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Evaluation of Tooth Shade in a Selected Sample of Patients visiting The Oral and Dental Hospital

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DECLARATION

I, Asma Amari, do hereby declare that this dissertation is the result of my own investigation and research and that this work has never been submitted before for any other degree at any other institution. All the sources I have used or quoted have been indicated and acknowledged by means of complete references.

June 2015

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DEDICATION

My loving and caring husband, Dr. Haithem Elmradi, and my wonderful children for their understanding, support and encouragement.

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ABSTRACT

Background: Aesthetics is an important aspect of modern day dentistry. Shade selection is one of the primary determinations for achieving good aesthetics in restorative dentistry. Shade selection has three parameters, namely value, chroma and hue. These can be determined by using either visual or instrumental shade guides. Previous publications have shown that teeth become darker with advancing age.[1] some studies suggest that tooth value and skin colour may be inversely related. People with medium to dark skin tones have lighter teeth; those with lighter skin tones have darker teeth.[2] However, other studies have found no correlation between skin tone and tooth shade.[3,4] there are no studies relating tooth shade to tooth number ;sex; skin tone; age and gingival pigmentation and smoking habits.

Objectives: The objectives of this study were the following:

■ To assess differences in tooth shade between the maxillary central incisor (11) and maxillary canine (13); between the mandibular central incisor (41) and the mandibular canine (43); between the maxillary central incisor (11) and mandibular central incisor (41) and between the maxillary canine (13) and the mandibular canine (43).

■ To establish if there are any differences in the shades of teeth 11, 41, 13, and 43, and whether sex or age influenced the shade in any way.

■ To determine if there is any correlation between the shades of teeth 11, 41, 13, 43 and patients' skin tone, gingival pigmentation (non-pigmented, focal, diffuse) or smoking habits.

Methods: The study sample comprised of 500 dental patients of which 305 were females and 195 were males. Their ages ranged from 18 to 81 years. These patients were divided into two age groups. Group one consisted of 291 patients, who were 35 years old and younger, Group two consisted of 209 patients older than 35 years of age. Their sex, skin tone (light, medium or dark), gingival pigmentation (non-pigmented, focal or diffuse) and smoking habits were recorded. The tooth shade of the middle third of the maxillary central incisor (11), maxillary canine (13), mandibular central incisor (41) and the mandibular canine (43), were taken, using the Vita Lumin Vacuum Shade Guide, Vita Linear 3 D-Master guide, as well as the spectrophotometer (Vita Easyshade Compact). Skin tone was recorded by using a specially designed skin tone guide; the skin tone of the inner aspect of the arm of the patient was recorded. The degree of gingival pigmentation was assessed by visual examination of the attached gingiva of the anterior part of the maxilla and mandible.

Results: The results of this study indicate that the central incisors had a lighter value than the canines, but there was no difference in value between the maxillary central and mandibular central incisors. The maxillary canine was found to be darker than the mandibular canine. A statistically significant relationship was found between tooth value and the patient's age, sex and skin tone. There was no significant relationship between gingival pigmentation and tooth value for the maxillary central incisor 11. However, there were significant relationships between tooth values for teeth 13, 41, and 43 and gingival pigmentation. There was also no significant relationship between the tooth values for teeth 13 or 43 with smoking

habits of the patients, although there was a significant relationship between teeth 11 and 41 with the patients' smoking habits.

Conclusion: The central incisor was lighter than the canine in both the mandible and the maxilla. The mandibular canine (43) was, however, lighter than the maxillary canine (13). There was a significant relationship between the age of patients and tooth value; older adults had darker and more yellow teeth than younger patients. Generally females had significantly lighter and less reddish teeth than males. There was a significant relationship between skin tone and tooth value in that lighter skin tone patients had darker teeth value while those with darker skin tone had lighter teeth value. Gingival pigmentation showed no association with the value of the maxillary central incisor (11), but was associated with lighter values for the maxillary canine (13), mandibular central incisor (41) and mandibular canine (43). Smoking darkened the incisor teeth, but had little or no effect on the value of canine teeth.

LIST OF ABBREVIATIONS

VC:	Vita Classical Shade Guide (Lumin Vacuum)
3DM:	3D-Master
LG:	Vitapan 3D-Master Linearguide
SM:	Spectrophotometer (Vita EasyShade Compact)
SMVC:	Spectrophotometer Vita Classical Shade Guide
SM3DM:	Spectrophotometer (3D-Master)
L:	Yellow hue
M:	Medium hue
R:	Red hue

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CHAPTER 1

INTRODUCTION

Background to the study

The success of restorative dentistry depends on form, function and aesthetics.[5] The aesthetic sense of a dentist is the ability to see the unseen, to see with the third eye, and engage all of the senses. The ultimate objective is to create a beautiful smile. This does not just involve beautiful teeth, but teeth of pleasing inherent proportions and a tooth arrangement in harmony with the gums, lips and face of the patient.[6] This puts pressure on both dentists and dental-related industries. Patients are immensely influenced by the media and they focus increasingly on aesthetics and clinically related measurements, including accurate colour matching. Precise colour matching has become integral to the success of aesthetic restorations.[7]

The matching of tooth colour is an important characteristic of perceived quality andmay lead to a patient's refusal to accept dentures for aesthetic reasons. Dentists can help restore patients' self-confidence by choosing the correct tooth colour.[8] The expertise needed for colour matching can be improved by studying and learning the language of colour and light characteristics. When matching tooth colour, the three parameters of value, chroma and hue are the most important factors in shade selection.[9]

These factors are all included in the "Munsell Colour Chart" Figure 1 system and it is therefore deemed highly accurate. The value describes the brightness of a colour (from white to black) Figure 2, while chroma is the dimension that describes

or measures the intensity Figure 3, saturation, strength and purity of the hue. The hue on the other hand is one of the properties of colour Figure 4. It refers to the dimension that distinguishes one family of colours from another, in other words how close or similar a particular colour is to red, blue or yellow.[2,9]

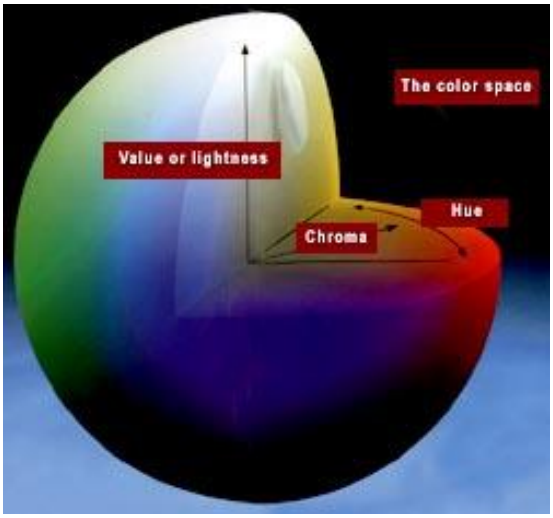

Figure 1: The colour space (Munsell Colour Chart)

space

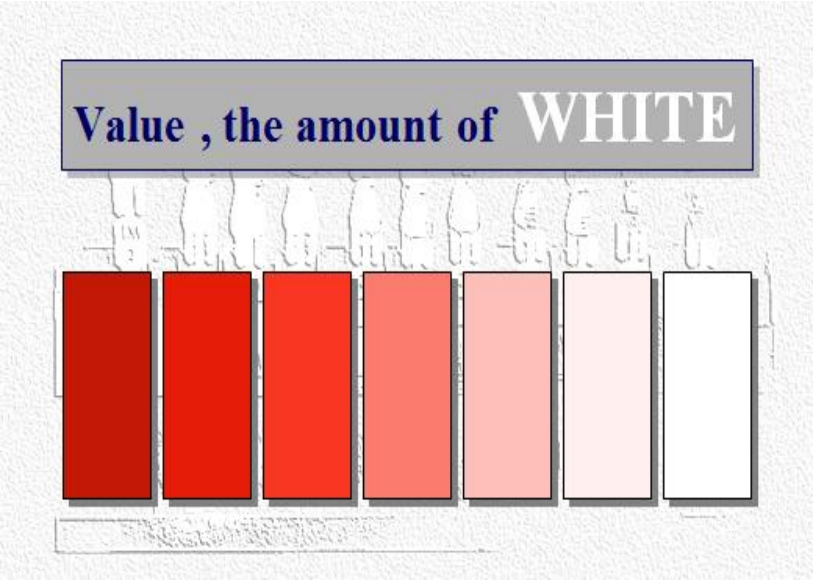

Figure 2: Value: the amount of white

Figure 3: Chroma: the amount of saturation

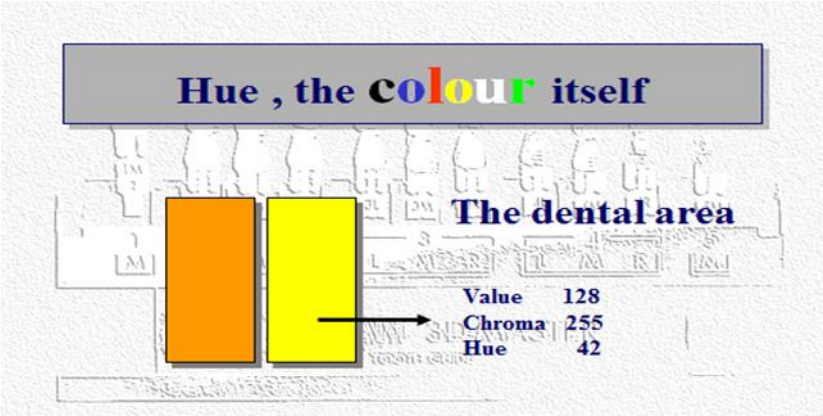

Figure 4: Hue: the colour itself

The shades and appearance of teeth is a complex phenomenon, with many factors determining the final outcome, such as lighting conditions, translucency, opacity, light scattering, and gloss. The human eye plays a major role because the brain's cognitive ability influences the overall perception of tooth colour.[10]

Teeth are typically composed of a number of colours. The colour of teeth determined by the combined effects of intrinsic and extrinsic colourations.[1]

Intrinsic tooth colour is associated with the light scattering and absorption properties of enamel and dentine.[12] In addition to intrinsic colour, teeth can change colour due to extrinsic staining.

Extrinsic stains can be divided into two categories: those compounds which are incorporated into the pellica and produce a stain as result of their basic colour, and those caused by chemical interactions on the tooth surface. Extrinsic dental stains include things such as food beverages, chromogenic bacteria, metallic compounds, topical medication such as chlorhexidine rinse and smoking tobacco[1], which is one of the main causes of extrinsic staining of teeth. The tobacco stains may be yellow, brown, dark brown or even black. The severity depends on the duration and frequency of the habit.[13]

When matching teeth, both intrinsic and extrinsic colous are important, but gradation must also be considered. The gradation of colour occurs in an individual tooth from the gingival margin to the incisal edge.[1]

Another of the influential factors to be considered for shade matching is the light source that is used. Light is composed of different wave lengths or frequencies and the same tooth viewed under different conditions will exhibit different colours, a phenomenon known as “metamerism”.[9]

The ideal light source for accurate colour comparison is natural light occurring between midday and 15:00.[14]

However, it is logical that a dentist would not be working only at that time and obviously a standard light source is needed to reduce the effect of metamerism.

