxillary canines (13 and 23) and permanent mandibular canines (33 and 43) of 13 years old with the gender by using T test for two independent samples. The sexual dimorphism was measured according to Garn, S.M., 1967.

5.15.3 The *mesiodistal width* for 13 years' old

The following Table 4. Presents the data of the evaluation of mesiodistal width of the permanent maxillary and mandibular canines of 13 years old females (12) and males (19) based on the comparison of their maxillary (13), maxillary (23), the mandible (33) as well as the mandible (43).

Table 4: Sexual dimorphism in 13 years old maxillary and mandibular canines.

Gender vs 13 years	Column1	N	Mean	Std. Error Mean	Sig.	Sexual dimorphism
Maxillary (13)	Female	12	7,75	0,11	0,747	1%
	Male	19	7,811	0,13		
Maxillary (23)	Female	12	7,583	0,097	0,318	2%
	Male	19	7,758	0,122		
Mandible (33)	Female	12	6,475	0,136	0,026	7%
	Male	19	6,911	0,12		
Mandible (43)	Female	12	6,558	0,127	0,154	5%
	Male	19	6,874	0,151		

The data presented in the above Table 4.41 reveal that as far as the upper right canine (Maxillary 13) is concerned the comparison between the females and the males indicated the

Sig. (2-Tailed) of 0.747 which implies that there is no statistically significant difference between the upper right canine in females and males aged 13. The data also assume a very low value of sexual dimorphism (1%).

In regard to the upper left canine (Maxillary 23), the comparison revealed a Sig. (2-Tailed) of 0.318 which indicated that there is no difference between females and males aged 13. However, the data also indicate the sexual dimorphism value of (2%) which is low but fairly significant.

The comparison of the two Maxillaries (13 and 23) revealed the Sig. (2-Tailed) of 0.747 and 0.318. In both cases, the P-values indicate that there is no significant difference between females and males. On the contrary, the upper left canine presents a sexual dimorphism value (2%) higher than the upper right's one (1%).

Concerning the lower left canine (Mandible 33), the Sig. (2-Tailed) of 0.026 indicates a significant difference between females and males aged 13. The data also assume a high value of sexual dimorphism (7%).

Finally, with regard to the lower right canine (Mandible 43), the Sig. (2-Tailed) of 0.154 indicates the absence of significant difference between 13 years old females and males. Yet, the 5% value of sexual dimorphism shows a considerable degree of the existent difference between them.

The comparison of the Mandibles (33 and 43) revealed the Sig. (2-Tailed) 0.026 and 0.154 which indicate that in both cases, there is no significant difference between male and females. However, the lower left canine presents a higher sexual dimorphism value (7%) than the lower right one (5%).

5.3 The *mesiodistal width* for 14 years' old

Having presented the data related to the comparison of mesio-distal width of the permanent maxillary and mandibular canines of 14 years old females and males in the preceding section, the present section presents the evaluation of the mesio-distal width of the permanent maxillary and mandibular canines of 14 years old, males (15) and females (8).

Table 5: Sexual dimorphism in 14 years old maxillary and mandibular canines.

Gender vs 14 years	Column1	N	Mean	Std. Error	P value	Sexual dimorphism
Maxillary (13)	Female	8	7,85	0,171	0,6	2%
	Male	15	7,98	0,153		
Maxillary (23)	Female	8	7,75	0,148	0,238	4%
	Male	15	8,033	0,15		
Mandible (33)	Female	8	6,8	0,132	0,222	3%
	Male	15	7,033	0,115		
Mandible (43)	Female	8	6,7	0,109	0,092	4%
	Male	15	6,953	0,087		

The data presented in the Table 4.52 above show that concerning the comparison of the mesiodistal width measure of (Maxillary 13) between 14 years old females and the males indicated the P-value of (0,600) which means that there is no statistically significant difference between the maxillary right canine in females and males at this age. However, (2%) exhibit a very low value of sexual dimorphism.

