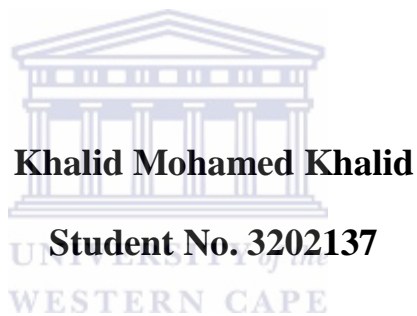




Palatal Rugae Patterns in a Sudanese Population Sample



Khalid Mohamed Khalid

Student No. 3202137

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

**Supervisor:
Prof. V. M. Phillips**

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Palatal Rugae patterns in a Sudanese Population Sample

Khalid Mohamed Khalid

Key words

Sudan

Cross sectional study

Palate

Rugae

Morphological patterns

Prevalence

Comparison

Gender

Dental identification

Forensic dentistry



Abstract

Palatal Rugae Patterns in a Sudanese Population Sample

Palatal rugae are ridges resulted from symmetrical and irregular mucosal folds of tissue and located in the alveolar third of the palate. Palatal rugae identification can have a significant role in forensic identification where it is difficult to use the normal identification methods. The aim of this study is to identify and compare the palatal rugal morphological patterns in a sample of adult males and females of Sudanese population.

Maxillary impression models obtained from 100 subjects (50 males and 50 females) of age group 21 – 23 years, of the dental students of University of Science and Technology, Sudan. The data were assessed based on the Thomas and Kotze classification (1983) for the length, shape and prevalence. The Independent - t - Test was used for the statistical analysis. Ethical approvals declared from the University of Science and Technology, Sudan and University of the Western Cape South, South Africa to conduct the study.

Statistical analysis showed that females had significantly more number of total rugae on the right side of the palate than in males. The prevalence of the palatine rugae numbers was significantly more in females than in males. Primary rugae were distributed more significantly in females more than males. On the right side of the palate, the straight type of rugae was significantly predominant in females than in males whilst the wavy shape was more in males than in females. On the left side of the palate, the curved type of rugae was significantly more presented in males than in females whilst the diverging unification type was more in females than in males. The distribution of number of rugae shapes in both males and females were seen as straight followed by wavy and least was the circular. The total number of straight rugae was significantly more in females than in males, as well as circular rugae and diverging rugae. In contrast, curved rugae were significantly more in males than in females. There were 11 individuals who did not comply with the Thomas and Kotze classification thus was recorded as unspecified.

This Sudanese study showed significant differences between males and females in the number, length and shapes of rugae. Hence, the individuality and uniqueness of palatine rugae can be used as a tool for forensic dental identification, and possibly distinction between males and females. There is also a possibility that there are ethnic differences in rugal patterns.



Dedication

To the soul of my friend,

Ikrma EL-Mahdi El-Sidig.

I am missing you.



Declaration

I declare that *Palatal Rugae Patterns in a Sudanese Population Sample* is my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

Khalid Mohamed Khalid

October 2013

Signed:

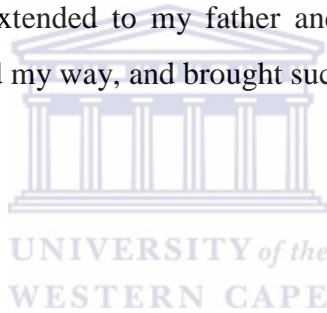


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Contents

| | Page |
|--|-------------|
| Key words..... | ii |
| Abstract..... | iii |
| Dedication..... | v |
| Declaration..... | vi |
| Acknowledgment..... | vii |
| Contents..... | viii |
| List of Figures..... | x |
| List of Tables..... | xii |
| Chapter 1: Introduction..... | 1 |
| Chapter 2: Literature Review and Objectives..... | 3 |
| 2.1 Historical review..... | 3 |
| 2.2 Classification of palatine rugae..... | 4 |
| 2.3 Rugal morphology in different Countries..... | 5 |
| 2.4 Rugae in forensic identification..... | 10 |
| 2.5 Aims and objectives..... | 12 |
| 2.5.1 Aims..... | 12 |
| 2.5.2 Objectives..... | 12 |
| Chapter 3: Materials and Methods..... | 13 |
| 3.1 Study design..... | 13 |
| 3.2 Study area and population..... | 13 |
| 3.3 Sample size..... | 13 |
| 3.4 Sampling procedure..... | 13 |
| 3.5 Inclusion criteria..... | 13 |
| 3.6 Exclusion criteria..... | 14 |
| 3.7 Methodology..... | 14 |

| | |
|---|----|
| 3.8 Ethical consideration..... | 19 |
| Chapter 4: Results..... | 20 |
| Chapter 5: Discussion..... | 31 |
| Chapter 6: Conclusion and Recommendations..... | 35 |
| References..... | 36 |
| Appendices: | |
| Annexure 1: Thomas & Kotze classification..... | 41 |
| Annexure 2: Information to the patient and Consent Form..... | 46 |
| Annexure 3: Data Collection Sheet..... | 48 |
| Annexure 4: The Ethics Approval from the University of Western Cape..... | 49 |
| Annexure 5: The Ethics Approval from the University of Science and Technology..... | 50 |



List of Figures

| Figure 1: | Page |
|--|------|
| The illuminated magnifier..... | 14 |
| Figure 2: | |
| The Vernier scale..... | 15 |
| Figure 3: | |
| The different shapes of the rugae (A)..... | 16 |
| Figure 4: | |
| The different shapes of the rugae (B)..... | 16 |
| Figure 5: | |
| The rugal patterns outlined in pencil showing different types of palatal rugae shapes (A)..... | 17 |
| Figure 6: | |
| The rugal patterns outlined in pencil showing different types of palatal rugae shapes (B)..... | 17 |
| Figure 7: | |
| The rugal patterns outlined in pencil showing unspecified rugae (A)..... | 18 |
| Figure 8: | |
| The rugal patterns outlined in pencil showing unspecified rugae (B)..... | 18 |
| Figure 9: | |
| Distribution of palatine rugae numbers in males and females..... | 22 |
| Figure 10: | |
| Distribution of rugae length on the right side of the palate in males and females..... | 23 |
| Figure 11: | |
| Distribution of rugae length on the left side of the palate in males and females..... | 24 |
| Figure 12: | |
| Distribution of rugae length in males and females..... | 25 |

Figure 13:
Distribution of different rugae shapes on the right side of the palate in
males and females..... 27

Figure 14:
Distribution of different rugae shapes on the left side of the palate in
males and females..... 28

Figure 15:
Distribution of different rugae shapes in males and females..... 30



List of Tables

| | |
|--|------|
| Table 1: | Page |
| Distribution of sample according to gender..... | 20 |
| Table 2: | |
| Age statistics..... | 21 |
| Table 3: | |
| Descriptive analysis of the total number of rugae..... | 21 |
| Table 4: | |
| Distribution of palatine rugae numbers in males and females..... | 22 |
| Table 5: | |
| Distribution of rugae length on the right side of the palate in males and females..... | 23 |
| Table 6: | |
| Distribution of rugae length on the left side of the palate in males and females..... | 24 |
| Table 7: | |
| Distribution of rugae length in males and females..... | 25 |
| Table 8: | |
| Distribution of different rugae shapes on the right side of the palate in males and females..... | 26 |
| Table 9: | |
| Distribution of different rugae shapes on the left side of the palate in males and females..... | 28 |
| Table 10: | |
| Distribution of different rugae shapes in males and females..... | 29 |

Chapter One

Introduction

Forensic science is defined as the application of science to the law (Senn & Stimson 2010). One of the most challenging processes in forensic science is forensic identification of the deceased (Paliwal et al 2010). Forensic identification has a major role socially and legally regarding the rights of the dead persons and their families (Filho et al 2009).

Visual recognition is the most common means for obtaining a positive identification because most of the deaths occur under normal circumstances (Bansode & Kulkarni 2009, Muthusubramanian et al 2005, English et al 1988). Visual identification is not desirable under unusual conditions of death where post-mortem changes associated with accidents, fire, decomposition or trauma make identification difficult (Bansode & Kulkarni 2009, English et al 1988).

The other common forensic methods of identification are fingerprints, DNA profiling and dental comparison (Saraf et al 2011, Sharma et al 2009, Pretty 2007). Finger prints have been the gold standard for human identification but has been limited by the lack of ante-mortem records or post-mortem applicability due to burnt or decomposing remains or massive trauma (Senn & Stimson 2010, English et al 1988). Although DNA is very accurate in identification it still has many limitations. It is a very expensive technique and always needs an ante-mortem record to compare it to. It is easily contaminated by extraneous DNA or destroyed by heat. Furthermore, the DNA extraction and identification is a lengthy process (Muthusubramanian et al 2005, Sweet & Di Zinno 1996).

Dental identification plays a major role in mass disaster identification of human remains. More than 90 % of the identified people in mass disasters are due to dental identification (Pretty, 2007). Palatal rugae may be regarded as an alternative comparative method for identification (Limson & Julian 2004). Studies that have been carried out on rugae showed highly unique rugae patterns and individuality throughout life (Saraf et al 2011). Palatal rugae identification

can have a significant role in forensic identification during mass disasters, terrorist acts, traffic accidents and burnt victims where it is difficult to use the normal identification methods (Gondivkar et al 2011, Patil et al 2008).

There is no extensive published literature review on the palatine rugal identification (Patil et al 2008) and most of the available studies are based on the classification systems designed by Lysell (1955), or Thomas and Kotze (1983). There is no published information or data base recording the pattern of palatal rugae among Sudanese people.

The aim of this study was to identify the different morphological rugal patterns in a sample of adult males and females of Sudanese origin for identification purposes.



Chapter Two

Literature Review and Objectives

2.1 Historical review

Palatal rugae, also called plicae palatinae transverse or rugae palatinae or Plicae Palatinae, are ridges resulted from symmetrical and irregular mucosal folds of tissue made from the lateral membrane of the incisive papilla, and located in the alveolar third of the palate (Patil et al 2008, Thomas et al 1987, Kapali et al 1997).

Carrea in 1937 found that the pattern of rugae is developed by the 12th to 14th week of prenatal life, and remains stable until death (cited in Patil et al 2008). The variation of number of rugae on each side of the palate varies between three to five and the palatine rugae never cross the midline of the palate (Bansode & Kulkarni 2009, Patil et al 2008).