The absence of ideal lighting in dental surgeries can be improved by the use of a light corrector (colour corrected light) which will help to reduce the effect of metamerism.[1]

CHAPTER 2

LITERATURE REVIEW

Much research has been carried out on tooth shade and the different variables that can influence it. The following is a summary of the findings of some of these studies.

A full denture service differs from the colour problems encountered in other fields of restorative dentistry. This is because the full denture service demands colour selection, while partial dentures, crowns, inlays and bridges require colour matching with adjacent, opposite teeth.[15]

Selecting colours is somewhat different, because the colour requirements of matching to adjacent teeth are well known. The selection of colour for an edentulous patient is different proposition, because the natural teeth are no longer present to act as a guide.[15]

The prosthodontist will then have to look elsewhere for guidelines to assist in the selection of artificial teeth for a completely edentulous patient.[3] Prosthodontists advocate the method of using the colour of the face (skin tone), as one basic guide in the selection of tooth colour; they insist that the hue of the teeth should be in harmony with the patient's facial complexion.[16]

Skin tone has also been proposed as an aid for artificial tooth selection during complete denture fabrication by Jahangiri et al,[2] Sharma et al,[17] and Haralur et al.[18]

The perception among restorative dentists is that individuals with dark skin tone have lighter shades of teeth. This perception is commonly explained by the illusion of greater contrast between skin tone and tooth shade. However, there is limited scientific information or confirmation about the relationship between tooth shade and skin tone and it may impact the ability of restorative dentists to select artificial teeth that complement the facial complexion of their patients.[2]

It has however been shown by various researchers that there is a significant relationship between tooth shade and skin tone. People with medium to dark skin tones are more likely to have teeth with high values (lighter) whereas individuals with lighter skin tones tend to have teeth with lower values (darker).[2 ,19,17 ,18]

Other studies have concluded that facial complexion is not significantly correlated to tooth colour.[16,3,4] The discrepancy in data regarding correlations between facial complexion and tooth colour data indicates that facial skin complexion may be a poor clinical indicator of tooth colour and therefore unreliable in the selection of artificial teeth for patients of different ethnic backgrounds.[16]

Other factors such as age, gender, and surrounding soft tissues must also be taken in consideration for a harmonious result.

The colour of the lips and gums also influence the perceived colour of teeth.[20]

Dummett et al [21] describes the colour of physiological gingival pigmentation as ranging from pale pink to bluish purple, with variable prevalence in different ethnic groups. Physiological gingival pigmentation is most commonly caused by deposits of melanin in the basal layer of the oral epithelium and it may be seen at any age without an inclination towards any particular gender. It is found across all races.[22]

Physiological pigmentation is prevalent among African as well as French, Filipino, Arab, Chinese, Indian, German, Italian, Jewish, Greek and Romanian nationalities.[23] The diagnosis of physiological pigmentation is made clinically, and does not require any treatment. Physiological pigmentation is classified as multifocal, diffuse or non-pigmented. [24]

Ibusuki[25] used the Munsell colour system to study gingival colour and reported that gingival pigmentation varied with the position of papillary, marginal and attached gingiva. He also found that the chroma was higher in the gingiva of older persons while younger study participants exhibited higher measures of value.

The idea that there is a strong relationship between facial skin complexion and gingival pigmentation was not supported by Dummet et al[16].

Power et al [26] used the Munsell colour matching system tabs, under both fluorescent light and simulated daylight to measure the value, chroma, and hue of attached gingiva for black and white subjects. They reported that the colour of non-pigmented gingiva were similar. Melanin-pigmented gingiva in black subjects were similar in hue, but lower in value and chroma than non-pigmented gingiva.

Furthermore, a recent study by Ponnaiyan et al[27] was conducted to assess the correlation between skin colour and gender, with the intensity of distribution of gingival pigmentation in a South Indian population. They concluded that there is a correlation between the intensity of gingival pigmentation and skin colour. It was observed that people with fair skin had mild gingival pigmentation, whereas people with dark skin had heavier gingival pigmentation. It was also reported that there is

no significant correlation between gender and distribution of gingival pigmentation. The highest rate of pigmentation was observed at the area of the incisors.

It is important to consider the other factors that play a role in tooth shade selection. age and sex are also important parameters in tooth shade matching.

Teeth become darker as physiological age changes[1]. Goodkind et al[28] showed that after the age of approximately 35 years patients' teeth tend to become somewhat darker, somewhat more red and saturated, with the exception of the cervical sites, which turn more yellow.

The older the adults are, the more likely it is for them to have darker teeth or "lower value". [2,3,19] Hasegawa et al[29] investigated the colour of the natural maxillary incisor tooth from Japanese people of all age groups. They concluded that the natural tooth shade in the middle third of a tooth has a tendency to decrease in lightness and to increase in yellowness with advance in age. Also, the shade of the natural teeth shows an increase in redness at the incisal site because of long term occlusal wear/loss in the incisor region.

In another study done by Gozalo et al[30], the age of participants were found to be directly proportional to the natural shade of the central incisor – the central incisor became darker (more reddish, and more yellow) with increasing age.

Finally, there is one other factor worth mentioning in the pursuit of an ideal colour selection. The dignity of advanced age must be appropriately portrayed in the denture and tooth colour selection as well as by mould refinement.

A prosthodontist must take into consideration the age, sex, and even personality of their patients before constructing their dentures.[31]

Determining tooth colour using gender as a parameters was only partially helpful in a sample of white elderly patients in a study by Hassel et al.[32] According to studies[29,2] involving natural teeth there are no significant differences in tooth shade between males and females. However, other gender studies done by Esan et al[3] and Azad et al[19], concluded that men have darker teeth than women and women also have lighter and less yellow central incisors than men.[30]

Goodkind et al,[28] found a statistically significant difference in hue, value, and chroma between males and females for all sites of the teeth studied. Female subjects' teeth were slightly yellower, lighter and less saturated.

The difference of shades between maxillary and mandibular incisors is also an anticipated variable that can help dentists when matching shades.[33]

Goodkind et al[28] found that maxillary anterior teeth are slight yellower than mandibular teeth. Similarly, the maxillary central incisor has a higher value than the mandibular central incisor. The canines also have lower values (darker) than the incisors.

The shade difference between central and canine teeth vary in different countries and regions due to ethnic variety and environmental factors.[33]

The canine teeth lacks lightness and has a reddish colour; it seems that they are darker and more saturated than the incisors.[29,27] Furthermore, maxillary canines are more yellow and maxillary centrals are lighter than other incisors.[33]

Two methods are commonly used to analyse the shades of natural teeth: the first method, which is most commonly used, involves visual comparison, and the second involves the use of instrumentation.[12]

Due to inter-human differences in the perception of colour, visual shade assessment of human teeth lacks standardization, which may be improved by the use of spectrophotometers. Spectrophotometric shade analysis is more accurate and more reproducible compared to human shade assessment.[34]

In another study done by Derdilopoulou et al,[35] the performance of visual and spectrophotometric tooth shade evaluation showed spectrophotometric shade determination to be significantly more reproducible than the visual procedure.

Despite the many studies conducted, there is insufficient data regarding tooth colour and its relationship to age, sex, skin tone, gingival pigmentation and smoking habits. Hence the reason for this study in the South African population.

CHAPTER 3

STUDY OBJECTIVES

The objectives of this study were:

- To assess differences in tooth shade between the maxillary central incisor (11) and maxillary canine (13), between the mandibular central incisor (41) and the mandibular canine 43), between the maxillary central incisor (11) and mandibular central incisor (41) and between the maxillary canine (13) and the mandibular canine (43).
- To establish if there are any differences in the shades of teeth (11), (41), (13), and (43), and whether sex or age influenced the shades in these teeth any way.
- To determine if there is any correlation between the shades of teeth (11), (41), (13), (43) and patients' skin tone, gingival pigmentation or smoking habits.

CHAPTER 4

METHODS

4.1 Sample selection

This is a cross-sectional descriptive diagnostic study that was conducted at the Oral and Dental Hospital(University of Pretoria). Five hundred patients (305 females and 109 males) with ages ranging from 18 to 81 were examined.

Participation in this study was completely voluntary and the decision as to whether or not to participate in this study had no influence on the participants' present or future status as a patient. Consent forms, designed for this study, were signed by patients after a thorough explanation of the nature of the procedure (see appendex). The confidentiality of data collected was assured at all times and no "personal" information provided or obtained in connection with this study can be attributed to an individual or will be disclosed to third parties. Only accumulative and aggregated information will be included in the resultant report. This study was approved by The Ethics Committee, Faculty of Health Sciences at the University of Pretoria (317/2014).

The teeth of the selected patients had to meet the following inclusion criteria:

- Not have active carious lesions.
- Not be endodontically treated.
- Not be restored.

- Not have orthodontic brackets.
- Not have been bleached in the last two years.
- Not have any congenital abnormalities.
- Not have any intrinsic stains.

4.2 Setting and data collection

The patients selected for this study were all seeking treatment at the Oral and Dental Hospital. Data selected were entered onto a spreadsheet using a standardized questionnaire. Demographic data was recorded at the time of examination. This data included: age, sex, skin tone, gingival colour (non-pigmented, focal and diffuse) and tooth number. Smoking habits were also recorded.

The tooth shade was recorded by one clinician (myself). The clinician was screened for colour vision deficiency using the Ishihara test[36] for colour blindness.

Calibration was made as outlined by the manufacturer on a daily basis and with different shade guides: Vita Lumin Vacuum Guide, Vita Linearguide 3D-Master as well as the spectrophotometer (Vita EasyShade Compact).

The patient was positioned upright with the mouth at the clinician's eye level and the clinician's position was at an arm's length from the subject. Patients were draped with a grey (neutral colour) cloth.

The shade guides were positioned adjacent to the middle third of each of the four anterior teeth namely the maxillary central incisor (11), maxillary canine

(13), mandibular central incisor (41) and mandibular canine (43). The shade selection was then done on the middle third of the labial surface to determine the correct shade as shown in Figure 5.

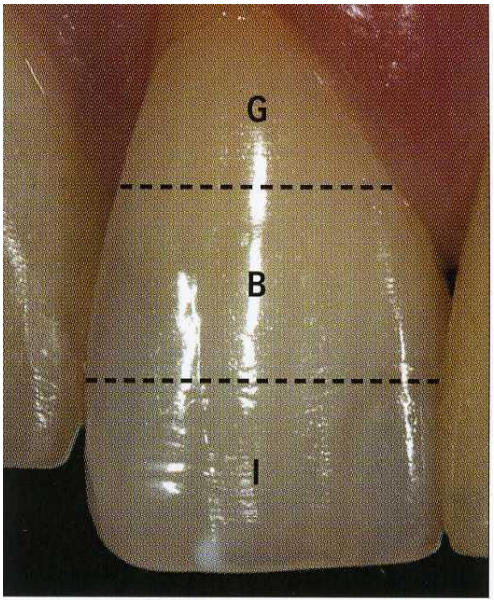

Figure 5: Middle third of maxillary incisor: Gingival (G), Body (middle third) (B), Insical (I)

This method was also described by Mayekar,[6] who stated that “the true shade is represented in only the middle third of the tooth because the range of colour changes from the incisal to gingival areas”.

Women with facial makeup such as lipstick were asked to remove it prior to shade selection as this could pose a contrasting influence when determining the shade. In order to reduce eye fatigue and any related inconsistencies or bias, a neutral background was used. It has been recommended that clinicians use a grey card as a background when viewing shade tabs and teeth to eliminate distructions in the surrounding environment and allow a more accurate determination of chroma and value. Shade selection

observations did not exceed 30 seconds. All patients were examined in the same surgery so as to standardize day light conditions without the presence of direct sunlight. The same colour-corrected lighting conditions were used for all patients. Tooth shade was recorded in terms of three colour components, namely value, chroma and hue.