As for the (Maxillary 23), the comparison of measures revealed a P-value of 0.238 which pointed out that statistically there is no significant difference between 14 years old females and males. However, the measures reveal a sexual dimorphism value of (4%) which indicates a significant difference between both sexes at this age group.

The comparison of the two Maxillaries (13 and 23) revealed the P-values of 0.600 and 0.238 which indicate that in both cases there is no significant difference between females and males. Yet, the upper left canine presents a sexual dimorphism value (4%) higher than the upper right's one (2%).

Then, about the lower left canine (Mandible 33), the comparison of measures revealed a P-value of 0.222 indicating that there is no difference between females and males aged 14. Yet, the same data unveil a significant value of sexual dimorphism (3%).

Finally, regarding the (Mandible 43), measures comparison revealed the P-value of 0.092 which indicates that there is no statistically significant difference between 14 years old females and males. However, the 4% value of sexual dimorphism expresses an acceptable degree of the existing difference between them.

The comparison of the Mandibles (33 and 43) revealed the P-value of 0.222 and 0.092 which indicate that in both cases, there is no significant difference between male and females. Yet, the lower right canine presents a higher sexual dimorphism value (4%) than the lower left one (3%).

5.3 The *mesiodistal width* for 16 years' old

Having presented the data related to the comparison of mesiodistal width of the permanent maxillary and mandibular canines of 14 years old females and males in the preceding section, the present section presents the evaluation of the mesiodistal width of the permanent maxillary and mandibular canines of 16 years old, males (4) and females (4).

Table 6: Sexual dimorphism in 16 years old maxillary and mandibular canines.

Gender vs 16 years	Column1	N	Mean	Std. Error	P value	Sexual dimorphism
Maxillary (13)	Female	4	7,125	0,3881	0,113	11%
	Male	4	7,925	0,1887		
Maxillary (23)	Female	4	7,5	0,2081	0,454	3%
	Male	4	7,725	0,1887		
Mandible (33)	Female	4	6,6	0,2646	0,423	4%
	Male	4	6,875	0,1797		
Mandible (43)	Female	4	6,6	0,1683	0,184	5%
	Male	4	6,9	0,108		

The comparison of the mesiodistal width measures of canines between 16 years old females and males presented in the Table 4.63 above indicate that as far as the (Maxillary 13) is

concerned a P-value of (0,113) indicates that there is no statistically significant difference between the (Maxillary 13) in both female and male. However, the sexual dimorphism value of (11%) exhibits a significant difference between both sexes when they are 16 years old.

Concerning the (Maxillary 23), the evaluation of measures exhibited on one hand a P-value of 0.454 which means that statistically there is no difference between a 16 years old females and males. On the other hand, the measures presented a sexual dimorphism value of (3%) which indicates a very low difference between both sexes at this age in comparison to the upper right canine of the same age group.

The comparison of the two Maxillaries (13 and 23) revealed the P-values of 0.113 and 0.454 which indicate that in both cases, there is no significant difference between females and males. But, the upper right canine presents a sexual dimorphism value (11%) higher than the upper left one (3%).

In regard of the (Mandible 33), the comparison of measures revealed a P-value of 0.423 indicating that there is no difference between a 16 years old females and males. Yet, the same data revealed a low value of sexual dimorphism (4%).

Lastly, about the (Mandible 43), the contrast of measures revealed the P-value of 0.184 which indicates the absence of significant difference between 16 years old females and males. However, the sexual dimorphism value of (5%) unveils the existence of an adequate degree of difference between them.

The comparison of the Mandibles (33 and 43) revealed the P-value of 0.423 and 0.184 which indicate that in both cases, there is no significant difference between male and females. But, the lower right canine presents a higher sexual dimorphism value (5%) than the lower left one (4%).