The role of palatal rugae in human oral function is very minor. It had been suggested that palatal rugae are involved in the swallowing process, and improve the relationship between the taste receptors in the dorsal part of the tongue; it also has a role in speech and suction in children (Venegas et al 2009).

In 1732, J.B Winslow first described the palatine rugae in general anatomy (cited in Patil et al 2008). The earliest illustration of the rugae was made by Santorini in 1775, where he drew three continuous wavy lines crossing the midline of the palate. This illustration increased awareness among anatomists to do further studies about the rugae (Thomas & Kotze 1983).

Harrison Allen in 1889 used the rugae as a method of identification (English et al 1988, Peavy & Kendrick 1967). In 1932, Torbo Hermosa, a Spanish investigator, was the first to propose palatal rugoscopy as a study of palatal rugae in order to establish person identity (Bansode & Kulkarni 2009). Since then many attempts to investigate the rugae have been undertaken, but Lysell was the first to scientifically classify the rugal patterns in 1955 (cited in Thomas & Kotze 1983).

2.2 Classifications of palatine rugae

The first attempt of classification was developed by Gorla in 1911 (Patil et al 2008). It was a rudimentary system in which the rugae pattern was categorized in two ways: either specifying the number of rugae or the extension of the rugal zone relative to the teeth. He included compound rugae of two or more branches as one rugae. He further distinguished two types of rugae: (a) simple or primitive and (b) more developed (Thomas & Kotze 1983).

Later Lysell (1955) classified the rugae according to their size into primary, secondary or fragmentary. He also classified rugae according to their shape, position or origin in relation to the median palatal raphe and described unification of rugae (Thomas & Kotze 1983). Another classification by Carrea in 1955 divided the palatal rugae into four main types according to their direction. Type I: posterior-anterior directed rugae, Type II: rugae perpendicular to the raphe, Type III: anterior-posterior directed rugae and Type IV: rugae directed in several directions (Caldas et al 2006). In 1961, Basauri classified the rugae into simple and compound. The compound type was subdivided into ten types: 0, pointed; 1, Straight; 2, Curved; 3, Angled; 4, Sinuous; 5, Circular; 6, Greek; 7, Calyx-shaped; 8, racket-shaped; 9, branched (Basurai 1961).

Lima (1968) recognized four main types of rugae: punctuate, straight, curved and composite (Thomas & Kotze 1983). One year later, Caruso subdivided the rugae morphology into lineo-morphism and configuration. In this study the volume and direction were considered, and the number of rugae together with the relationship between their distal margin and the teeth were observed (Patil et al 2008, Thomas & Kotze 1983). Tzatscheva and Jordanov (1970) classified the rugae according to their direction, branching, symmetry and radially. In 1972 Thomas used Lysell's classification with minor variations to create a new classification. He added a feature called "cross-link". This is a small ruga that is a distinct identity and joins two rugae usually at right angle (Thomas & Kotze 1983). Comoy (1973) developed a classification system according to the length of the rugae. He classified the rugae into principal rugae (over 5 mm), accessory rugae (3 to 4 mm) and fragmental rugae (less than 3 mm). Moreover, the form (line, curve and angle) and origin and direction of each of the rugae were

described (Caldas et al 2006, English et al 1988).

Thomas and Kotze (1983) proposed a new detailed classification of the rugae pattern based on the classification of Lysell (1955) (Annexure 1). The new classification consisted of four parts: (i) Rugae dimensions and prevalence. (ii) Special details of individual primary rugae. (iii) Dimension of the rugae pattern. (iv) Dimensions of the dental arch and palate in width and depth.

2.3 Rugal morphology in different countries

Kapali et al (1997) compared the number and pattern of rugae in Australian Aborigines and Caucasians. A sample of 100 dental casts of Aborigines and 200 of Caucasians, ranging in age from 13 – 17 years were examined. The study was based on the Thomas and Kotze classification. The most common shapes of rugae in both groups were wavy and curved, while the straight and circular types were uncommon.

Abou El-Fotouh and El-Sharkawy (1998) conducted a study in Egypt to describe the palatine rugae in an Egyptian population sample. Six-hundred dental casts were used in the study, and divided into three groups. Each group consisted of 100 males and 100 females. The age range of group 1 was 15 – 30 years while group 2 and group 3 were of age range 50 – 65 years. The most common rugal pattern according to shape were crosslink, annular, papillary, branching, unification, breaks, unification with non-primary, crossover, reticular and irregular rugae. There was no statistically significant sexual dimorphism. The study revealed that rugoscopy could be a definite means of identification in forensic odontology.

Fahmi et al (2001) studied the rugae pattern in a Saudi male and female sample. One hundred and twenty subjects were selected from the students of the Dental College, King Saud University, KSA. Their ages were between 20 – 26 years. The rugae study was based on the Thomas and Kotze classification. The results showed no significant difference in the total number of rugae in males and females. Two shapes of rugae were statistically significant; the converging type which was found to be more common in females and the circular type was found commonly in males.

In 2007, Nayak et al investigated the difference in the shapes of palatal rugae in two Indian populations using the Thomas and Kotze classification. Wavy and curved rugal patterns were the most prevalent shapes in the whole sample, followed by the straight rugal pattern, circular patterns were not observed. Significant differences between the two populations were observed with regard to the straight and curved rugae but no significant sex differences were observed (Nayak et al 2007).

Virdi M, Singh Y and Kumar A (2009) analyzed palatal rugae as a method of identification of pediatric patients at Prabhu Dayal Memorial dental college. Twenty five dental casts were used in the study, and were analyzed based on the Thomas and Kotze classification. This study supported the uniqueness of palatal rugae for identification purposes.

Using the classification of Thomas and Kotze, palatal rugae patterns were compared between two different populations in India (Madhya Pradesh and Kerala) (Paliwal et al 2010). After analyzing the subjects, the wavy pattern was more dominant followed by the curved and the straight patterns in the population samples. On comparing the left and right sides of the palate, the straight shape rugae pattern was predominantly found on the right side of the palate of the Madhya Pradesh group and more common in males whilst wavy shaped rugae were predominantly seen in the Kerala population and more in males. The total number of rugae in the two populations on both sides of the palate showed no significant difference (Paliwal et al 2010).

Assessment of the number and different patterns of rugae among the student population in Mangalore in India was done by Shetty & Premalatha in 2011. The age of the subjects ranged between 17 – 25 years. The rugae assessment used the Thomas and Kotze classification. Curved, straight and forwardly directed rugal patterns were prevalent amongst the females, while wavy, perpendicular and backwardly directed rugal patterns were prevalent in males. The wavy pattern was the most common pattern among males and females. There were no significant difference in the total number of rugae on the right side or the left side of the palate among males and females. This study demonstrated the gender differences and individuality of rugal pattern (Shetty & Premalatha 2011).

Aiming to determine the predominant rugae of a Pondicherry population in India, a study was conducted in 2011 based on the classification of Thomas and Kotze (Sumathi et al 2011). Forty subjects aged between 15 – 25 years were selected as the study group. The wavy pattern was the most prevalent rugal shape followed by the straight, curved, branched and circular patterns. There was no significant difference between the sexes with regard to the palatal rugal patterns (Sumathi et al 2011).

A study undertaken by Kotrashetti (2011) to examine the palatal rugae shapes in two Indian populations and included one hundred plaster casts, with the age ranging between 18 and 40 years, and analyzed using the Thomas and Kotze classification. Females were found to have a greater mean number of rugae than males. The study showed that the wavy, straight, circular and divergent rugal patterns were significantly different in the two population groups. The wavy and straight patterns of rugae were also significantly different in males and females. The wavy pattern was more common in females while the straight pattern was more common in males (Kotrashetti et al 2011).

Gondivkar et al (2011) identified and compared different morphological rugal patterns in males and females of a western Indian population sample. The study showed a statistically significant difference in the total number, shape and unification of the rugae between males and females. The total number of rugae was higher in females than males. They also concluded that the rugae can be another method of differentiation between males and females in forensic sciences.

An investigation in 2011 of rugal patterns in an Indian male and female sample to assist in differentiating the sexes took place (Saraf et al 2011). Sixty males and 60 females were selected from the students of Sharad Pawar Dental College. The Thomas and Kotze classification and Kapali classification was used. There was no significant difference of the total number of rugae or their prevalence between the two sexes. The wavy and curved patterns of rugae were the most common in both males and females. The converging type of rugae was statistically prevalent in females whilst the circular type of rugae were statistically prevalent in males (Saraf et al 2011).

In 2011, a further study was conducted in Bapuji Dental College and Hospital in India (Jibi et al 2011). The aim of this study was to identify and compare rugal patterns between males and females in two different communities. The method of identification of rugal patterns followed the methods of Lysell and Thomas and Kotze. The study revealed no significant difference in total number or length of rugae between the two communities and sexes. Females had a highly significant number of diverging rugal types while males had a significant number of circular and converging rugal types. It was concluded that the rugal pattern was another method of sex differentiation in forensic sciences (Jibi et al 2011).

Bharath et al (2011) investigated the palatal rugae patterns in males and females of a coastal Andhra population. The Thomas and Kotze classification was applied on one hundred pre-orthodontic plaster casts of males and females aged 15 – 30 years. The total number of rugae in males and females was not statistically significant. The average number of rugae in females was slightly greater when compared to males. The unification patterns of the rugae in males and females were however statistically significant.

A study was conducted in India in 2012, to analyze the different types of rugae in two different populations (Shanmugam et al 2012). The sample included 940 subjects from South and North India. The age range of the study sample was 18 – 23 years old. The study was based on the Thomas and Kotze classification. Wavy, curved and straight palatal rugal shapes were the most common form on both groups. There were a greater total number of rugae in Northern Indians than in the Southern Indians. The study suggested that “palatal rugae could be a simple and reliable tool for population identification in forensic science” (Shanmugam et al 2012).

Santos and Caldas (2012) conducted a study in Portugal to analyze the palatal rugal patterns in a Portuguese population sample. It was a cross sectional study based on evaluation of the rugae shape, frequency, and association with sex. Fifty plaster dental casts were examined. The study revealed, in females, the prevalence of the straight type of rugae in the right side of the palate, and the curved type of rugae in the left side. While in males, the straight type of rugae

was dominant on both sides. It was suggested that different ethnic groups could have any particular rugae pattern.

In Ambedkar Dental College and Hospital, India, a study was conducted to investigate the role of rugal patterns in person identification (Indera et al 2012). One hundred study models of subjects over 14 years of age were used in the sample. The rugae patterns were not symmetrical in number or distribution when the right and the left side of the palate were compared. The results showed each individual had a different rugal pattern regarding its number or distribution (Indera et al 2012).