4.3 Measurements

4.3.1 Determination of tooth shade

One of the measuring instruments used was the Vita Lumin Vacuum shade guide (Vita Classical Shade Guide), (Vita Zahnfabrik, H. Rauter GmbH and Co KG, Bad Sackingen, Germany). The Vita Classical Shade Guide consists of 16 tabs arranged in four groups based on the hue. It is grouped according to increasing chroma (Figure 6) .

Hue is categorized by the letters A, which indicates orange; B, which indicates yellow; C, which indicates yellow to grey; and D, which indicates orange to grey. Chroma and value are categorized by the numbers 1 to 4, in which 1 signifies the lowest chroma but highest value, and 4 the highest chroma but lowest value.

After the patient was positioned on the chair, the shade guide was held parallel to the selected tooth. The tooth was then matched to the shade guide and the value (lightness) of the colour was assessed first, followed by chroma and hue.

Figure 6: Vita Classical Shade Guide

The second measuring instrument the Vitapan 3D-Master (Vita Zahnfabrik, H. Rauter GmbH and Co KG, Bad Sackingen, Germany) (Figure 7):

- The guide consists of 26 tabs divided into 5 groups according to lightness. The tabs are arranged according to the chroma (vertically) and hue (horizontally) within the groups. The tabs are marked on the front with the numbers 1, 2, 3, 4 and 5, to indicate lightness.
- A lower number corresponds to greater lightness, and a second number below the group number designates the chroma level (1, 1.5, 2, 2.5, and 3). More chromatic tabs have higher numbers.
- The letter M designates the midline (medium) hue in each group, whereas the letters L and R designate the yellow (left) and red (right) tabs respectively.

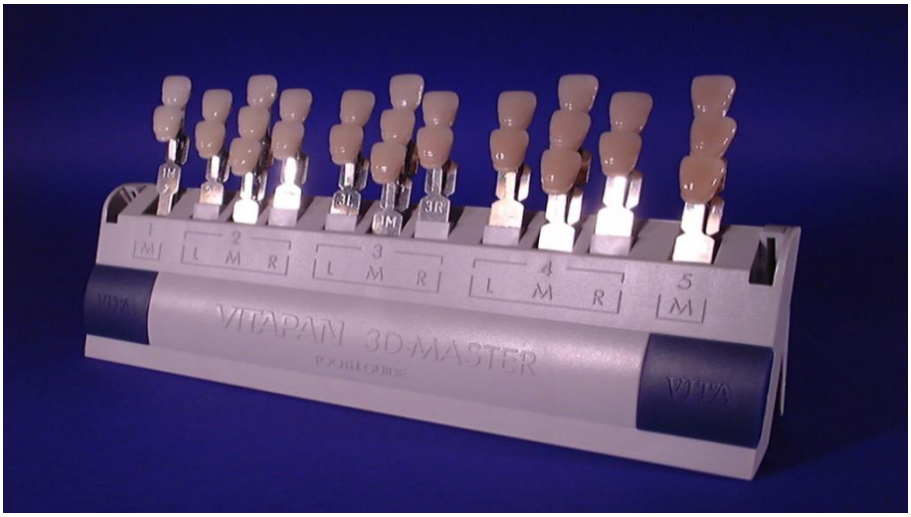

Figure 7: Vitapan 3D-Master

A modified 3D-Master shade guide (3D-Master Linearguide) commonly used in Europe was utilised for this study. The Vita 3D-Master Linearguide enables the quick determinations of precise tooth shades and use the same scientific principles and shades found in the Vita 3D-Master shade guide but in a much better tab holder that allows more accurate positioning and evaluation. The Vita 3D-Master linear guide feature a sleek, linear designe simple, fast, precise shade determination (Figure 8). The shade match was done in only two steps:

1. Selecting the value: by selecting the vita value guide from the dark grey holder containing only six middle tabs (0m2 to 5m2).
2. Selecting chroma and hue: the final selection based on chroma and hue was made from the initial value group.

Figure 8: Linearguide 3Dmaster

The third measuring instrument used in addition to the manual shade guides was the Vita Easyshade Compact Spectrophotometer (Vita Zahnfabrik, H. Rauter GmbH and Co KG, Bad Sackingen, Germany):

Spectrophotometers are the scientific standard for colour measurement for the following reasons:

- They provide the most colorimetric information possible.
- There are many different types of spectrophotometers, from ones that measure small areas of an object to those measuring entire objects at spot measurement once, for e.g. the Vita Easy Shade compact (Figure 9).
- It is a useful and relevant tool for measurement and analysis, and is particularly useful for quality control in the colour production process.
- The VITA Easyshade Compact quickly and precisely measures the 16 VITA Classical shades, as well as the 26 VITA System 3D-Master shades.
- The Vita Easyshade consists of a base and handpiece. Prior to measurement, the device is isolated with a single use plastic cover (infection control sleeve) in order to avoid contamination. After placing the infection control sleeve over the handpiece, the device is switched on by depressing the middle button. Calibration is done by placing the handpiece over the ceramic block so that the probe tip is flush with and perpendicular to the calibration block. The calibration process is complete once three beeps are heard. The device is then set to single tooth mode (Figure 10), and the probe tip positioned directly onto the

middle-third area of the tooth surface (Figure 11). The measurement button on the handpiece is pressed until the device beeper indicates that the measurement is completed and the result is then reflected on the device screen.

Figure 9: The VITA Easyshade Compact

Figure 10: Single tooth mode

Figure 11: The probe tip positioned directly to the middle-third area of the tooth surface.

4.3.2 Determination of Skin Tone

Patients' skin tone was measured by a guide designed and provided by Mr F. du Plessis (dental technician) from oral and dental hospital university of Pretoria (Figure 12). The guide differentiates between light (1, 2, 3), medium (4, 5, 6) and dark tones (7, 8, 9). Skin tone was determined by looking at the inner aspect of the arm, which is relatively unexposed to sunlight. Tanned patients and those with albinism were excluded from the study.

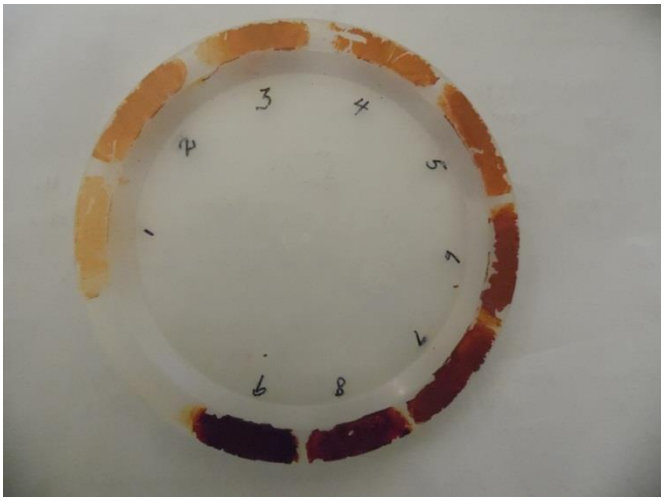

Figure 12: Skin tone guide

4.3.3 Determination of Gingival colour

Gingival colour was assessed by visual examination of the attached gingiva (Figure 13) and recorded as either non-pigmented (Figure14), focal (Figure 15) or diffuse (Figure 16).

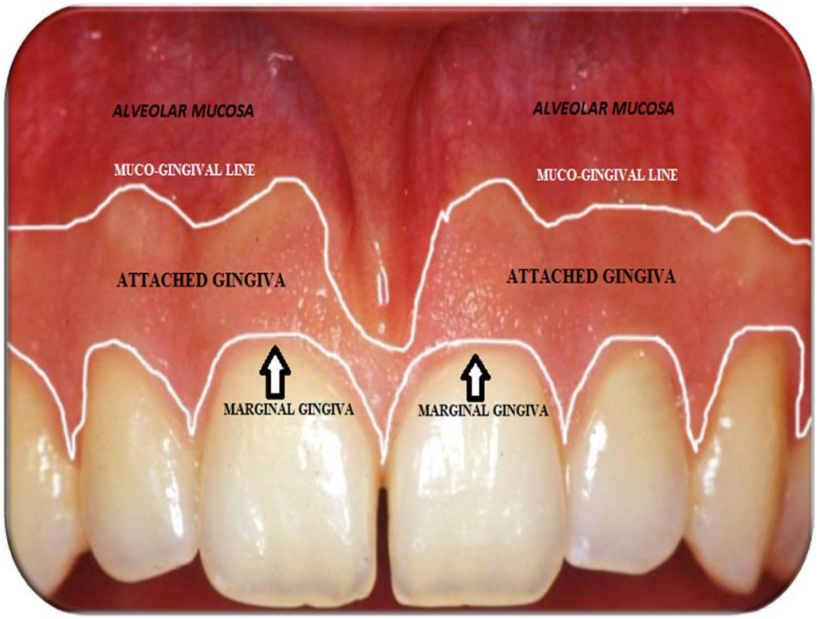

Figure 13: Attached gingiva

Figure 14: Non-pigmented gingiva

Figure 15: Focal gingval pigmentation

Figure 16: Diffuse gingival pigmentation

4.3.4 Tooth shade according to value:

For standardisation and uniformity we converted the vita classical shade guide (Vita Lumin Vacuum) values to the 3D Master values. The conversion values were provided by Vita North America (Table A). Because of the large amounts of data this study focused specifically on

the relationship between tooth value and all the variables, and on the relationship between hue and some variables (age, sex and smoking). Chroma was not included.

Table A: Tooth shade conversion chart according to value

1	2				3				4		5
1M1.5	2M1	2M2	2R2.5	2L1.5	3M3	3L2.5	3L1.5	3M1	4L1.5	4L2.5	5M1
B1	A1	A2	A3	B2/C1	A3.5	B3/B4	C2/D3/D4	D2	C3	A4	C4

4.3.5 Data analysis:

Data analysis was by way of frequency distribution over colour category within the teeth 11, 13, 41 and 43, for eye assessment as well as spectrophotometer assessment. The distribution of colour categories for teeth 11, 13, 41 and 43 assessed (SM.VC) was compared to categories of demographic variables such as sex (male, female) age (35 and younger, older than 35), smoking habits (yes, no), skin tone (light, medium and dark) and gingival pigmentation (non-pigmented, focal and diffuse). The latter was done using Fisher's exact test at 0.05 level of significance in Statas release 13 statistical software.[37]

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CHAPTER 5

RESULTS

5.1 Patient demographics

Data was collected by use of a questionnaire and then captured using Microsoft Excel (version 2003). The sample comprised of 500 dental patients of which 305 were females and 195 were males. Their ages ranged from 18 to 81 years. These patients were divided into two age groups: group one consisted of 291 patients 35 and younger (176 females and 115 males). Group two consisted of 209 patients older than 35 (129 females and 80 males), as shown in Table 1 below.

Table 1: Distributions of patients according to age and sex

Age group	Female	Male	Total
35 and younger	176	115	291
Older than 35	129	80	209
Total	305	195	500

5.2 Skin tone

Skin tone was divided into three groups: light, medium and dark. Two hundred and thirteen patients had light skin tone, 108 had medium skin tone and 179 had dark skin tone, as shown in Table 2 below.