5.4 The The results of *mesiodistal width* for 18 years' old

In keeping with presenting the data related to the comparison of mesiodistal width of the permanent maxillary and mandibular canines, this section presents the evaluation of the mesiodistal width of the permanent maxillary and mandibular canines of 18 years old, males (3) and females (2).

Table 7: Sexual dimorphism in 18 years old maxillary and mandibular canines

Gender vs 18 years	Column1	N	Mean	Std. Error	P value	Sexual dimorphism
Maxillary (13)	Female	2	7,95	0,45	0,935	1%
	Male	3	8,033	0,819		
Maxillary (23)	Female	2	7,8	0,7	0,49	9%
	Male	3	8,5	0,289		
Mandible (33)	Female	2	6,3	0,1	0,061	19%
	Male	3	7,467	0,328		
Mandible (43)	Female	2	6,65	0,45	0,218	15%
	Male	3	7,667	0,233		

The study of the mesiodistal width measures of canines between 18 years old females and males presented in the Table 4.74 above reveals that in regard to the (Maxillary 13) a P-value of (0,935) indicates that statistically there is no important difference between both female and male. Besides, the sexual dimorphism value of (1%) also unveils a very low difference between both sexes at this age.

About the (Maxillary 23), the measures revealed a P-value of 0.490 which means that there is no statistically significant difference between 18 years old females and males, but the (9%) value of sexual dimorphism indicates there is a considerable difference between both sexes at this age.

The comparison of the two Maxillaries (13 and 23) revealed the P-values of 0.935 and 0.490 which indicate that in both cases, there is no significant difference between females and males. On the contrary, the upper left canine presents a sexual dimorphism value (9%) higher than the upper right's one (1%).

As far as the (Mandible 33) is concerned, the study of measures revealed a P-value of 0.061 which indicates that there is no significant statistical difference between 18 years old females and males. However, the same study indicated a high sexual dimorphism value of (19%) which implies that there is considerable difference between them.

Lastly, in regard to the (Mandible 43), the measures unveiled the P-value of 0.218 which indicates that statistically there is no significant difference between 18 years old females and males. On the contrary, the sexual dimorphism value of (15%) indicates the existence of a lesser considerable degree of difference between them when compared to the lower left canine.

The comparison of the Mandibles (33 and 43) revealed the P-value of 0.061 and 0.0218 which indicate that in both cases, there is no significant difference between male and females. But, the lower left canine presents a higher sexual dimorphism value (19%) than the lower right one (15%).

5.5 The major result:

After having presented the data related to the comparison of mesiodistal width of the permanent maxillary and mandibular canines of 13, 14, 16 and 18-years old females and males in the preceding sections, the present section presents the evaluation of the mesiodistal width of the permanent maxillary and mandibular canines of 50 males and 50 females aged from 13 to 30.

Table 8: Sexual dimorphism in males and females' maxillary and mandibular canines (from 13 to 30 years old).

Gender from 13 to 30	Column1	N	Mean	Std. Error	P value	Sexual dimorphism
Maxillary (13)	Female	50	7,682	0,071	0,048	3%
	Male	50	7,9	0,083		
Maxillary (23)	Female	50	7,63	0,057	0,005	4%
	Male	50	7,902	0,075		
Mandible (33)	Female	50	6,562	0,057	0	6%
	Male	50	6,958	0,071		
Mandible (43)	Female	50	6,606	0,058	0,001	5%
	Male	50	6,932	0,074		

The study of the mesiodistal width measures of canines between females and males aged from 13 to 30 presented in the Table 4.85 above reveals that as far as the (Maxillary 13) is concerned a P-value of (0,048) indicates that there is no statistically significance difference between both female and male. However, the sexual dimorphism value of (3%) shows that there is a low difference but significant between both sexes at this age.

Table 9: Showing the probability of gender determination using (13) as percentage is 56% accuracy for females and 64% for males with over all of 60%.