Another study was conducted in India to compare the palatal rugae in the Manipuri and Kerala population (Surekha et al 2012). Sixty study models, thirty males and thirty females, were examined based on the Thomas and Kotze classification. The study showed that the curved shape of rugae was significantly more common in the Manipuri than the Kerala population whilst the wavy shape was predominant in both populations. There was no significant difference found in the total number of rugae between the right and the left side of the palate in both populations. The left side of the palate showed a slightly greater number of palatal rugae than the right side. The predominant rugae shapes in both populations were wavy patterns followed by curved and straight patterns. The study concluded that palatal rugae are distinctive to an individual and can be used as an aid for person identification (Surekha et al 2012).

Eboh D (2012) described the shape and gender distribution among 42 males and 42 females from Southern Nigeria. Females showed a greater number of rugae than males but without statistical significance. The right side of the palate showed a slightly higher number of rugae compared to the left side among the sample. Eboh concluded that the individualized pattern of palatal rugae made it a reliable tool in forensic identification.

In India, 2013, a recent study was conducted to determine the number, patterns of rugae in children from 5 to 15 years (Rajan et al 2013). One hundred study models of 50 males and 50 females were involved in the study. The study was based on the Thomas and Kotze classification. The results showed that the total

number of rugae as well as primary rugae occurred more often in the females compared to the males. Regarding the shape of rugae in both genders, the wavy shape showed predominance following by the curved shape. None of the study models showed any circular shaped rugae. The study concluded that the rugae of each individual had unique patterns which could be used in person identification (Rajan et al 2013).

Mustafa et al (2013) investigated on the morphology of palatine rugae among Jordanians. The assessment of 327 dental casts (137 males and 190 females) was done based on the Thomas and Kotze classification (1983). The results showed no statistical significant difference between the numbers of the rugae regarding to their length, shape or gender. The number of primary rugae was significantly more prevalent compared to secondary and fragmentary rugae. The number of wavy rugae was significantly greater followed by diverging, straight, curved, converging and circular rugal patterns.

Goyal and Goyal (2013) studied the palatal rugae patterns of Rwandan patients attending the dental department at King Faisal Hospital, Rwanda. The study used the Thomas and Kotze classification (1983) and modified by using furcated rugae. In both genders, the wavy rugal shape was the mostly commonly found followed by straight, curved, converging and circular patterns. No significant difference between the genders in any type of rugae patterns was evident. The distribution of wavy and circular rugae was more common in males on the left side of the palate, while straight rugae were more common on the right. In females the wavy pattern of rugae was more common on the right side of the palate, and furcate rugae were more common on the left side.

2.4 Rugae in forensic identification

The importance of palatal rugae in forensic identification has been shown due to their morphological stability during life (Jain & Chowdhary 2013). The individualization and uniqueness of palatine rugae can be equated to finger prints. Studies have proved that palatine rugae is an alternative method of forensic identification when the routine methods failed (Jain & Chowdhary 2013, Patil et al 2008).

During the challenging situations of mass disasters, palatal rugae are protected by the lips, the buccal pad of fat and the teeth (Nayak et al 2007). Muthusubramanian et al (2005) assessed the morphology of palatine rugae in burn patients with third degree burns after having emergency treatment and compared them to cadaver who had undergone decomposition. The authors found that 93 % of the burned patients had normal palatine rugae and 77 % of decomposed human cadavers had no change in the colour or surface anatomy of the palatine rugae. This showed the stability of the rugae for identification.

Other studies have been conducted to confirm the characteristics of palatal rugae for identification purposes. Dawasaz and Dinkar (2013) investigated one hundred and twenty dental casts of Indian patients to analyze rugal characteristics. After assessment, no two individuals had exactly matching rugae patterns. They concluded that rugae possessed unique characteristics that could be used when there was difficulty in identifying a dead person.

De Angelis et al (2013) studied two successive maxillary casts from 39 subjects. The second cast was made after a period of time ranging from 4 to 65 months after the first cast. The first cast simulated ante-mortem information while the second cast was post-mortem one. Ante-mortem and post-mortem data from the same individual were correctly matched. Palatal rugae could be reliable as an individualizing marker (De Angelis et al 2013).

In 1988, Thomas and Van Wyk identified a severely burnt edentulous body of a female in South Africa. A denture in the victim's mouth was compared to another one found in the victim's house. The comparison procedure included the tracing of the palatal rugae in both maxillary dentures which established concordance between the two sets of dentures and thus positive identification (Thomas and Van Wyk 1988).

2.5 Aim and objectives

2.5.1 Aim

The aim of this study was to examine the rugal patterns of a Sudanese adult population sample for identification purposes.

2.5.2 Objectives

1. To study the morphology of palatal rugal patterns in a sample of the Sudanese population for identification purposes.
2. To determine if there is a gender differentiation in the rugal patterns.
3. To compare the findings with the results published in the literature, particularly the Thomas and Kotze classification that was undertaken on a South African population sample



Chapter Three

Material and Methods

3.1 Study design

This was a cross-sectional community-based study.

3.2 Study area & population

The study was conducted on the students of the faculty of dentistry, University of Science and Technology in Sudan during the period between 1st – 31st May 2013.

3.3 Sample size

A total of 100 participants, 50 males and 50 females aged between 21 – 23 years were selected for the study. The sample size of 100 participants was based on Johnson and Brook (2010) that a large sample size of $N = (100 - 200)$ should be used for conducting pilot studies to ensure validity of the results.

3.4 Sampling procedure

A simple random sampling procedure was used among the full list of students of the Faculty of Dentistry – University of Science and Technology in Sudan for this study

3.5 Inclusion criteria

1. Participant was Sudanese (both parents)
2. Participant was registered as a student in faculty of dentistry – university of Science and technology for the academic year 2012 – 2013.
3. Participant participated in the study after signing the consent form (Annexure 2).

3.6 Exclusion criteria

1. Students who have a fixed orthodontics appliance.
2. Students with congenital malformation or defects of the palate.
3. Previous orthoganthic surgery.

Methodology

- The mouth of the patient was rinsed with mouthwash before taking the impression.
- An irreversible hydrocolloid (alginate) impression of the upper jaw of the patient was taken, and then cast in dental plaster of Paris material.
- Calcorrugoscopy, or the overlay print of palatal rugae in a maxillary cast, can be used in order to perform comparative analysis.
- A very sharp (2H) pencil, illuminated magnifier and a Vernier scale were used to trace the palatal rugae on the plaster cast (Figure 1, Figure 2).



Figure 1: The illuminated magnifier

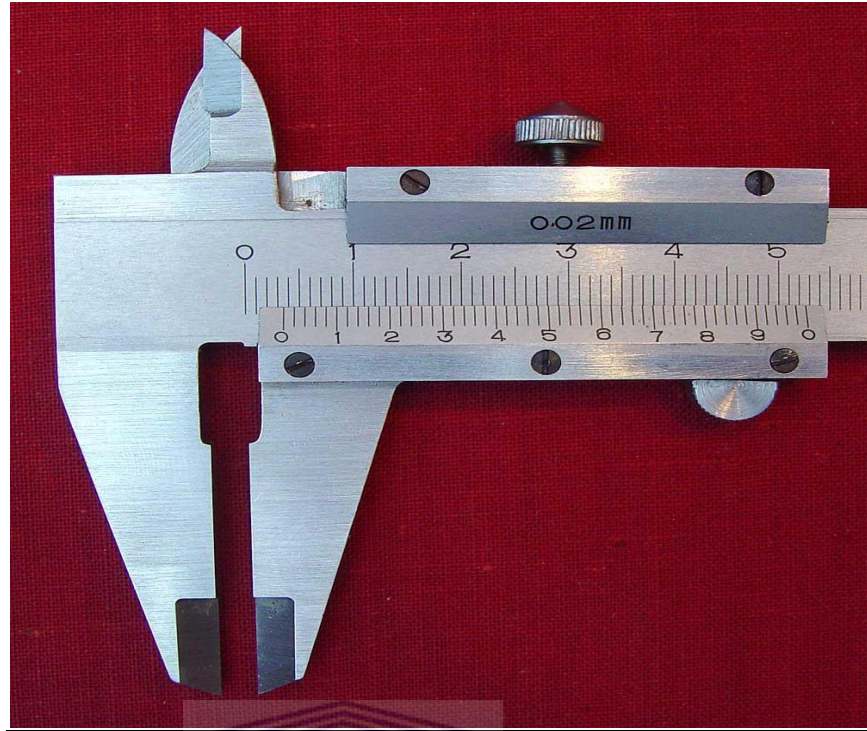


Figure 2: The Vernier scale

- The rugae pattern was analyzed using the Thomas and Kotze classification (1983). Of all the other palatine rugae classifications, it was the easiest, most practical and standardized (Bhartath et al 2011).
- The Thomas and Kotze classification categorized the rugae according to their length into primary (more than 5 mm), secondary (3 – 5 mm) and fragmentary (2 – 3 mm). Rugae less than 2 mm were disregarded. The prevalence of rugae was measured by counting them per palate. Thomas and Kotze classified the rugae into six major types according to their shape. The classification included straight, curved, wavy, circular, diverging unification and converging unification (Figure 3, Figure 4).
- The straight type of rugae runs directly from its place of origin to termination. The curved type always shows simple crescent shape which curved gently. The basic shape of the wavy type is serpentine. If there is

any slight curve of the origin or termination of a curved rugae then it will be wavy. When rugae display a definite continuous ring it would be classified as circular.

- Unification is the joining between two rugae at their origin or termination. When two rugae begin from the same origin then immediately diverged, they classified as diverging unification. Rugae with different origins which joined in their lateral portion are classified as converging unification.

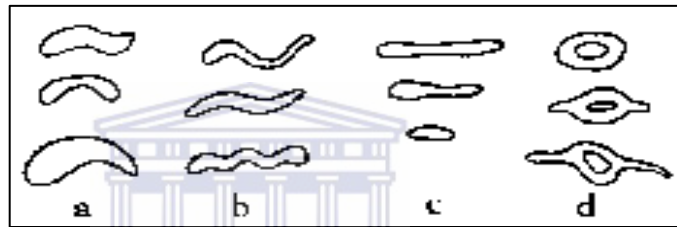


Fig 3: The different shapes of the rugae (A): (a) curved (b) wavy (c) straight (d) circular. (Kapali et al 1997)



Fig 4: The different shapes of the rugae (B): (a) converging. (b) diverging (Paliwal et al 2010)

- Then the rugae were outlined on the cast using the (2H) pencil under the illuminated magnifier (Figure 5, Figure 6).