Table 2: Distributions of patients according to skin tone

Skin tone	Females	%	Males	%	Total	%
Light	146	47.8%	67	34.35%	213	42.6%
Medium	66	21.6%	42	21.53%	108	21.6%
Dark	93	30.4%	86	44.10%	179	35.8%
Total	305	100%	195	100%	500	100%

As can be seen from Table 2 above, 42.6% of the patients had light skin tone, 21.6% had medium skin tone and 35.8% had dark skin tone. The majority of females 47.8% had light skin tone whereas dark skin tone was the dominating shade under male patients 44.10%.

5.3 Gingival Pigmentation

Patients' gingival pigmentation was classified as non-pigmented, focal and diffuse, as set out in Table 3.

Table 3: Distributions of patients according to their gingival pigmentation

Gingival pigmentation	Light skin tone		Medium skin tone		Dark skin tone		Total	
	F	%	F	%	F	%	F	%
Non-pigmented	210	98.59	52	48.15	32	17.88	294	58.80
Focal	1	0.47	36	33.33	68	37.99	105	21
Diffuse	2	0.94	20	18.52	79	44.13	101	20.20
Total	213	100	108	100	179	100	500	100

Two hundred and ninety-four patients had no gingival pigmentation, 105 had focal gingival pigmentation and 101 had diffuse gingival pigmentation (Table 3). Almost all of the study participants (210, which amounts to 98.59%) with light skin tone had non-pigmented gingiva, whilst the majority of medium and dark skin tone patients had diffuse and focal gingival pigmentation.

5.4 Smoking habits

A simple differentiation was made between smoker and non-smoker patients. The percentages of these patients are set out according to gender in the following table.

Table 4: Distributions of patients according to smoking habits:

Smoke	Female		Male		Total	
	F	%	F	%	F	%
Smoker	43	14.10	62	31.79	105	21
Non-Smoker	262	85.90	133	68.21	395	79
Total	305	100	195	100	500	100

One hundred and five patients were smokers and 395 were non-smokers (Table 4). Of the patients studied 79% were non-smokers, of which 85.90% were females and 68.21% males. In contrast, only 21% were smokers, of which 14.10% were females and 31.79% males. It is evident that the smoking group had a slightly higher proportion of male patients.

5.5 Comparing tooth values with different variables

Values for the maxillary central incisor (11), maxillary canine (13), mandibular central incisor (41), and mandibular canine (43) were compared with the patients' age, sex, skin tone, gingival pigmentation, and smoking habits. Table 5 compares age with values for the maxillary central incisor (11).

5.5.1 Tooth value compared to age

Table 5: Comparison between age and value for tooth (11)

Age						
SMVC11	35 and younger		Older than 35		Total	
	F	%	F	%	F	%
1	59	20.27	16	7.66	75	15
2	217	74.57	140	66.99	357	71.40
3	9	3.09	33	15.79	42	8.40
4	5	1.72	13	6.22	18	3.60
5	1	0.34	7	3.35	8	1.60
Total	291	100	209	100	500	100
Fisher's exact = 0.000						

For the maxillary central incisor, the percentages of patients who were 35 and younger were as follows: 20.27% were value 1, and 74.57% were value 2 (light values). Only 7.66% of patients older than 35 represented value 1, whereas 66.99% were value 2. Also of note is the fact that the percentage of patients in this age group decreased as the value increased: 15.79% of the patients' maxillary central incisors were value 3, 6.22% were value 4 and a mere 3.35% were value 5 (dark value). However, these values (3 – 5) were represented by significantly fewer

patients in the younger age group. It can be seen that patients who were older, had more teeth with darker values. A statistically significant relationship was found between age and value for tooth 11 (Fisher's exact = 0.000). Table 6 compares age to the values of the maxillary canine (13).

Table 6: Comparison between age and value for tooth (13)

Age						
SMVC13	35 and younger		Older than 35		Total	
	F	%	F	%	F	%
1	4	1.37	0	0	4	0.80
2	184	63.23	112	53.59	296	59.20
3	84	28.87	55	26.32	139	27.80
4	16	5.50	37	17.70	53	10.60
5	3	1.03	6	2.39	8	1.60
Total	291	100	210	100	500	100
Fisher's exact=0.000						

For the maxillary canine, 63.23% of patients who were 35 and younger represented value 2 (lighter value), which was only slightly more than the 53.59% of patients who were older than 35. Value 3 was represented almost equally by both age groups, but a significantly higher amount of the older patients represented value 4. This shows that the value of the tooth grows darker with increased age, but showing a slightly different pattern

from what was seen in the maxillary central incisor (11). The maxillary incisor clearly does not darken as much as the maxillary canine and this is important when matching tooth colour. A statistically significant result was found between age and value for tooth 13 (Fisher's exact = 0.000). Table 7 shows the value for tooth (41) compared with age.

Table 7: Comparison between age and value for tooth (41)

Age						
SMVC 41	35 and younger		Older than 35		Total	
	F	%	F	%	F	%
1	60	20.62	25	11.96	85	17.
2	220	75.60	141	67.46	361	72.20
3	9	3.09	20	9.57	29	5.80
4	1	0.34	21	10.05	22	4.40
5	1	0.34	2	0.96	3	0.6
Total	291	100	210	100	500	100
Fisher's exact = 0.000						

For the mandibular central incisor (41), the data shows that 20.62% of patients who were 35 and younger represented value 1 and 75.60% represented value 2. 11.96% of patients who were older than 35 represented value 1, and 67.46% represented value 2 (lighter value). The older patients' percentages of values 3 and 4 were significantly more than the younger age group's percentages. It can be seen from Table 7 that the tooth values compared to age are quite similar to those shown for the

upper central incisor tooth (11) in Table 5. A statistically significant result was found between age and value for tooth 41(Fisher's exact = 0.000). Table 8 compares age to value for tooth 43.

Table 8: Comparison between age and value for tooth (43)

Age						
SMVC43	35 and younger		Older than 35		Total	
	F	%	F	%	F	%
1	0	0	2	0.96	2	0.40
2	192	65.98	143	68.42	335	67.00
3	89	30.58	38	18.18	127	25.40
4	8	2.75	23	11	31	6.20
5	2	0.69	3	1.44	5	1
Total	291	100	209	100	500	100
Fisher's exact = 0.000						

Table 8 shows findings for the mandibular canine (43), and is clearly different from the incisors but similar to the findings for the maxillary canine (13) (Table 6). 65.98% of patients who were 35 and younger had value 2 for the mandibular canine, 30.58% were value 3, and 2.75% were value 4. 68.42% of the patients who were older than 35 represented value 2, 18.18% value 3, and 11% value 4. A statistically significant result was found between the age and tooth value for the tooth (43). (Fisher's exact = 0.000).

When age was compared to tooth value, more patients of age 35 and younger recorded a lighter value (1 and 2) for the maxillary central incisor (11) and mandibular central incisor (41), as shown in tables 5 and 7. The data also reveals a decrease in frequency of value 3 in the maxillary and mandibular canine as shown in tables 6 and 8.

5.5.1.1 Visual comparison between age and tooth value

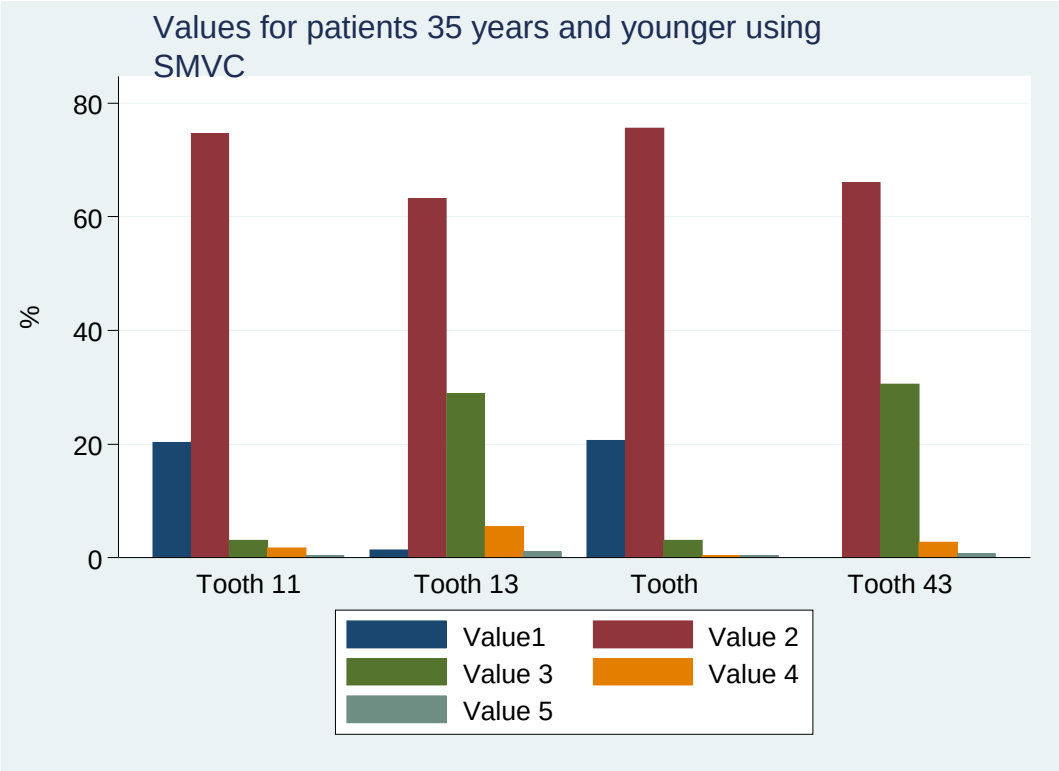

Figure 17: Values for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43) were compared to the patients' ages (those 35 years or younger), using the Spectrophotometer Vita Classic (SMVC)

It is clear that the dominant value for patients 35 and younger was 2. The only other values of note were 1 (in the incisors) and 3 (in the canines). Values 4 and 5 were poorly represented in this age group.