Classification Tables

Observed			Predicted Sex: Female	Predicted Sex: Male	Percentage Correct
Step 1	Sex	Female	28	22	56,0
		Male	18	32	64,0
	Overall Percentage				60,0

As for the (Maxillary 23), the measures unveiled a P-value of 0.005 which means that statistically there is a significant difference between females and males. Equally important, the (4%) value of sexual dimorphism indicates that there is a fairly considerable difference between both sexes in comparison to other canines.

Table 10: Showing the probability of gender determination using (23) as percentage is 72% accuracy for females and 60% for males with over all of 66%

Classification Tables

Observed			Predicted Sex: Female	Predicted Sex: Male	Percentage Correct
Step 1	Sex	Female	36	14	72,0
		Male	20	30	60,0
	Overall Percentage				66,0

The comparison of the two Maxillaries revealed that the upper left canine (Maxillary 23) presents a P-value of 0.005 which is higher than the upper left's one (0.048). In the same way, the upper left canine also presents a sexual dimorphism value (4%) slightly higher than the upper right one (3%).

About the (Mandible 33), the study of measures revealed a P-value of 0.000 which indicates a statistically significant difference between females and males. Furthermore, the same measures indicate a high sexual dimorphism value of (6%) which means that there is a highly considerable difference between them in comparison to other canines.

Table 11: Showing the probability of gender determination using (33) as percentage is 76% accuracy for females and 68% for males with over all of 72%.

Classification Tables

Observed			Predicted Sex: Female	Predicted Sex: Male	Percentage Correct
Step 1	Sex	Female	38	12	76,0
		Male	16	34	68,0
	Overall Percentage				72,0

Lastly, in regard to the (Mandible 34), the measures unveiled the P-value of 0.001 which indicates that statistically there is a significant difference between females and males. Besides, the sexual dimorphism value of (5%) indicates that there is a considerable difference between them when in comparison to other canines.

Table 12: Showing the probability of gender determination using (43) as percentage is 64% accuracy for females and 74% for males with over all of 69%.

Classification Tables

Observed			Predicted Sex: Female	Predicted Sex: Male	Percentage Correct
Step 1	Sex	Female	37	13	74,0
		Male	18	32	64,0
	Overall Percentage				69,0

The comparison of the Mandibles revealed that the lower left canine (Mandible 33) presents P-value of 0.000 which is higher than the lower right one 0.001. The two P-values indicate that in both cases, there is a significant difference between male and females. Equally important, the lower left canine also presents a higher sexual dimorphism value (6%) than the lower right one (5%).

Table 13: Over all result when using the four quadrants (12), (23), (33), (43), showing gender determination probability 76% for females and 64% for males with over all of 70%.

Classification Tables

Observed			Predicted Sex		
			Female	Male	Percentage Correct
Step 1	Sex	Female	38	12	76,0
		Male	18	32	64,0
	Overall Percentage				70,0

Chapter 6

Discussion

There are many methods of human identification, starting with the DNA as a gold standard, in addition to fingerprints, dental profiling and visual inspection. The methods employed for human identification may differ in different situations, such as catastrophic disasters involving aircrafts, bombings, tsunamis, fires and incineration (teeth can handle almost 1800 centigrade). Skeletonization and time also play a determining role in the choice of method used for human identification. However, metric analysis has proved useful in cases of fragmented dental remains as a method of gender determination.

Scientifically sexual dimorphism is a term used when two sexes of the same species exhibit different characteristics in addition to their sexual organ differences. This condition occurs in humans, animals and certain plants (Prabhakar, 2019).

This study aimed to investigate the gender dimorphism between males and females by measuring the mesiodistal width of the permanent maxillary and mandibular canines in a sample of the South African population in Cape Town.

Many studies have investigated sexual dimorphism using different teeth such as incisors, molars and canines, with different methods and measurements. According to the literature, measurement of the canines was the most effective indicator of sexual dimorphism (Ibeachu *et al*., 2012).