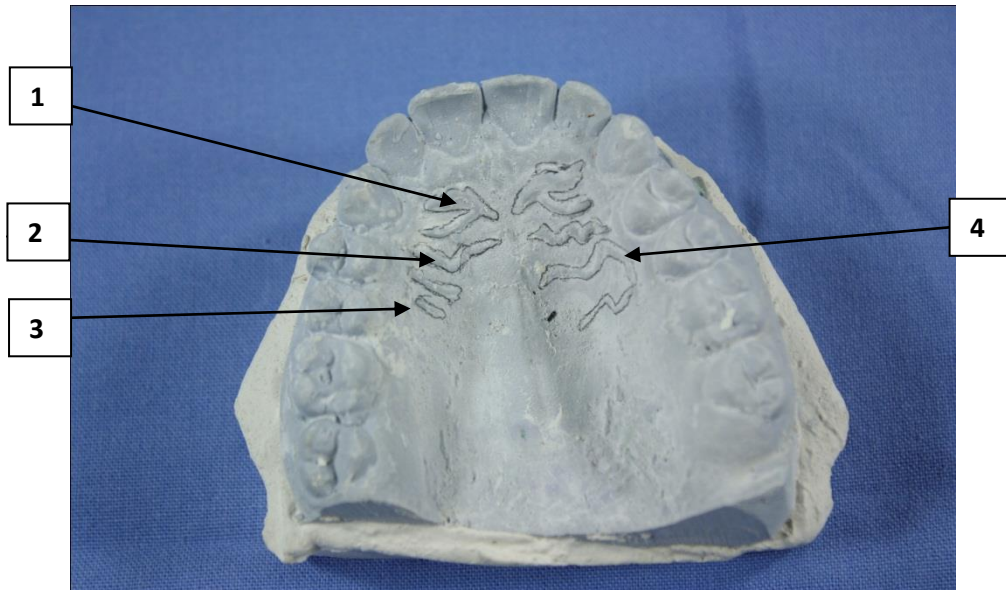


Fig 5: The rugal patterns outlined in pencil showing different types of palatal rugae shapes (A): (1) diverging (2) curved (3) straight (4) wavy



Fig 6: The rugal patterns outlined in pencil showing different types of palatal rugae shapes (B): (1) converging (2) circular

- The rugal shape that did not match with the Thomas and Kotze classification were recorded as unspecified (Fig 7, Fig 8).

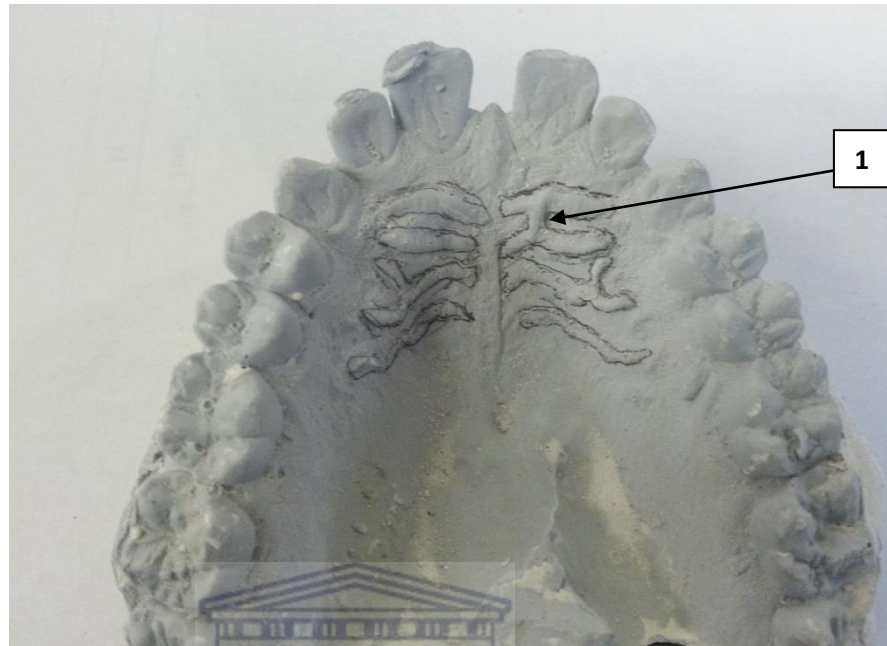


Fig 7: The rugal patterns outlined in pencil showing unspecified rugae (A): (1) cross-link between two primary rugae

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Fig 8: The rugal patterns outlined in pencil showing unspecified rugae (B): (1) unspecified rugae

- The number of each type of the palatal rugae was recorded in the collection data sheet (Annex 3).
- The data obtained was transferred to Microsoft Excel then to the Statistical Package of Social Sciences (SPSS) version 19 software for analysis. The Independent-t-Test was used to assess the significant difference of the total number of each type of palatal rugae between males and females. Descriptive statistical analysis was applied using SPSS to obtain the means, standard deviations, from the data of each category.
- The results were compared to the published data based on Thomas and Kotze (1983) classification.

Ethical consideration

- The research was approved by the Research and Ethics Committee of the University of the Western Cape (Annexure 4).
- The research was approved by the Research and Ethics Committee of the Faculty of Dentistry – University of Science and Technology – Sudan (Annexure 5).
- Students were required to sign an informed consent prior to impression taking.

Chapter Four

Results

A total of 100 dental students, (50 males and 50 females) from the University of Science and Technology – Sudan participated in this study [Table 1].

Table 1: Distribution of sample according to gender

| | Frequency | Percentage (%) |
|---------------|------------------|-----------------------|
| Male | 50 | 50 |
| Female | 50 | 50 |
| Total | 100 | 100 |



The age of the participants ranged from 21 – 23 years old. The mean age of the participants was 21.7 years [Table 2].

Table 2: Age statistics (N = 100)

| | |
|----------------|-------|
| Mean | 21.66 |
| Std. Deviation | 0.61 |
| Minimum | 23 |
| Maximum | 21 |

The mean of the rugae total number was 10.27. The total number of the primary type of palatine rugae had the largest mean (9.15) comparing with the secondary (1.07) and fragmentary (0.05) ones. The means of total number of rugae shapes from the most common to the least common were; straight (3.01), wavy (2.84), curved (2.17), diverging (1.45), converging (0.53), circular (0.16) respectively. There were only 11 rugae (mean 0.11) that could not be applied to the Thomas and Kotze classification and were considered as unspecified [Table 3].

Table 3: Descriptive analysis of the total number of rugae with means

| | N | Total No. Of Rugae | Mean | SD |
|--------------------|----------|-----------------------------------|-------------|-----------|
| Prevalence | 100 | 1027 | 10.27 | 1.74 |
| Primary | 100 | 915 | 9.15 | 1.35 |
| Secondary | 100 | 107 | 1.07 | 1.25 |
| Fragmentary | 100 | 5 | 0.05 | 0.22 |
| straight | 100 | 301 | 3.01 | 2.02 |
| Wavy | 100 | 284 | 2.84 | 1.66 |
| Curved | 100 | 217 | 2.17 | 1.66 |
| Diverging | 100 | 145 | 1.45 | 1.22 |
| Converging | 100 | 53 | 0.53 | 0.76 |
| Circular | 100 | 16 | 0.16 | 0.39 |
| Unspecified | 100 | 11 | 0.11 | 0.39 |

Statistical analysis using the Independent-t-test showed significant difference in the number of palatal rugae between Sudanese males and females ($P = 0.024$). This indicated that the total number of the palatal rugae in females (mean 10.66) was significantly more than in males (mean 9.88). Similarly, the total number of the palatine rugae in the right side of the palate was statistically significant in females (mean 5.24) more than males (4.76) ($P = 0.017$). Also, the prevalence of palatine rugae in the left side of the palate was more common in females (mean 5.42) than in males (mean 5.12) without any statistical significance [Table 4, Figure 9].

Table 4: Distribution of palatine rugae numbers in males and females

| | Gender | N | Rugae number | Mean | SD | P-value |
|---------------------------|--------|----|--------------|-------|------|---------|
| Prevalence (Right) | Male | 50 | 238 | 4.76 | 0.8 | 0.017* |
| | Female | 50 | 262 | 5.24 | 1.15 | |
| Prevalence (Left) | Male | 50 | 256 | 5.12 | 1.32 | 0.254 |
| | Female | 50 | 271 | 5.42 | 1.32 | |
| Prevalence (Total) | Male | 50 | 494 | 9.88 | 1.29 | 0.024* |
| | Female | 50 | 533 | 10.66 | 1.81 | |

*P-value is significant

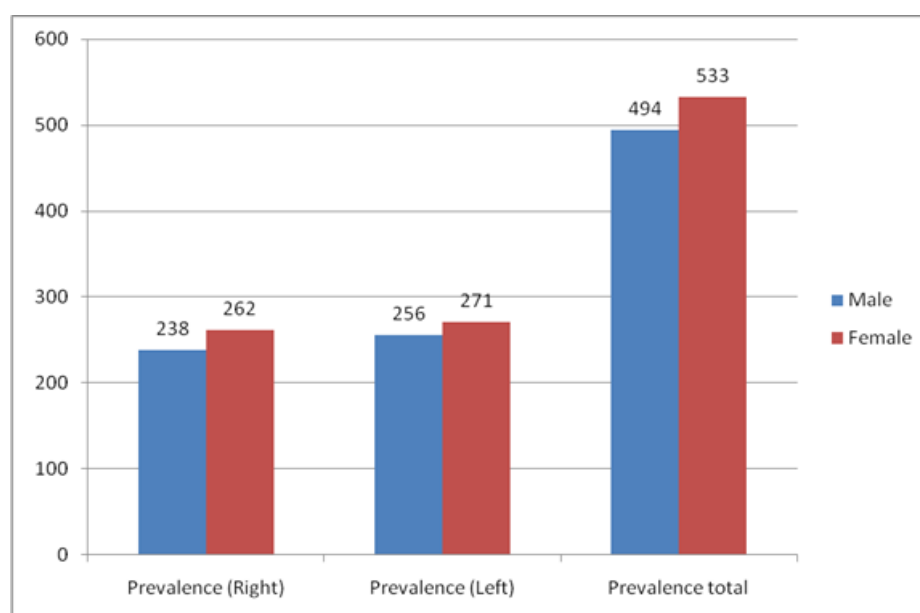


Figure 9: Distribution of palatine rugae numbers in males and females

There were no significant gender differences in the number of primary, secondary and fragmentary rugae seen in the right side of palate of our sample. The primary rugae were more common in the right side of the palate. The number in males was 218 (mean = 4.36) whilst in females it was 230 (mean = 4.6). The secondary rugae number were 32 in females and 19 in males while the fragmentary rugae were 2 in males and 1 in females [Table 5, Figure 10].