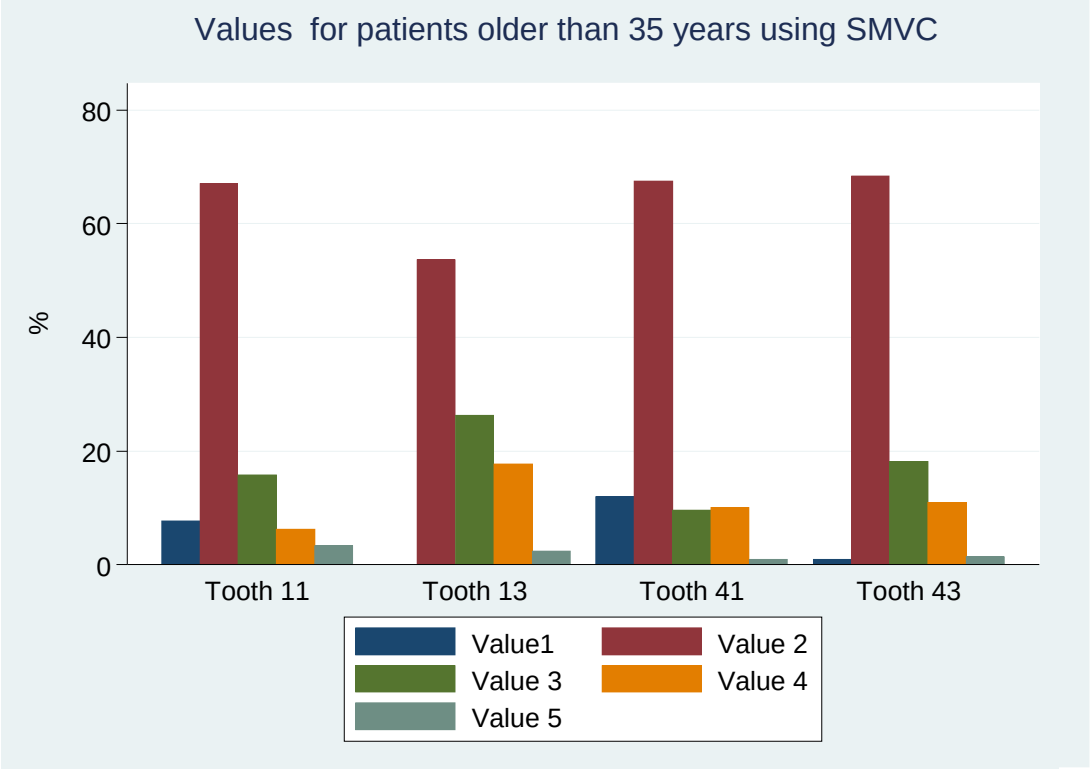

Figure 18: Values for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43) were compared to patients' ages (those older than 35 years), using the Spectrophotometer Vita Classic (SMVC)

Figure 18 provides an overview of values for all the teeth examined in the older age group. Similarly, patients 35 years and younger have a dominant value of 2. Value 1's prevalence decreased dramatically compared to the younger age group and value 3's presence is more noticeable in all the teeth. There are also a significantly higher number of teeth with value 4, and a significant decrease in values 1 and 5.

5.5.2 Comparison of the sex of patients with tooth value for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43)

Table 9: Comparison between patient sex and value for tooth (11)

Sex						
SMVC 11	Female		Male		Total	
	F	%	F	%	F	%
1	52	17.05	23	11.79	75	15
2	221	72.46	136	69.74	357	71.40
3	22	7.21	20	10.26	42	8.40
4	5	1.64	13	6.67	18	3.60
5	5	1.64	3	1.54	8	1.60
Total	305	100	195	100	500	100
Fisher's exact = 0.017						

It can be seen from Table 9 that more female patients than males had teeth with lighter values (1 and 2). For the upper central incisor (11), 17.05% of females represented value 1, while 72.46% represented value 2. Whilst only 11.79% of the males represented value 1. Value 2 was represented by more males 69.74%. By using Fisher's exact test a statistically significant result was found between the sex of patients and

tooth value for the maxillary central incisor (11). Fisher's exact = 0.017. Table 10 compares sex to the value of tooth 13.

Table 10: Comparison between patient sex and value of tooth (13)

Sex						
SMVC 13	Female		Male		Total	
	F	%	F	%	F	%
1	3	0.98	1	0.51	4	0.80
2	194	63.61	102	52.31	296	59.20
3	78	25.57	61	31.28	139	27.80
4	27	8.85	26	13.33	53	10.60
5	3	0.98	5	2.56	8	1.60
Total	305	100	195	100	500	100
Fisher's exact =0.067						

Table 10 shows that 63.61% of female patients represented value 2 for the maxillary canine (13), whilst 52.31% of the male patients represented value 2. When the darker values 3, 4, and 5 are considered it is clear that a higher percentage of males than females had darker teeth values. In general, females had lighter values for the maxillary canine tooth (13) than males. No statistically significant relationship between sex and tooth value for the maxillary canine (13) could be established. Fisher's exact = 0.067. Table 11 compares the sex of patients to the value for tooth 41.

Table 11: Comparison between patient sex and value for tooth (41)

Sex						
SMVC 41	Female		Male		Total	
	F	%	F	%	F	%
1	55	18.03	30	15.38	85	17.00
2	220	72.13	141	72.31	361	72.20
3	18	5.90	11	5.64	29	5.80
4	10	3.28	12	6.15	22	4.40
5	2	0.66	1	0.51	3	0.60
Total	305	100	195	100	500	100
Fisher's exact=0.584						

For the mandibular central incisor (41), 18.03% of the female patients represented value 1, and 72.13% value 2. The results also indicated that there is no statistically significant relationship between sex and the mandibular central incisor (41) (Fisher's exact=0.584). In general, the lower central incisor (41) was lighter in females and males. Table 12 below compares sex to the value for tooth (43).

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Table 12: Comparison between patient sex and value for tooth (43)

Sex						
SMVC 43	Female		Male		Total	
	F	%	F	%	F	%
1	2	0.66	0	0	2	0.40
2	211	69.41	124	63.59	335	67.13
3	75	24.67	52	26.67	127	25.45
4	16	5.26	15	7.69	31	6.21
5	1	0.3	4	2.05	5	1
Total	305	100	195	100	500	100
Fisher's exact=0.158						

Table 12 shows that 69.41% of female patients and 63.59% of males represented value 2. The males however had darker values than female patients. This confirms again that females have lighter values than males.In general the canines are however darker than the central incisors (11) and (41) (Tables 9 and 11). There is no statistically significant relationship between sex and tooth value for the mandibular canine (43) (Fisher's exact = 0.158).

5.5.2.1 Visual comparison between tooth value and patient sex

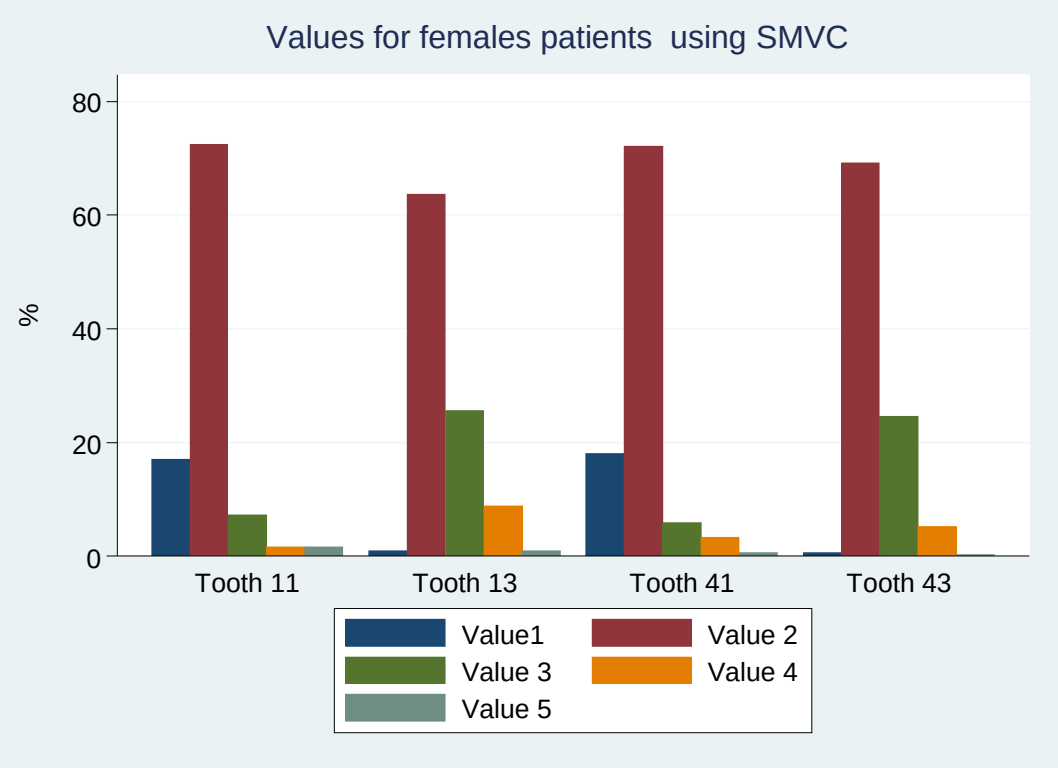

Figure 19: Comparing Values for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41) and the mandibular canine (43) for female patients, using the Spectrophotometer Vita Classic (SMVC)

The figure above provides an overview of all the female patients' teeth and their values. Value 1 is dominant, followed by values 3 and 2. It is evident that females have lighter tooth value.

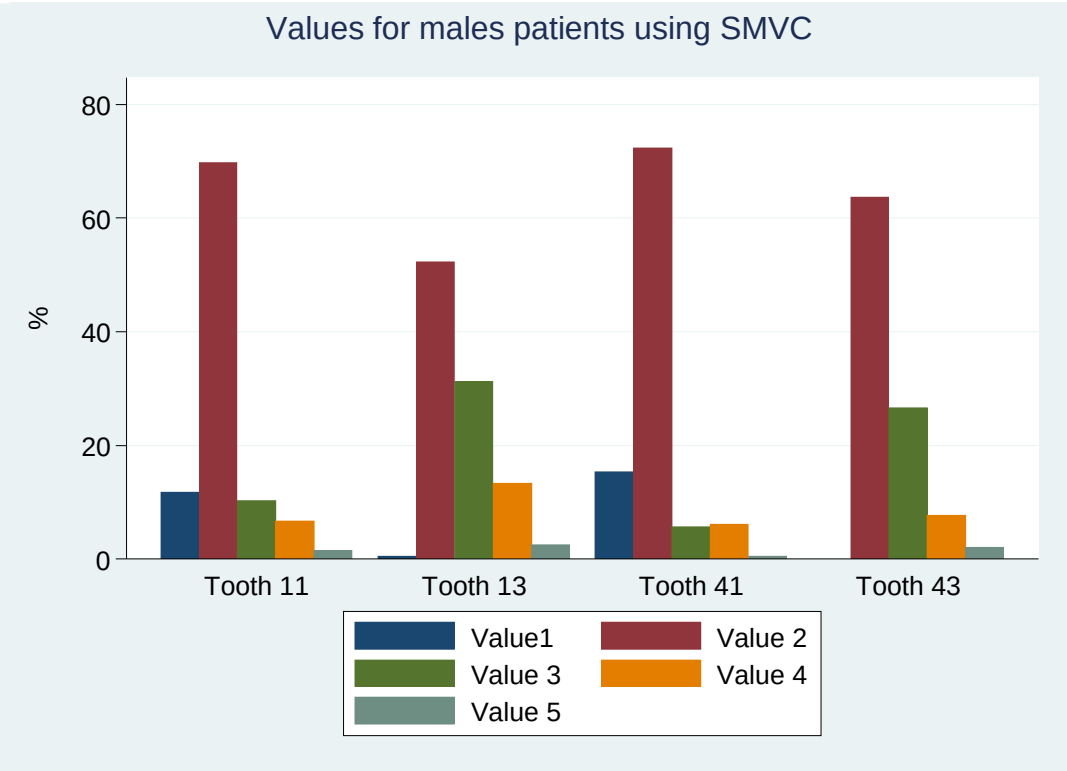

Figure 20: Comparing values for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43) for male patients, using the Spectrophotometer Vita Classic (SMVC)

This figure clearly illustrates when compared to Figure 9 that male patients had a higher percentage of darker tooth values.