Data were collected from one hundred individuals, 50 males and 50 females, who attended the Tygerberg Oral Health Centre. Their study models were used for measurement instead of intraoral measurements in accordance with the study by Hunter & Priest (1960) that indicated that measurement of dental casts was more effective. Patnaik (2003) concluded in his study that there were no significant differences between measurements intraorally or on dental casts.

According to the results of this study, comparison between the left and right maxillary and mandibular canines showed no differences in neither males nor females. This finding was in

agreement with the findings of Hashim & Murshid (1993) who concluded in their study of a sample of the Saudi Arabian population, between the ages of 13-20, that there were no differences between the right and left maxillary and mandibular permanent canines in neither males nor females. Furthermore, canines are the only teeth that showed sexual dimorphism. Al-Rifaiy *et al.*, (1997) investigated sexual dimorphism in the Saudi population by using the maxillary and mandibular canine width in the age group 15-18 years of age and concluded that there was no significant feature between the right and left maxillary and mandibular canines in neither males nor females.

This was disconfirmed by Claassens (2016) who investigated sexual dimorphism in a sample of the South African population by measuring the mesiodistal width of the maxillary incisors, canines and mandibular canines. She found that canines showed significant features in terms of sexual dimorphism. In the current result the tooth that showed the most sexual dimorphism was (33) with a percentage of 68% probability for males and 76% probability for females which was in agreement with the study by Claassens (2016), as the accuracy of their result was 52% for males and 74% for females by measuring the teeth (13) and (33) using the logistic regression model.

According to a study established by Peckmann *et al.*, (2016) who investigated sexual dimorphism in a sample of the Chilean population aged between 13-37 years old, measuring the mesiodistal width of the permanent maxillary incisors and canines, indicated that only canines and central incisors were statistically significant. His predictions of males identified were 54.4% to 63.3% which was consistent with our study, as our predictability for males was 64%.

Khangura *et al.*, (2011) concluded in their results that the left and right maxillary canine could be used for gender determination with a prediction and accuracy of 58% for males and 64% for females. This was consistent with our study as the overall predictability for males was 64% and 76% for females.

In terms of sexual dimorphism between males and females this study was consistent with the study by Naikoo *et al.* (2017) that investigated sexual dimorphism in a sample of the Kashmiri population. Their findings indicated that the probability of sex determination between males and females was 95% for males when the mesiodistal width was more than

7.852mm. This study was in agreement with the findings of Ayoub *et al.*, (2014). According to a study conducted on a sample of the Lebanese population, they demonstrated that the mesiodistal width of the right and left mandibular permanent canines was greater in males than in females in addition to the probability to determine male sex with a percentage of 95% when canine width was greater than 7.104mm.

The study by Kapila *et al., (*2011) on sexual dimorphism in permanent mandibular canines revealed a 90% probability for gender determination as male if the mesiodistal width of the canines was greater than 7mm. Their findings also indicated that the left mandibular canine (7.7) mm was greater than the right mandibular canine (7.4) in terms of sexual dimorphism, which is in accordance with the results of this study where it was found that the left mandibular canine was greater in size than the right mandibular canine.

Srivastava *et al.,* (2014) used permanent maxillary incisors and canines in their study of gender determination and found that males' measurements showed significant features when compared to females. Jha *et al.,* (2015) concluded in their study that sexual dimorphism was statistically significant between males and females by measuring the mesiodistal width of the canines. Gupta *et al.,* (2014) proved in their study that sexual dimorphism was highly significant by measuring the mesiodistal width of the maxillary permanent canines.

In this study 100 participants were involved in the data collection in the age group of 13-30 years as this age group presented the lowest rate of carious and non-carious lesions such as attrition, abrasion and abfraction. Regarding the sample of this study we had to divide it into subgroups in terms of age as some age groups were only males without females or *vica versa.* There was no significant feature between the age groups 13-30.

Limitations of the study

The limitations of this study were that the statistics and the percentage for sexual dimorphism could only be applied to the specific age group 13-30 and was confined to the South African population living in Cape Town. However, grouping of this study may affect the probability and validity of gender determination.