Table 5: Distribution of rugae length on the right side of the palate in males and females

| | Gender | N | Rugae number | Mean | SD | P-value |
|--------------------|--------|----|--------------|------|------|---------|
| Primary | Male | 50 | 218 | 4.36 | 0.66 | 0.127 |
| | Female | 50 | 230 | 4.6 | 0.88 | |
| Secondary | Male | 50 | 19 | 0.38 | 0.63 | 0.103 |
| | Female | 50 | 32 | 0.64 | 0.92 | |
| Fragmentary | Male | 50 | 2 | 0.04 | 0.19 | 0.563 |
| | Female | 50 | 1 | 0.02 | 0.14 | |

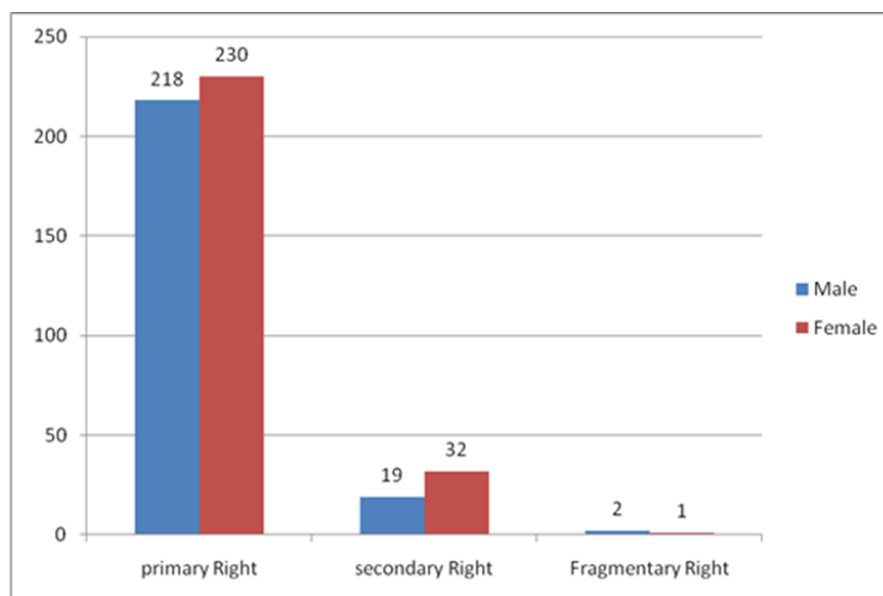


Figure 10: Distribution of rugae length on the right side of the palate in males and females

The number of fragmentary rugae in both males and females was equal on the left side of the palate ($P = 1$). There were no significant differences between the genders and the number of primary, secondary and fragmentary rugae in the left side of the palate. Primary rugae were common (males 224, females 243) followed by secondary rugae (males 29, females 27) and then fragmentary rugae (males 1, females 1). The primary rugae on the left side of the palate were more common in females than males while the secondary rugae were more common in males than females without any significant different [Table 6, Figure 11].

Table 6: Distribution of rugae length on the left side of the palate in males and females

| | Gender | N | Rugae number | Mean | SD | P-value |
|--------------------|--------|----|--------------|------|------|---------|
| Primary | Male | 50 | 224 | 4.48 | 0.95 | 0.051 |
| | Female | 50 | 243 | 4.86 | 0.97 | |
| Secondary | Male | 50 | 29 | 0.58 | 0.95 | 0.826 |
| | Female | 50 | 27 | 0.54 | 0.86 | |
| Fragmentary | Male | 50 | 1 | 0.02 | 0.14 | 1 |
| | Female | 50 | 1 | 0.02 | 0.14 | |

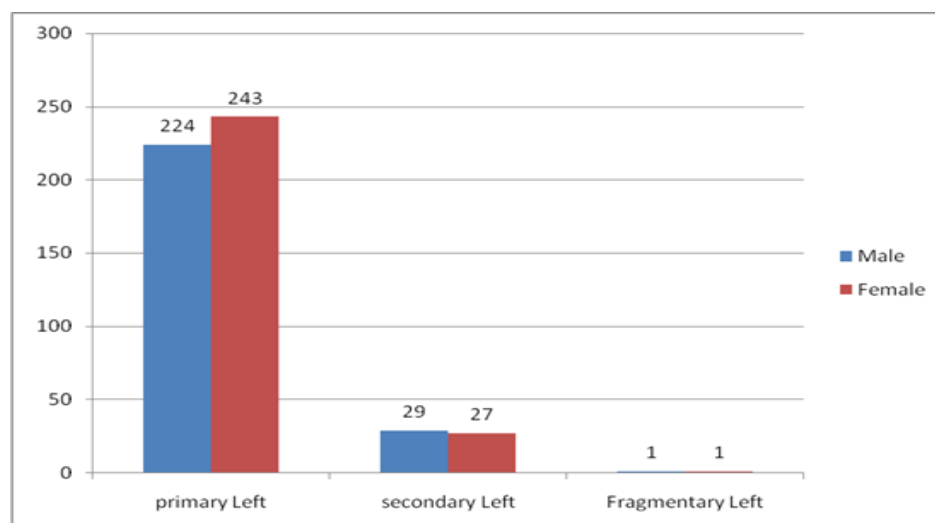


Fig 11: Distribution of rugae length on the left side of the palate in males and females

The total number of primary rugae in females (473) were significantly more common than in males (442) (P-value = 0.021). The primary palatine rugae were the most common (925) in males and females, followed by secondary rugae (107), then fragmentary rugae (5). The number of secondary rugae was more common in females (59) than in males (48) while in fragmentary rugae more common in males (3) than in females (2) [Table 7, Figure 12].

Table 7: Distribution of rugae length in males and females

| | Gender | N | Rugae number | Mean | SD | P-value |
|--------------------|--------|----|--------------|------|------|---------|
| Primary | Male | 50 | 442 | 8.84 | 1.23 | 0.021* |
| | Female | 50 | 473 | 9.46 | 1.4 | |
| Secondary | Male | 50 | 48 | 0.96 | 1.21 | 0.384 |
| | Female | 50 | 59 | 1.18 | 1.3 | |
| Fragmentary | Male | 50 | 3 | 0.06 | 0.24 | 0.65 |
| | Female | 50 | 2 | 0.04 | 0.19 | |

*P-value is significant

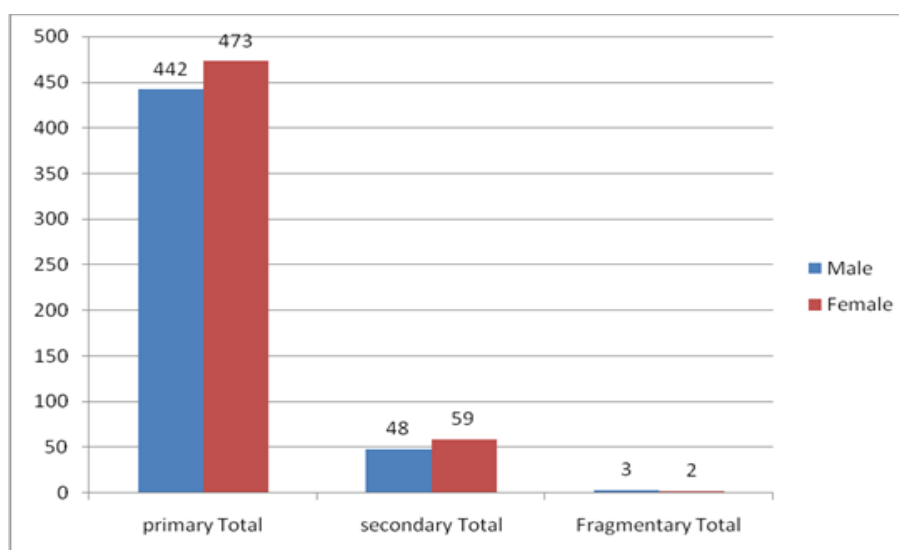


Fig 12: Distribution of rugae length in males and females

The number of wavy shape of palatine rugae were most common on the right side of the palate (146), followed by straight shape (145), curved (95), diverging (72), converging (30) and circular (10). There were only 2 rugae that could not be identified with the Thomas and Kotze classification on the right side of the palate. The total number of straight rugae on the right side of the palate was significantly more common in females (87) than in males (58) ($P = 0.012$) whilst the wavy shape was significantly more common in males (90) than in females (56) ($P = 0.003$). The total number of all other shapes of rugae on the right side of the palate was greater in females than in males: circular (females 7, males 3), curved (females 49, males 46), diverging (females 43, males 29) and converging (females 18, males 12). Both of the unspecified rugae on the right side of the palate were in females [Table 8, Figure 13].