5.5.3 Comparing skin tone with tooth value for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43)

Table 13: Comparison between skin tone and value for tooth (11)

Skin tone								
	Light		Medium		Dark		Total	
Smvc11	F	%	F	%	F	%	F	%
1	21	9.86	24	22.22	30	16.76	75	15
2	158	74.18	67	62.04	132	73.74	357	71.40
3	23	10.80	10	9.26	9	5.03	42	8.40
4	7	3.29	4	3.70	7	3.91	18	3.60
5	4	1.88	3	2.78	1	0.56	8	1.60
Total	213	100	108	100	179	100	500	100
Fisher's exact = 0.029								

Table 13 compares the skin tone of patients with the value of tooth (11). It is evident that the majority of patients 74.18% with light skin tone represented value 2, whereas values 1 and 3 were almost equally represented by 9.86% and 10.80% of patients respectively. Although the highest number of patients with medium skin tone still represented value 2 with 62.04%, value 3 was represented by 9.26% of patients with medium skin tone. 16.76% of patients with dark skin tone represented value 1, and

the majority of patients with dark skin tone 132 (73.74%) represented value 2. Only 5.03% patients with dark skin tone represented value 3.

It is clear from these results that patients with medium and dark skin tone generally had slightly lighter teeth values. The results show that there is a statistically significant relationship between skin tone and tooth value for the maxillary central incisor (11). Fisher's exact = 0.029. Table 14 compares skin tone with the value for tooth 13.

Table 14: Comparison between skin tone and value for tooth (13)

Skin tone								
SMVC13	Light		Medium		Dark		Total	
	f	%	f	%	f	%	f	%
1	3	1.41	0	0	1	0.56	4	0.80
2	109	51.17	63	58.33	124	69.27	296	59.20
3	70	32.86	35	32.41	34	18.99	139	27.80
4	27	12.68	9	8.33	17	9.50	53	10.60
5	4	1.88	1	0.93	3	1.68	8	1.60
Total	213	100	108	100	179	100	500	100
Fisher's exact =0.018								

Table 14 shows that in the maxillary canine (13), value 2 was represented by the highest number of patients with light skin tone: 51.17%. Value 3 was represented by the second highest number of patients with light skin

tone 32.86% and only 12.68% represented value 4. This was similar to patients with medium skin tone: value 2 was represented by the highest number of patients 58.33%, value 3 by the second highest number of patients 32.41% and value 4 only by 8.33%. This trend is continued in patients with dark skin tone: value 2 is represented by 69.27% of patients, value 3 by 18.99% of patients and value 4 by 9.50% of patients. Overall, the maxillary canine tooth (13) proved to be darker than the maxillary central incisor tooth (11) (Table 13). However, patients with medium and dark skin tones were still more likely to exhibit lighter teeth values. There is also a statistically significant relationship between skin tone and tooth value for the maxillary canine (13): Fisher's exact = 0.018. Table 15 compares skin tone with the value of tooth 41.

Table 15: Comparison between skin tone and value for tooth (41)

Skin tone								
SMVC 41	Light		Medium		Dark		Total	
	F	%	F	%	F	%	F	%
1	8	3.76	30	27.78	47	26.26	85	17
2	178	83.57	62	57.41	121	67.60	361	72.20
3	15	7.04	10	9.26	4	2.23	29	5.80
4	11	5.16	5	4.63	6	3.35	22	4.40
5	1	0.47	1	0.93	1	0.56	3	0.60
Total	213	100	108	100	179	100	500	100
Fisher's exact=0.000								

Table 15 depicts the relation between skin tone and the values of the mandibular central incisor (41). An exceptionally large number of patients 83.57% with light skin tone represented value 2, whereas value 1 was represented by only a small number of patients 3.76%. Value 1 was represented by almost an equal number of patients with medium and dark skin tones: 27.78% and 26.26% respectively. Patients with dark skin tone did however have a higher percentage of value 2 (67.60%) than patients with medium skin tone 57.41%.

The table illustrates that the mandibular central incisor (41) had a lighter value, and patients with medium and dark skin tone were more likely to be associated with lighter teeth value. There was a statistically significant relationship found between skin tone and tooth value for the mandibular

central incisor (41). Fisher's exact = 0.000. Table 16 compares skin tone with the value for tooth 43.

Table 16: Comparison between skin tone and value for tooth (43)

Skin tone								
SMVC 43	Light		Medium		Dark		Total	
	F	%	F	%	F	%	F	%
1	0	0	0	0	2	1.12	2	0.40
2	121	56.81	79	73.15	135	75.42	335	67
3	76	35.68	22	20.37	29	16.20	127	25.40
4	15	7.04	5	4.63	11	6.15	31	6.20
5	1	0.47	2	1.85	2	1.12	5	1
Total	213	100	108	100	179	100	500	100
Fisher's exact= 0.000								

Table 16 shows that for the mandibular canine (43), 56.81% of patients with light skin tone represented value 2 and in 35.68% of teeth the value was 3. The distinction between values was more marked in patients with medium skin tone: for these patients value 2 was represented by 73.15%, and value 3 by 20.37%. Practically the same distinction can be seen in patients with dark skin tone: value 2 was represented by 75.42% of patients, but only 16.20% represented value 3.

Consistent with the pattern thus far, patients with medium and dark skin tone exhibited lighter teeth values. The results showed a statistically

significant relationship between skin tone and tooth value for the mandibular canine (43). Fisher's exact = 0.000.

5.5.3.1 Visual comparison between tooth value and skin tone

1. Data for patients with light skin tone.

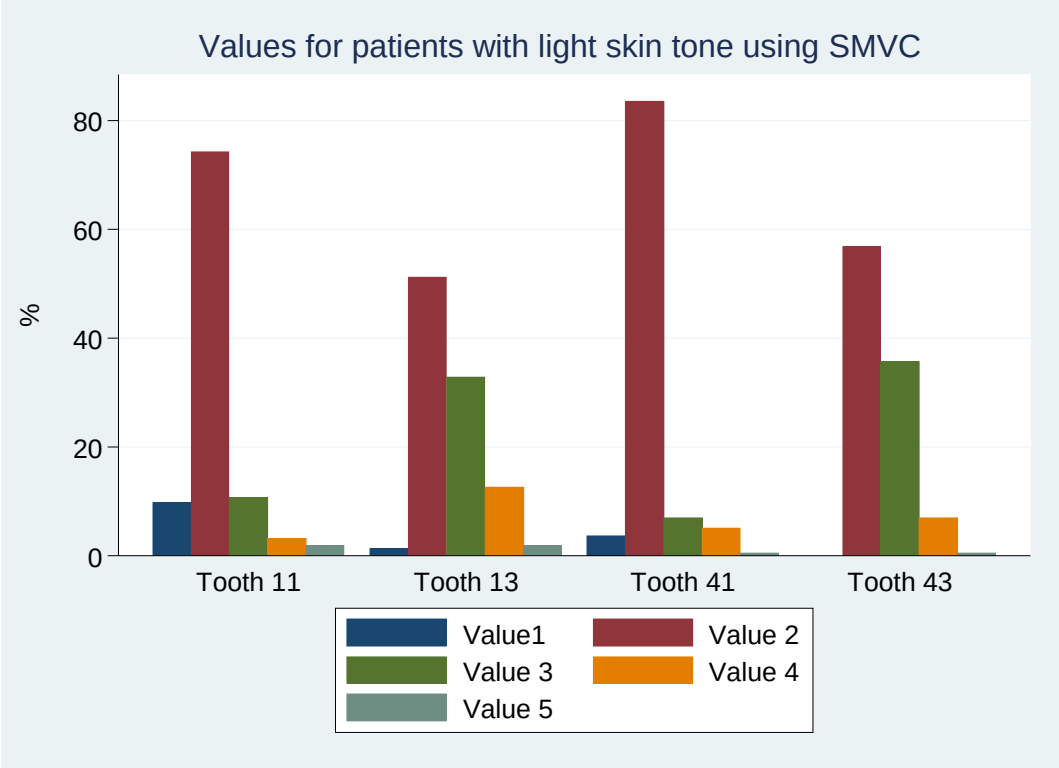

Figure 21: Comparing Values for the maxillary central incisor (11), maxillary canine (13), mandibular central incisor (41), and mandibular canine (43) for patients with light skin tone, using the Spectrophotometer Vita Classic (SMVC)

Figure 21 provides an overview of all the teeth of patients with light skin tone. The majority value of incisors (11) and (41) was 2 and the other values were poorly represented. with the canine teeth the values were more balanced: even though the dominant value was 2, value 3 was well represented in comparison to values 1, 4 and 5. The fact that value 2 was balanced relatively well by value 3 and that value 1 was very poorly

represented showed that patients with light skin tone were more likely to exhibit somewhere darker values.

2. Data for patients with medium skin tone.

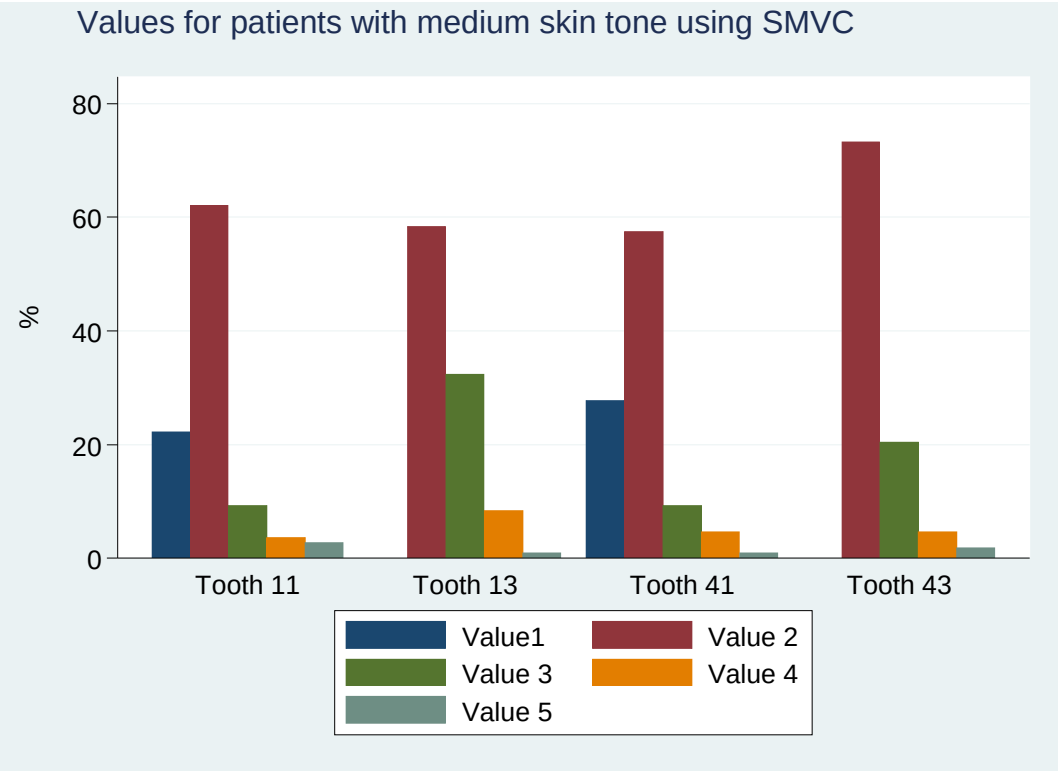

Figure 22: Comparing values for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43) for patients with medium skin tone, using a Spectrophotometer Vita Classic (SMVC).

Figure 22 shows data for patients with medium skin tone. While the dominant value was still 2, there was a higher representation of value 1 than in patients with light skin tone. Even though value 3 was also relatively well represented, this was balanced by value 1 and proved that patients with medium skin tone were more likely to exhibit lighter values.