The technique used in measuring the maximum width of the mesial and distal distances was effortless and uncomplicated when compared with the DNA. However, DNA is the gold standard for human identification, but the complexity, time and the lost or damaged evidence could be an obstacle for extracting DNA.

Chapter 7

Conclusion

This study showed the prevalence of sexual dimorphism between males and females according to the mesiodistal width of the permanent maxillary and mandibular canines as follows: -.

There is no sexual dimorphism when measuring the maxillary right permanent canine 13 as it does not show a statistically significant feature.

There is sexual dimorphism when measuring the maxillary left permanent canine 23 as it shows a statistically significant feature.

There is sexual dimorphism when measuring the mandibular right permanent canine 33 as it shows a highly statistically significant feature.

There is sexual dimorphism when measuring the mandibular left permanent canine 43 as it shows a statistically significant feature.

Comparison between the right and left permanent maxillary canines reveals that the upper left canine 23 represents higher sexual dimorphism than the upper right canine 13.

Comparison between the right and left permanent mandibular canines reveals that the lower left canine 33 represents higher sexual dimorphism than the right canine 43.

No significant differences between the right and left maxillary and mandibular canine width in males.

No significant differences between the right and left maxillary and mandibular canine width in females.

Moreover, both left side 23 and 33 were higher than right side 13 and 43 when compared per quadrant.

According to the highest percentage of sexual dimorphism:

Lower left canine 33 registered the highest percentage of sexual dimorphism namely, 72% gender determination probability,
Followed by lower right canine 43 with 69% gender determination probability,
Followed by upper left canine 23 with 66% gender determination probability,
Followed by the upper right canine 13 with 60 % gender determination probability.

Recommendations for future studies:

Similar studies should be conducted in which the sample size should be increased to cover a larger part of the population, keeping in mind the diversity and multi-ethnic groups in South Africa. Moreover, the age group should be increased as the limitation of age is 13-30 in the present study. Furthermore, measuring the inter-canine distance would be more valid as the size of the maxilla and mandible is greater in males when compared to females and this may render significant results.

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Appendices

File number	Gender	Age	Max.R 13)	Max.L(23)	Man.l(33)	Man. (43)
1	F	14	7,6	7,2	6,6	6,7
2	F	14	8,6	8,3	7,5	7,3
3	F	23	7,3	7,4	6,3	6,6
4	F	13	7,8	7,6	6	6,3
5	F	15	7,6	7,3	6,4	6,4
6	F	24	7,9	7,7	6,6	6,6
7	F	13	7,9	7,7	7,7	7,7
8	F	16	8,1	8	7,1	7,1
9	F	19	7,4	7,5	6,2	6,4
10	F	14	7,7	7,5	6,9	6,5
11	F	13	7,6	7,3	6,5	6,5
12	F	13	7,7	7,5	6,5	6,5
13	F	14	8	7,5	6,8	6,3
14	F	15	7,7	7,5	6,7	6,2
15	F	25	7,4	7,4	5,8	5,7
16	F	15	7,2	7,7	6,5	6,8
17	F	13	7	6,9	6,5	6,3
18	F	23	7,9	7,8	6,3	6,8
19	F	21	7,6	7,6	6,7	6,6
20	F	20	7,6	7,3	6,5	6,3
21	F	13	7,3	7,3	6	6,1