Table 8: Distribution of different rugae shapes on the right side of the palate in males and females

| | Gender | N | Rugae number | Mean | SD | P-value |
|-------------------------------|--------|----|--------------|------|------|---------|
| Straight | Male | 50 | 58 | 1.16 | 0.95 | 0.012* |
| | Female | 50 | 87 | 1.74 | 1.29 | |
| Circular | Male | 50 | 3 | 0.06 | 0.24 | 0.186 |
| | Female | 50 | 7 | 0.14 | 0.35 | |
| Curved | Male | 50 | 46 | 0.92 | 1.05 | 0.774 |
| | Female | 50 | 49 | 0.98 | 1.04 | |
| Wavy | Male | 50 | 90 | 1.8 | 1.14 | 0.003* |
| | Female | 50 | 56 | 1.12 | 1.06 | |
| Diverging unification | Male | 50 | 29 | 0.58 | 0.7 | 0.068 |
| | Female | 50 | 43 | 0.86 | 0.81 | |
| Converging unification | Male | 50 | 12 | 0.24 | 0.48 | 0.234 |
| | Female | 50 | 18 | 0.36 | 0.52 | |
| Unspecified | Male | 50 | 0 | 0.00 | 0.00 | 0.156 |
| | Female | 50 | 2 | 0.04 | 0.19 | |

*P-value is significant

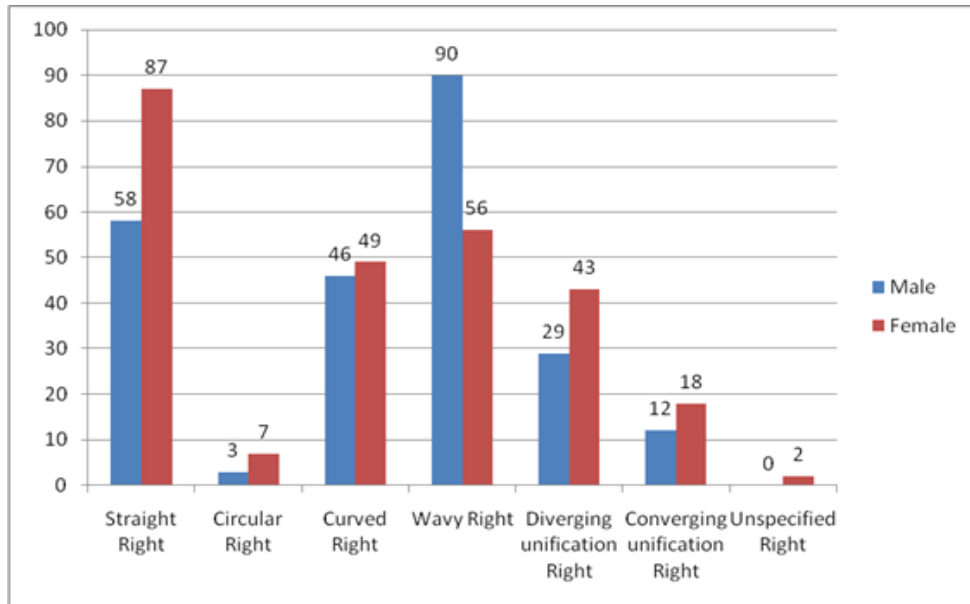


Figure 13: Distribution of different rugae shapes on the right side of the palate in males and females

On the left side of the palate, the curved shape of rugae showed statistical significance ($P = 0.004$) between the total number and gender. It was more prevalent in males (77) than females (45). The total number of diverging unification shape of rugae were significantly ($P = 0.008$) more in females (46) than in males (27) on the left side of the palate. The number of straight shape of palatine rugae were the most represented in both males and females on the left side of the palate (156), followed by wavy shape (138), curved (122), diverging (73), converging (23) and circular (6). There were 9 rugae that could not be matched with the Thomas and Kotze classification on the left side of the palate. The total number of rugae was greater in females than in males on the left side of the palate of the following types: straight (females 88, males 68), diverging (females 46, males 27) and converging (females 15, males 8). The wavy shape was distributed equally on the left side of the palate between males and females ($P = 1$). The unspecified rugae shapes on the left side of the palate were more common in males (6) than in females (3) [Table 9, Figure 14].

Table 9: Distribution of different rugae shapes on the left side of the palate in males and females

| | Gender | N | Rugae number | Mean | SD | P-value |
|-------------------------------|--------|----|--------------|------|------|---------|
| Straight | Male | 50 | 68 | 1.36 | 1.19 | 0.146 |
| | Female | 50 | 88 | 1.76 | 1.52 | |
| Circular | Male | 50 | 1 | 0.02 | 0.14 | 0.095 |
| | Female | 50 | 5 | 0.1 | 0.3 | |
| Curved | Male | 50 | 77 | 1.54 | 1.18 | 0.004* |
| | Female | 50 | 45 | 0.9 | 0.99 | |
| Wavy | Male | 50 | 69 | 1.38 | 1.12 | 1 |
| | Female | 50 | 69 | 1.38 | 0.9 | |
| Diverging unification | Male | 50 | 27 | 0.54 | 0.58 | 0.008* |
| | Female | 50 | 46 | 0.92 | 0.8 | |
| Converging unification | Male | 50 | 8 | 0.16 | 0.37 | 0.136 |
| | Female | 50 | 15 | 0.3 | 0.54 | |
| Unspecified | Male | 50 | 6 | 0.12 | 0.48 | 0.432 |
| | Female | 50 | 3 | 0.06 | 0.24 | |

*P-value is significant

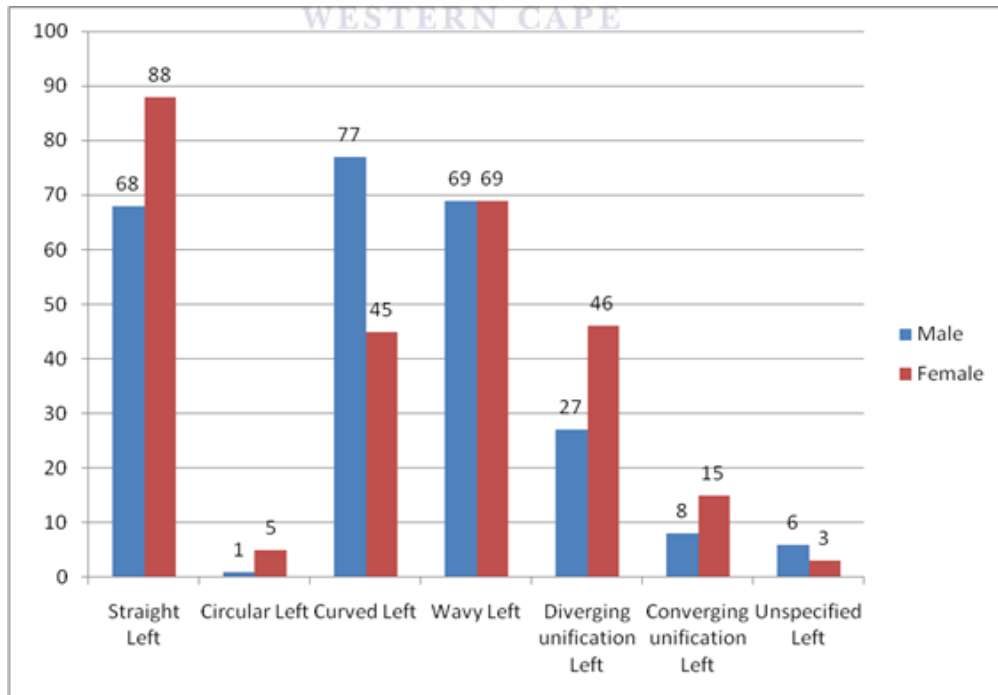


Fig 14: Distribution of different rugae shapes on the left side of the palate in males and females

The distribution of number of rugae shapes in both males and females were seen as straight (301), wavy (284), curved (217), diverging unification (145), converging unification (53), circular (16), and the unspecified (11). The total number of straight rugae was significantly more common in females (175) than in males (126) ($P = 0.014$), as well as circular rugae (females 12, males 4) with significant $P = 0.043$ and diverging rugae (females 89, males 56) ($P = 0.006$). Converging rugae were common in females (33) than in males (20) while the curved rugae were more common in males (123) than in females (94). The unspecified rugae shapes were found more in males (6) than in females (5) [Table 10, Figure 15].

Table 10: Distribution of different rugae shapes in males and females

| | Gender | N | Rugae number | Mean | SD | P-value |
|-------------------------------|--------|----|--------------|------|------|---------|
| Straight | Male | 50 | 126 | 2.52 | 1.7 | 0.014* |
| | Female | 50 | 175 | 3.5 | 2.19 | |
| Circular | Male | 50 | 4 | 0.27 | 0.27 | 0.043* |
| | Female | 50 | 12 | 0.48 | 0.48 | |
| Curved | Male | 50 | 123 | 2.46 | 1.68 | 0.08 |
| | Female | 50 | 94 | 1.88 | 1.59 | |
| Wavy | Male | 50 | 159 | 3.18 | 1.77 | 0.04* |
| | Female | 50 | 125 | 2.5 | 1.49 | |
| Diverging unification | Male | 50 | 56 | 1.12 | 1.06 | 0.006* |
| | Female | 50 | 89 | 1.78 | 1.29 | |
| Converging unification | Male | 50 | 20 | 0.4 | 0.7 | 0.086 |
| | Female | 50 | 33 | 0.66 | 0.79 | |
| Unspecified | Male | 50 | 6 | 0.12 | 0.48 | 0.804 |
| | Female | 50 | 5 | 0.1 | 0.3 | |

*P-value is significant

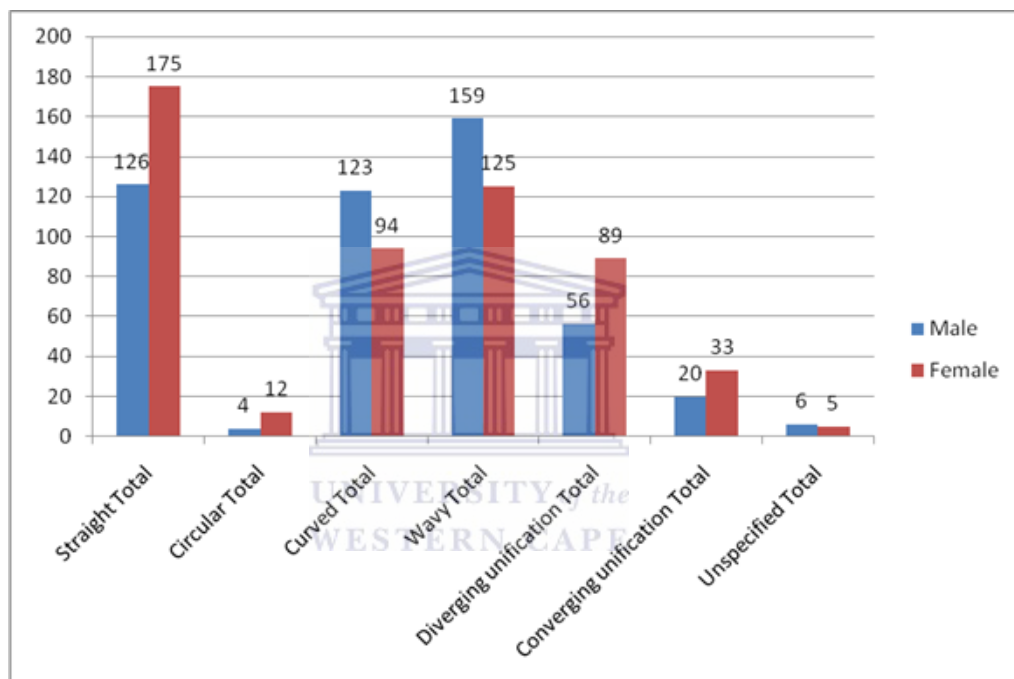


Fig 15: Distribution of different rugae shapes in males and females

Chapter Five

Discussion

This study is the first to investigate the morphology of palatal rugae in Sudan. The importance of rugal patterns emerges from their individuality which can be used in establishing identity. The study results identify the possible different patterns of rugae that may be present in a sample of Sudanese population. These findings can be used to initiate a system that can save the records of palatine rugae as a data base for purposes of identification.