3. Data for patients with dark skin tone.

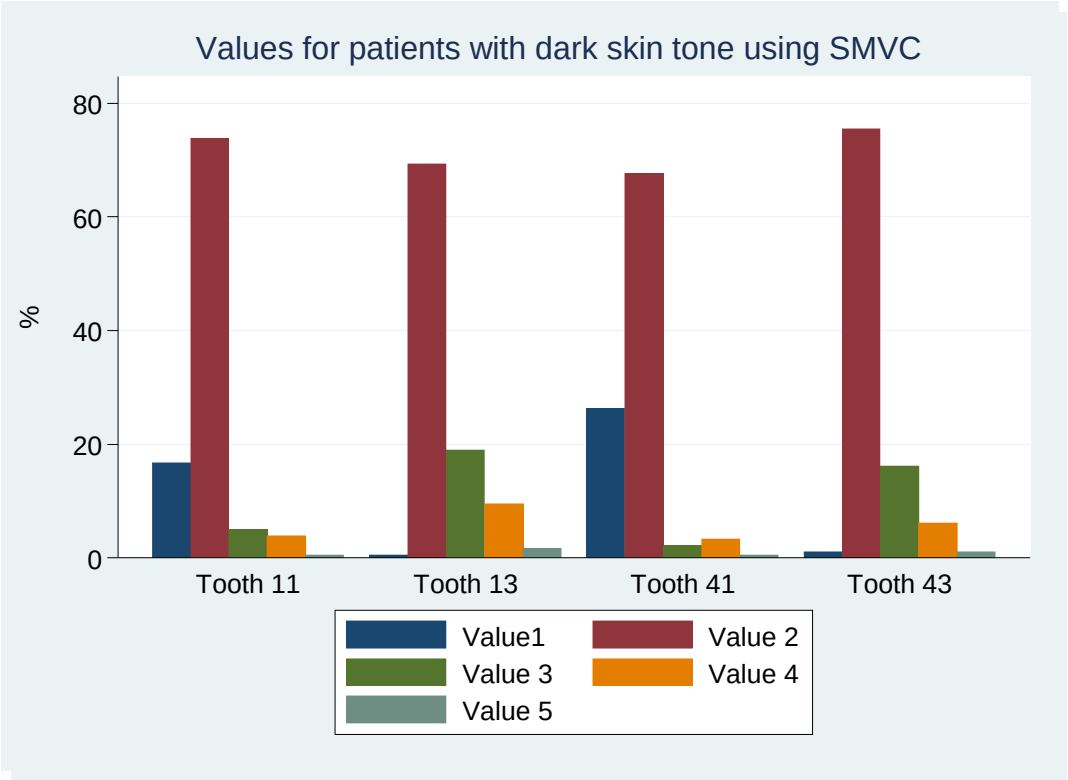

Figure 23: Values for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43) for patients with dark skin tone, using a Spectrophotometer Vita Classical (SMVC)

The values for patients with dark skin tone. Value 2 was represented exceptionally well, and the second most prominent value was 1, which shows to some extent that patients with dark skin tone were more likely to exhibit lighter values.

5.5.4 Comparing the gingival pigmentation (non-pigmented, diffuse, focal) with tooth value for the maxillary central incisor (11), the maxillarycanine (13), the mandibular central incisor (41, and the mandibular canine (43)

Table 17: Comparison between gingival pigmentation and value of tooth(11).

Gingival pigmentation								
SMVC 11	Non-pigmented		Focal		Diffuse		Total	
	F	%	F	%	F	%	F	%
1	37	12.59	20	19.05	18	17.82	75	15
2	206	70.07	77	73.33	74	73.27	357	71.40
3	32	10.88	5	4.76	5	4.95	42	8.40
4	12	4.08	3	2.86	3	2.97	18	3.60
5	7	2.38	0	0	1	0.99	8	1.60
Total	294	100	105	100	101	100	500	100
Fisher's exact = 0.193								

It can be seen from Table 17 that for the maxillary central incisor (11), the percentages of patients who had non-pigmented gingiva were 12.59% for value 1, 70.07% for value 2 and 10.88% for value 3. 19.05% of the patients who had focal gingival pigmentation represented value 1, 73.33% of patients represented value 2, and a mere 4.76% of patients represented

value 3. These values were represented in practically the same number by patients with diffuse gingival pigmentation: 17.82% of patients represented value 1, 73.27% of patients represented value 2, and 4.95% of patients represented value 3.

Gingival pigmentation was therefore associated with a lighter value for the maxillary central incisor tooth (11). The results found no statistically significant relationship between gingival pigmentation and tooth value for the maxillary central incisor (11) (Fisher's exact = 0.193). The table below compares the level of pigmentation with the value for the maxillary canine tooth (13).

Table 18: Comparison between gingival pigmentation and value for tooth (13)

Gingival pigmentation								
SMVC 13	Non - pigmented		Focal		Diffuse		Total	
	f	%	f	%	f	%	f	%
1	3	1.02	1	0.95	0	0	4	0.80
2	158	53.74	71	67.62	67	66.34	296	59.20
3	96	32.65	20	19.05	23	22.77	139	27.80
4	33	11.22	13	12.38	7	6.93	53	10.60
5	4	1.36	0	0	4	3.96	8	1.60
Total	294	100	105	100	101	100	500	100
Fisher's exact= 0.018								

Table 18 compares gingival pigmentation with the value of the maxillary canine tooth (13). The percentage of patients with non-pigmented gingiva for value 2 was 53.74% and for values 3 and 4 it was 32.65% and 11.22% respectively. 67.62% of patients with focal gingival pigmentation represented value 2, 19.05% of patients represented value 3, and 12.38% represented value 4. With regards to diffuse gingival pigmentation, a very small number of patients 6.93% represented value 4, value 3 was represented by 22.77% of patients and value 2 was represented by 66.34% of patients.

Patients with both focal and diffuse gingival pigmentation are inclined to have lighter tooth values. The results showed a statistically significant relationship between gingival pigmentation and tooth value for the maxillary canine (13) (Fisher's exact= 0.018). Table 19 below compares the level of pigmentation with the value for the mandibular central incisor tooth (41).

Table 19: Comparison between gingival pigmentation and value for tooth (41)

Gingival pigmentation								
SMVC 41	Non - pigmented		Focal		Diffuse		total	
	f	%	f	%	f	%	f	%
1	25	8.50	37	35.24	23	22.77	85	17
2	226	76.87	63	60	72	71.29	361	72.20
3	25	8.50	2	1.90	2	1.98	29	5.80
4	17	5.78	3	2.86	2	1.98	22	4.40
5	1	0.34	0	0	2	1.98	3	0.60
Total	294	100	105	100	101	100	500	100
Fisher's exact= 0.000								

Table 19 shows that, for the mandibular central incisor, there is a marked distinction between values for patients with non-pigmented gingiva: value 1 was represented by only 8.50% of patients, and value 2 by 76.87% of patients. For patients with focal gingival pigmentation the distinction between values was slightly more balanced with value 1 represented by 35.24% of patients and value 2 by 60% of patients. For patients with diffuse gingival pigmentation value 1 was represented by 22.77% of patients, and value 2 by 71.29% of patients.

It can be seen from the table that patients with both focal and diffuse gingival pigmentation had lighter tooth values. The results also show a statistically significant relationship between gingival pigmentation and tooth value for the mandibular central incisor (41). Fisher's exact = 0.000. Table 20 below compares the level of pigmentation with the value for the mandibular canine tooth (43).

Table 20: Comparison between gingival pigmentation and value for tooth (43)

Gingival pigmentation								
SMVC 43	Non - pigmented		Focal		Diffuse		Total	
	F	%	F	%	F	%	F	%
1	2	0.68	0	0	0	0	2	0.40
2	181	61.56	76	72.38	78	77.23	335	67.
3	89	30.27	21	20	17	16.83	127	25.40
4	21	7.14	7	6.67	3	2.97	31	6.20
5	1	0.34	1	0.95	3	2.97	5	1
Total	294	100	105	100	101	100	500	100
Fisher's exact = 0.010								

Table 20 compares the type of gingival pigmentation and value for the mandibular canine tooth (43). The percentage of patients with non-pigmented gingiva for value 2 was 61.56%, and for value 3 it was 30.27%. Patients with focal gingival pigmentation accounted for 72.38% of value 2 and 20% of value 3. The biggest contrast between values reflected in patients with diffuse gingival pigmentation: 77.23% represented value 2, and only 16.83% represented value 3. It is evident that the relationship between gingival pigmentation and tooth value is similar to the maxillary canine (13), with several minor differences. The results showed a statistically significant relationship between gingival pigmentation and tooth value for mandibular canine 43 (Fisher's exact = 0.010).

5.5.4.1 Visual comparison between tooth value and gingival pigmentation

1. Data for patients with non-pigmented gingiva.

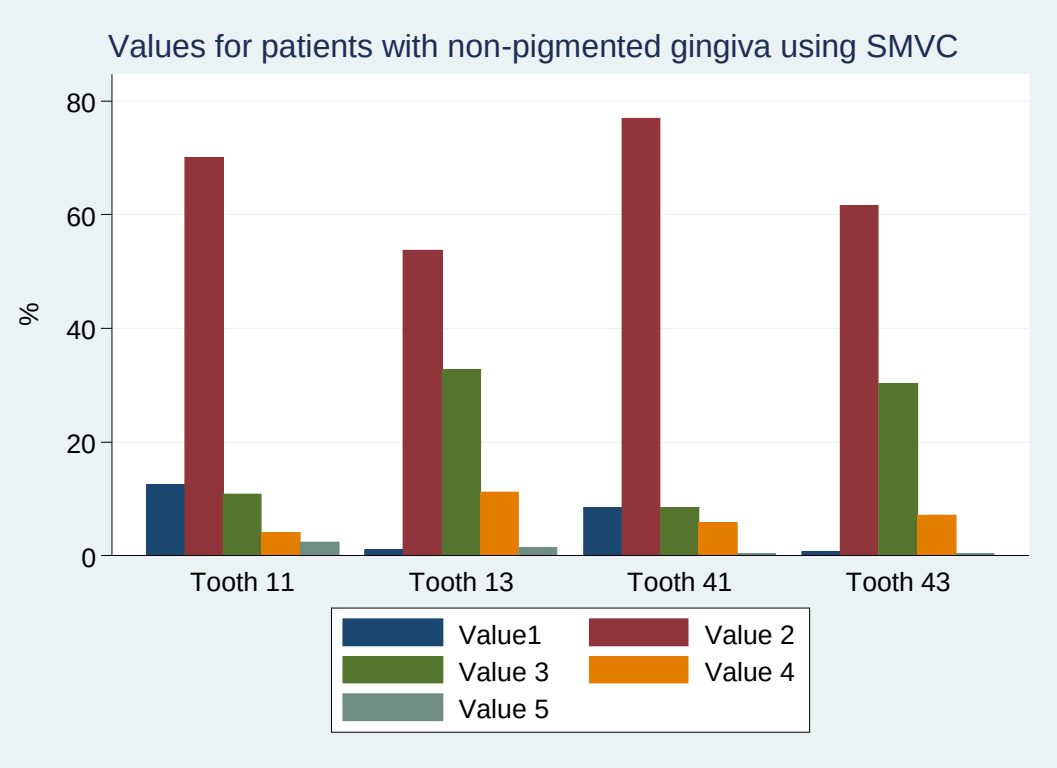

Figure 24: Values for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43) for patients with non-pigmented gingiva, using the Spectrophotometer Vita Classical (SMVC)

The data depicted in Figure 24 show that values 2 and 3 were most prevalent in patients with non-pigmented gingiva, this pattern appears to be repeated in with non-pigmented gingiva showing some what darker values.