22	F	14	8,2	8,4	7,1	6,9
23	F	16	7,4	7,4	6,9	6,4
24	F	21	6,7	7	6,6	6,6
25	F	13	7,8	7,7	6,6	6,6
26	F	23	8,5	8,5	7,4	8
27	F	14	7	7,6	6,7	6,5
28	F	13	7,9	7,4	6,1	6,2
29	F	13	8,1	7,9	6,5	7
30	F	15	6,7	7,1	6,5	6,2
31	F	13	7,4	7,6	6,2	6,7
32	F	15	7,7	7,5	7	7
33	F	15	7,8	7,6	6,5	6,6
34	F	13	8,2	8,1	6,9	6,6
35	F	14	7,6	7,6	6,5	6,6
36	F	19	7,3	7,4	6,2	6,3
37	F	15	8,5	8,1	7	6,9
38	F	18	7,5	7,1	6,2	6,2
39	F	26	8,1	7,5	6,6	6,7
40	F	29	7,3	7,2	6	6,5
41	F	16	6,5	7,6	6,5	6,5
42	F	14	8,1	7,9	6,3	6,8
43	F	13	8,3	8	6,2	6,2
44	F	21	7,6	7,3	6,4	6,4
45	F	15	8	8,2	6,7	6,6
46	F	16	6,5	7	5,9	6,4
47	F	18	8,4	8,5	6,4	7,1
48	F	28	8,5	8,6	7,3	7,3
49	F	24	7,7	7,7	6,3	6,1
50	F	30	7,9	8	6,5	6,7

Female (13), (23), (33), (43) measurements in (mm).

File number	Gender	Age	Max.R(13)	Max.L(23)	Man. R(44)	Man. (43)
1	M	18	6,5	8,5	7,6	7,3
2	M	14	7,6	7,4	6,8	6,7
3	M	18	9,3	9	8,1	8,1
4	M	14	8,4	8,6	7,1	7,3
5	M	16	8,2	7,8	7,2	7,1
6	M	16	7,6	7,3	6,8	6,8
7	M	13	7,6	7,8	7	6,8
8	M	17	8,7	8,4	7,6	7,8
9	M	15	8	8	6,7	6,3
10	M	13	7,3	7	6,6	6,8
11	M	13	7,7	8	6,9	6,9
12	M	13	7,8	7,4	7	6,7
13	M	14	7,2	7,6	6,8	6,8
14	M	17	8	8,3	7,3	7,3
15	M	13	8,1	7,9	7,5	7,4
16	M	13	7,9	7,5	6,5	6,2
17	M	13	8,7	8,4	7,6	7,3
18	M	13	8,1	8	7,2	7,6
19	M	13	8,1	7,5	7,1	7

20	M	20	7,4	7,2	6,7	7,1
21	M	13	7,3	7	5,4	5,9
22	M	16	7,6	7,6	6,7	6,4
23	M	14	6,8	6,7	6,3	6,4
24	M	14	7,4	7,7	6,7	6,6
25	M	21	8	7,6	6,9	7
26	M	13	7,3	7,1	6,1	6,8
27	M	13	7,4	7,7	6,4	6,4
28	M	13	8,1	7,9	7,3	6,6
29	M	14	8,5	8,6	7,2	7,6
30	M	14	8	8,1	6,8	6,8
31	M	13	6,3	7,4	5,8	6,9
32	M	14	7,8	7,5	6,9	6,6
33	M	13	8,4	8,7	7,9	7,7
34	M	13	8,2	7,5	6,6	6,4
35	M	16	8,3	8,2	6,9	7,2
36	M	14	7,8	8,2	7,6	7,9
37	M	28	7,5	7,9	6,7	6,2
38	M	25	8	7,9	6,4	6,5
39	M	14	8,8	8,8	7,3	7,6
40	M	23	7,5	7,5	6,1	6,2
41	M	13	8,1	8,7	7,5	7,7
42	M	14	8,9	8,8	6,7	6,8
43	M	17	8	8	6,7	6,8
44	M	14	8,4	7,9	7	7

45	M	13	7,4	7,4	6,6	6,6
46	M	14	8,4	8,2	7,5	7,5
47	M	14	7,9	8,1	6,8	6,8
48	M	13	8,6	8,5	7,6	7,6
49	M	14	7,8	8,3	6,8	7,1
50	M	18	8,3	8	7,3	7

Male 31, 23, 33, 43 measurements in (mm).