Although Lysell (1955) suggested that rugae decreased in number from 23 years of age, recent publications have shown that the characteristic patterns of palatal rugae are not affected by growth, and remain stable with an unchanged number from birth to death (Filho et al 2009, Nayak et al 2007, English et al 1988). The age range of the participants in the study was 21 – 23 years. Similar studies; such as (Santos & Caldas, 2012, (Shanmugam et al 2011, Jibi et al 2011), used similar age ranges.

In this study there were 11 individuals who did not comply with the Thomas and Kotze classification (1983), thus were recorded as unspecified. Some of the unspecified rugae showed known features such as a cross-link (Figure 7). Such feature is mentioned in the Thomas and Kotze classification (1983) and defined as a small ruga which has a distinct identity and joins two rugae usually at right angles (Thomas and Kotze 1983). This small link was disregarded by Kapali et al (1997) when they were the pioneers in applying the Thomas and Kotze classification (1983) to compare rugal patterns between two Australian samples. Most of the following studies followed their methodology using the Thomas and Kotze classification (1983) to different population samples. In this study the Thomas and Kotze classification was used but included the cross-link shape of ruga. An unspecified ruga in the study (Figure 8) did not appear in the Thomas and Kotze classification or any other published classification. These kinds of rugae should be investigated and classified if possible. It can be suggested that the Thomas and Kotze classification (1983) is applicable to the population

sample of Sudanese origin with the addition of the unspecified ruga added to the classification.

The forensic importance of palatal rugae is equated with finger prints. This study showed individuality and uniqueness of the palatal rugae. There were no identical patterns or even bilateral symmetry between the two sides of the palate noticed in any of the plaster casts. This valuable characteristic of the palatine rugae can be used as a means of forensic identification. This is similar to other previous studies: Dawasaz & Dinkar (2013), Abdellatif et al (2011) and Patil et al (2008).

Determination of gender based on the variation of rugal patterns was one of the concerns of many researchers in the last decade such as Bharath et al (2011) and Saraf et al (2011). Differentiating between males and females is a distinct possibility for narrowing the biological profile of unidentified human remains in forensic investigation.

The total number of straight rugae in this study was found to be significantly more prevalent in Sudanese females. Shetty et al (2011) obtained the same result in their Indian sample. The circular and diverging unification rugae were statistically significant in Sudanese females which disagreed with Saudi people who had a significant prevalence of the converging patterns (Fahmi et al 2001). These variations of the prevalence of specific palatal rugae shapes in females suggested a means to identify both Sudanese genders from their rugae patterns.

In this study, on the right side of the palate, the total number of straight rugae was more common in females than in males, whilst the wavy shape was significantly more common in males than females. These observations did not agree with the Rwandan sample that showed that the right side of the palate had a greater number of straight rugae in males than in females. The wavy rugal shape was more common in females (Goyal & Goyal, 2013). Another statistically significant finding of this study was the presence of a greater number of palatine rugae on the right side of the palate in females than in males. This observation was similar to that found by (Shetty et al 2005) in both the Mysorean and Tibetan studies

On the left side of the palate, the curved shape of rugae were more prevalent in males than in females; this conflicted with the Rwandan study in which the straight shape was more common in males than females while the furcated pattern was more often found in females than in males (Goyal & Goyal 2013). The total number of the diverging unification shape of rugae in the left side of palate was significantly greater in females than in males which differed from the findings in the Portuguese population who showed domination of curved rugae on the left side of palate in females (Santos & Caldas 2012).

Although the anatomy of the human body is always regarded to be symmetrical, the human palate is not. The right and the left side of the palate may have the same size but the rugae prevalence, rugae length and rugae shapes are different. This may be a tool for identification by using the sides of the palate to distinguish between males and females from the same area or nationality.

The mean of the total number of the palatal rugae in this study was statistically significant and found to be greater in females (10.66) than in males (9.88). This was consistent with the Nigerian (Eboh, 2012) and Indians (Rajan et al 2013, Surekha et al 2012) studies. In contrast, these findings were not similar to Jordanian (Mustafa et al 2013) and Japanese (Dohke & Osalo, 1994) studies. In the Saudi sample (Fahmi et al 2001) both genders had the same mean number of total rugae without any significant difference. This finding suggests that the total number of palatal rugae may differentiate between Sudanese males and females.

Moreover, the total number of primary rugae in females in this study was significantly greater than in males. These results agreed with these of Gondivkar et al (2011) who found similar results in their western Indian population sample. The length of rugae may also be used in gender differentiation in Sudanese samples.

This study showed a significant difference in the males and females with regard to the number, shape and length of palatine rugae. This followed some studies which reported sex dimorphism (Shetty et al 2005, Saraf et al 2011, Kapali et al 1997, Gondivkar et al 2011 and Kotrashetti et al 2011).

The unique nature of the rugae and their anatomical position make them viable for forensic identification. This study revealed that the most common types of rugae in both males and females were the straight pattern followed by the wavy and then the curved pattern. The least prevalent was the circular pattern.

These results comparing to other studies based on the Thomas and Kotze classification (1983) showed some variations. It differed from Australian Aborigines and Caucasians (Kapali et al 1997), Rwandan (Goyal & Goyal), Saudi (Fahmi et al 2001) and Jordanian (Mustafa et al 2013) in all of whom the wavy shape was the most prevalent in males and females. A review of 11 articles based on the Thomas and Kotze classification (1983) that were undertaken in the Indian subcontinent in the period between 2007 – 2013 (Nayak et al 2007, Sharma et al 2009, Paliwal et al 2010, Kotrashetti et al 2011, Sumathi et al 2001, Saraf et al 2011, Bhrath et al 2011, Shetty and Premalath 2011, Surekha et al 2012, Shanmugm et al 2012, Rajan et al 2013) also showed that the wavy shape was the more common type of rugae in both males and females. These observations compared to our study in which the straight shape was prevalent suggest an identification feature with regard to nationalities. For example, if we compare a group of dental casts of people from India with Sudan, we should consider the predominant rugal shapes in each cast. If the straight rugae are more predominant, this may suggest this cast is of a Sudanese person. Further studies on this issue could help in improving forensic identification based on ruga shapes.

Chapter Six

Conclusion and Recommendations

Conclusion

This Sudanese study has shown statistically significant differences between males and females in the number of rugae, length of rugae and shapes of rugae. Hence, the individuality and uniqueness of palatine rugae can be used as a tool for forensic dental identification, and possibly distinction between males and females. There is also a possibility that there are ethnic differences in rugal patterns.

Recommendations

- To extend this study by a larger sample that representative of the Sudanese population.
- To establish if there are differences in the various ethnic groups in Sudan.
- To investigate the possibility that there is a distinct ethnic difference in the palatal rugal morphology.

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Appendices

Annexure 1: The Thomas and Kotze Classification (1983)

In 1983, Thomas and Kotze presented a detailed new classification of the palatine rugae modified from Lysell's classification, and presented as follow:

(1) Rugae dimension and prevalence:

i. Length:

- Primary: 5 mm or more in length.
- Secondary: 3 – 5 mm.
- Fragmentary: 2 – 3 mm.
- Rugae under 2 mm are disregarded.

ii. Prevalence

The rugae are not numbered or sided but each category per palate is simply counted and noted.

iii. Area:

Photograph the palate to determine the surface area of the primary rugae.

(2) Primary rugae details:

It classified as:

i. Annular rugae

This formation must be a definite ring (Figure i)



Figure i: An annular formation (Thomas & Kotze 1983)

ii. Papillary rugae.

A rugae termed papillate when 3 or more clefts transverse the ruga right across and at any depth but not down to the surrounding mucosal surface (Figure ii).

iii. Breaks.

If a papillation cleft is extended down to the level of the surrounding epithelium it becomes a break (Figure ii).

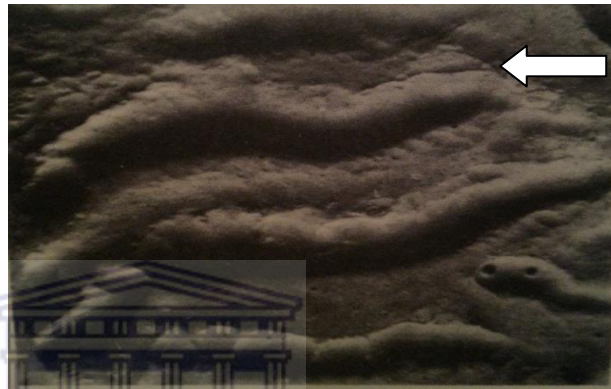


Figure ii: A raphe process (arrowed). A break is seen in the lower adjacent ruga and papillations in the ruga below that (Thomas & Kotze 1983)

iv. Cross link.

This is a small ruga which is a distinct identity and joins two rugae usually at the right angle (Figure iii)

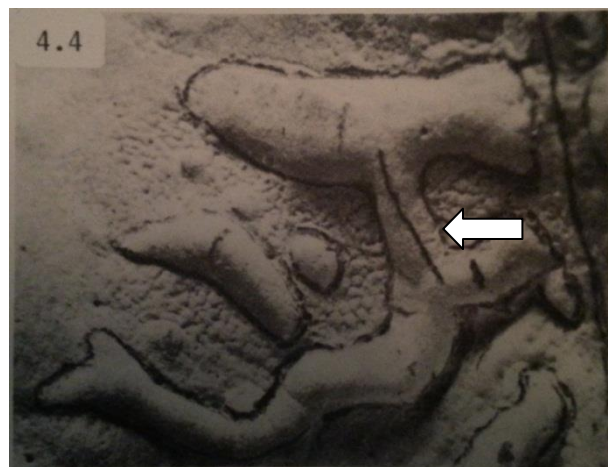


Figure iii: Cross-link joining two primary rugae (Thomas & Kotze 1983)

v. Branches.

A branch in a ruga which is 1 mm or more in length and leaves the parent ruga 1 mm or more from its origin in a lateral direction (Figure iv).



Figure iv: Branch (a) (Thomas & Kotze 1983)

vi. Unification.

a. Convex unification: this phenomenon occurs when two primary rugae are joined at their origins and then diverge laterally (Figure v)

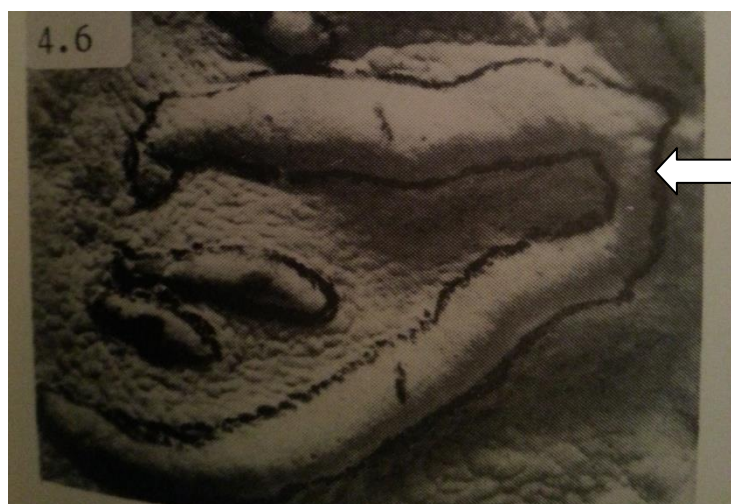


Fig v: Convex unification between two primary rugae

(Thomas & Kotze 1983)

- b. Concave unification: this occurs when two rugae converge laterally and join at one or both of their termination (Figure vi).

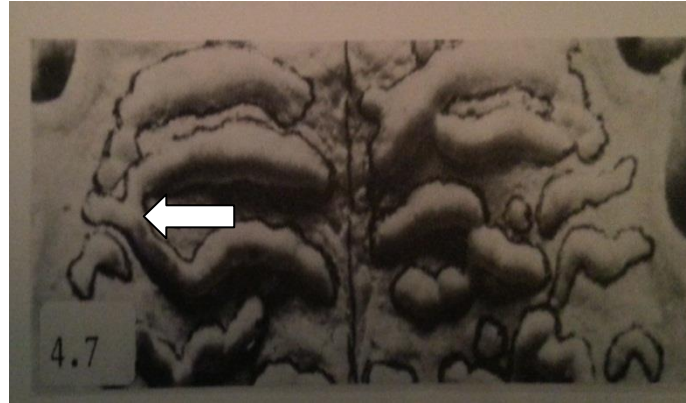


Figure vi: A concave unification between two primary rugae (Thomas & Kotze 1983)

- vii. Unification with non-primary rugae.
This is a convex or a concave unification occurring between a primary ruga and a ruga that is between 1 mm and 5 mm in length (Figure vii)

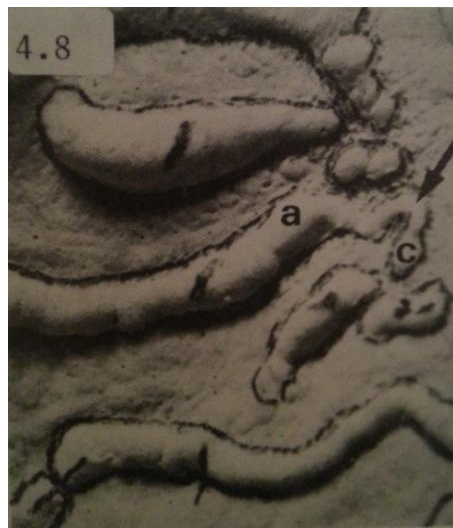


Fig vii: unification (arrowed) between a primary ruga (a) and a non-primary ruga (c) (Thomas & Kotze 1983)

Occasionally two rugae cross each other and continue on their way. This cross-over may involve what appear to be unifications, branches and breaks but these are ignored if the rugae are obviously continuous. Each then remains a separate entity (Figure viii).

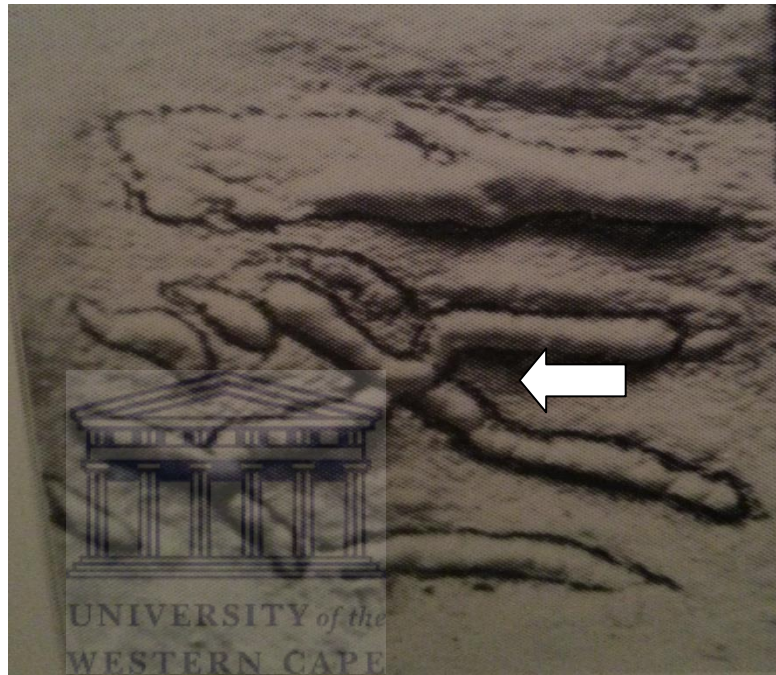


Figure viii: A cross-over of two primary rugae. Both retain their identity (Thomas & Kotze 1983)

Annexure 2: Information to the patient and consent form

Information to the patient

Dear student

Greetings,

My name is Dr. Khalid Mohamed Khalid. I am dentist in the Ministry of Health, Sudan and doing my Master's degree in the University of the Western Cape – South Africa. I am conducting research under the supervision of the Forensic Dentistry Department. The research is on determination of different patterns of markings on the palate among a sample of the Sudanese population

The aim of this study is to determine the different patterns of lines on the palate among Sudanese population and compare it to other studies that have been done. The importance of this investigation is to determine whether the lines on the palate have unique patterns that may be used to identify people just like fingerprints.

This study will be conducted among the dental students in the University of Science and Technology, Sudan. As a dental student in this university, you are being invited to consider taking part in the study, which involves taking an impression of your upper jaw using an alginate impression material. This impression will be cast and then will be compared with the findings published in literature.

Your participation is completely voluntary. If you are uncertain about participating, you can always ask questions, and I will try my best to clarify any areas of concern. The procedure will only be done with your permission and you have the right to withdraw at any time without any adverse consequences or penalties. If you have any queries, more information may be obtained from Dr. Khalid at telephone number 0912388072. If you are happy to take part in the study, please read and sign the attached consent form.

Thanking you in anticipation

Yours sincerely

Dr Khalid Mohamed Khalid

Annexure 3: Data collection sheet

Data collection sheet

Cast No.:Gender:Age:

1- Rugae length

| | | | Total |
|--------------------|-------|------|-------|
| | Right | Left | |
| Primary (> 5 mm) | | | |
| Secondary (3-5 mm) | | | |
| Fragmentary(< 3mm) | | | |

2- Rugae shape

| | | | Total |
|------------------------|-------|------|-------|
| | Right | Left | |
| Straight | | | |
| Circular | | | |
| Curved | | | |
| Wavy | | | |
| Diverging unification | | | |
| Converging unification | | | |
| Unspecified | | | |

3- Rugae prevalence

| | Right | Left | Total |
|--------|-------|------|-------|
| Number | | | |

Annexure 4: The ethics approval from the University of Western Cape



**Office of the Deputy Dean
Postgraduate Studies and Research**
Faculty of Dentistry & WHO Collaborating Centre for Oral Health

UNIVERSITY OF THE WESTERN CAPE
Private Bag XI, Tygerberg 7505
Cape Town
SOUTH AFRICA



Date: 3rd May 2013

For Attention: Dr Khalid Khalid
Forensic Dentistry

Dear Dr Khalid

STUDY PROJECT: Palatal rugae patterns in a Sudanese population sample

PROJECT REGISTRATION NUMBER: 13/4/30

ETHICS: Approved

At a meeting of the Senate Research Committee held on Friday 3rd May 2013 the above project was approved. This project is therefore now registered and you can proceed with the study. Please quote the above-mentioned project title and registration number in all further correspondence. Please carefully read the Standards and Guidance for Researchers below before carrying out your study.


Patients participating in a research project at the Tygerberg and Mitchells Plain Oral Health Centres will not be treated free of charge as the Provincial Administration of the Western Cape does not support research financially.

Due to the heavy workload auxiliary staff of the Oral Health Centres cannot offer assistance with research projects.

Yours sincerely

Professor Sudeshni Naidoo

**Annexure 5: The ethics approval from the University of
Science and Technology**

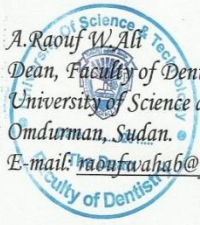
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| <p>University of Science & Technology Faculty of Dentistry Office of the Dean Fax no. +249187644212, Phone no. +249187644213, Mobile no. 249912164033 P.O. Box 30, Umdurman, Sudan</p> |  | <p>جامعة العلوم والتقانة كلية طب الأسنان مكتب العميد فاكس: 249187644212 تلفونات: 249187644213 موبايل: 249912164033 ص.ب: 30 امدرمان-السودان Email: roaufwahab@yahoo.com</p> |
|--|--|--|

Date: 10/3/2013

To whom it may concern

This is to certify that the Faculty of Dentistry, University of Science and Technology has approved Dr. Khalid Mohammed Khalid to conduct his research at the faculty Teaching Dental Hospital under the following condition:

- *The research title: Morphological Patterns of palatine among Sudanese population
- *Fill consent forms
- *Collect upper jaw impressions
- *During the period between the 1st of May 2013 to the 30th of Jun 2013.


A. Raouf W. Ali
Dean, Faculty of Dentistry,
University of Science and Technology
Omdurman, Sudan.
E-mail: raoufwahab@yahoo.com