2. Data for patients with focal gingival pigmentation

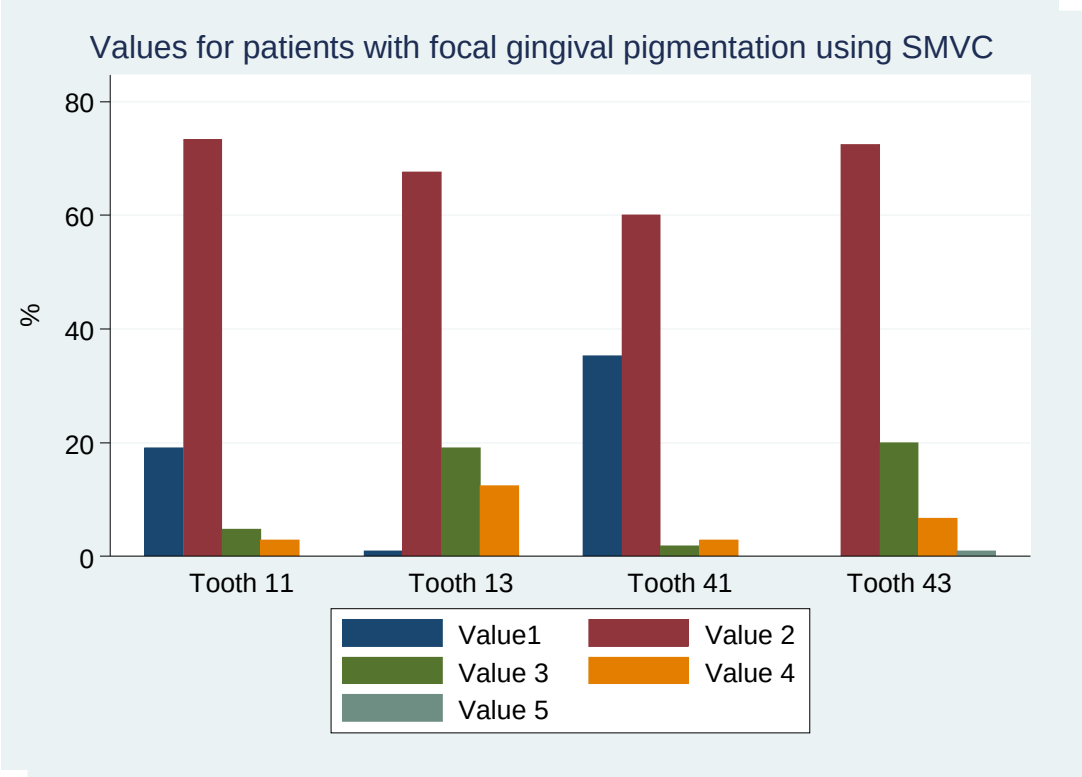

Figure 25: Values for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43) for patients with focal gingival pigmentation, using the Spectrophotometer Vita Classic (SMVC)

The most prevalent values in patients with focal gingival pigmentation were 1 and 2, although value 3 was also relatively well represented. This shows that patients with focal gingival pigmentation are more likely to exhibit lighter values.

3. Data for patients with diffuse gingival pigmentation:

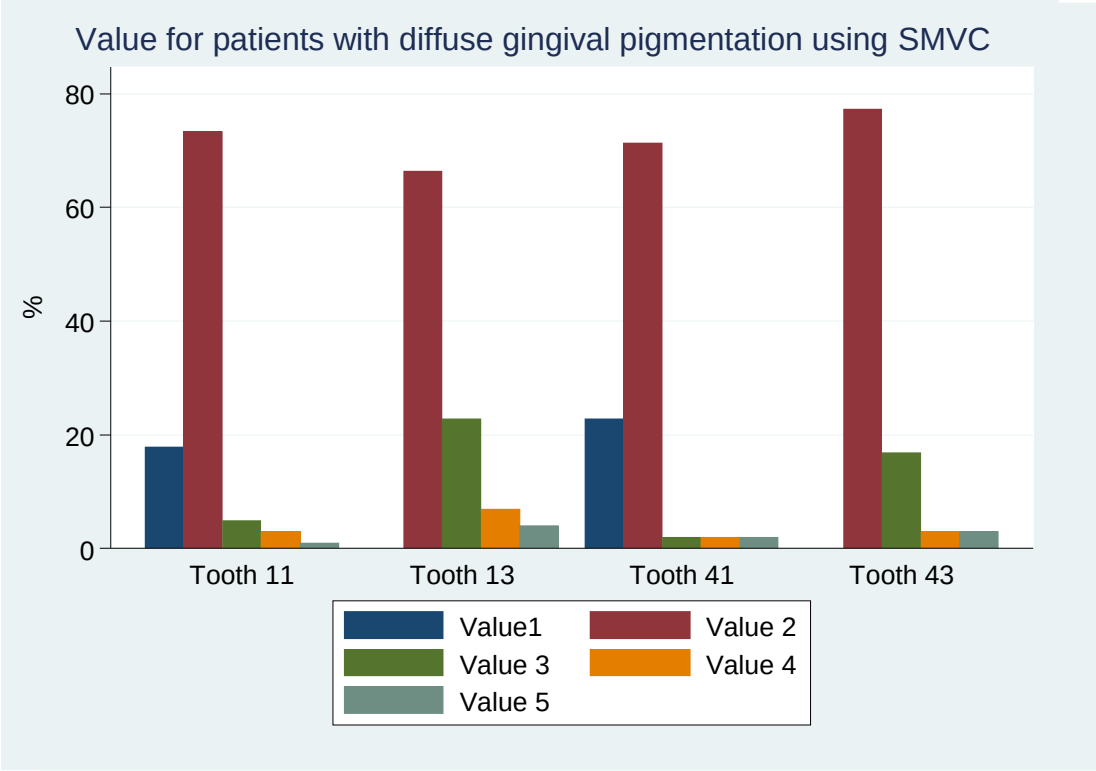

Figure 26: Values for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43) for patients with diffuse gingival pigmentation, using the Spectrophotometer Vita Classic (SMVC)

The above figure shows tooth values for patients with diffuse gingival pigmentation and as with most of the patients examined, the dominant value was 2. Values 1 and 3 were represented almost equally. This representation of values underlines that patients with diffuse gingival pigmentation are likely to exhibit lighter tooth values.

5.5.5 Comparing the smoking habits of patients with tooth value for the maxillary central incisor (11), maxillary canine (13), mandibular central incisor (41), and mandibular canine (43)

It is well known that nicotine stains teeth[38]. It is however interesting to compare its effect on different types of teeth: (11), (13), (41) and (43). Table 21 compares the effects of smoking on tooth value for the maxillary central incisor 11.

Table 21: The effects of smoking on value for tooth (11)

Smoking						
SMVC 11	Smoker		Non-smoker		Total	
	f	%	f	%	f	%
1	9	8.57	66	16.71	75	15
2	65	61.90	292	73.92	357	71.40
3	16	15.24	26	6.58	42	8.40
4	10	9.52	8	2.03	18	3.60
5	5	4.76	3	0.76	8	1.60
Total	105	100.00	395	100.00	500	100.00
Fisher's exact = 0.000						

For the maxillary central incisor, a majority of 61.90% represented value 2, whereas only 15.24% of patients represented value 3. Value 1 was represented by the fewest patients: 8.57%. While value 2 was also represented by the majority of non-smoker patients 73.92%, it was value 3 that was represented by the fewest patients, a mere 6.58%. 16.71% of non-smoker patients represented value 1. The total percentages of smoker patients in lighter values (1,2,3) were 85.71%, and the total percentages for non smoker patients in lighter values (1,2,3) were 99.2%. However, in the darker values (4,5) the total percentages for smoker patients were 13.28%, and only 2.79% for non smoker patient in the darker value.

It can be seen that non-smokers had lighter tooth values for tooth 11 than smokers. The results also showed a statistically significant relationship between smoking and tooth value for the maxillary central incisor (11). Fisher's exact = 0.000. Table 22 compares the effect of smoking with the value for tooth 13.

Table 22: The effects of smoking on value for tooth (13)

Smoking						
SMVC 13	Smoker		Non smoker		Total	
	F	%	F	%	F	%
1	1	0.95	3	0.76	4	0.80
2	65	61.90	231	58.48	296	59.20
3	22	20.95	117	29.62	139	27.80
4	14	13.33	39	9.87	53	10.60
5	3	2.86	5	1.27	8	1.60
Total	105	100.00	395	100.00	500	100.00
Fisher's exact = 0.218						

The results found in Table 22 shows that the percentages of smoker patients at value 2 were 61.90% and 20.95% at value 3. The non-smoker patients represented 58.48% of value 2 and 29.62% of value 3. It is interesting to note that in this study smoking did not seem to have much influence on the value of tooth 13 in comparison to the results seen in Table 21. Also, the results showed no statistically significant relationship between smoking and tooth value for the maxillary canine (13) Fisher's exact = 0.218. Table 23 compares the effects of smoking on tooth value for the mandibular central incisor 41.

Table 23: The effects of smoking on value for tooth (41)

Smoking						
Smvc41	Smoker		Non smoker		Total	
	F	%	F	%	F	%
1	6	5.71	79	20.00	85	17.00
2	80	76.19	281	71.14	361	72.20
3	10	9.52	19	4.81	29	5.80
4	7	6.67	15	3.80	22	4.40
5	2	1.90	1	0.25	3	0.60
Total	105	100.00	395	100.00	500	100.00
Fisher's exact=0.000						

Table 23 above compares the effect of smoking with the tooth value for the mandibular central incisor 41. The percentages of smoker patients that had value 1 were 5.71%, 76.19% for value 2, and 9.52% for value 3. Value 2 was the dominant value in non-smoker patients with 71.14%, while values 1 and 3 were represented by 20% and 4.81% of patients respectively. It is evident that smokers had darker values for tooth (41). The results showed a significant relationship between smoking and the value for the mandibular central incisor (41) Fisher's exact = 0.000. Table

24 compares the effects of smoking on tooth value for the mandibular canine 43.

Table 24: The effects of smoking on value for tooth(43)

Smoking						
SMVC 43	Smoker		Non smoker		Total	
	F	%	F	%	F	%
1	0	0.00	2	0.51	2	0.40
2	72	68.57	263	66.58	335	67.13
3	23	21.90	104	26.33	127	25.45
4	7	6.67	24	6.08	31	6.21
5	3	2.86	2	0.51	4	0.80
Total	105	100.00	395	100.00	499	100.00
Fisher's exact = 0.243						

Table 24 above provides information on the effects of smoking on tooth value for the lower canine (43). The percentages of smoker patients for value 2 was 68.57%, 21.90% for value 3, and for non-smoker patients they were 66.58% for value 2, and 26.33% for value 3. The percentages for the lower canine (43) were quite similar to the upper canine (13) presented in Table 22. The results showed no statistically significant

relationship between smoking and tooth value for the lower canine (43) (Fisher's exact = 0.243).

5.5.5.1 Visual comparison between tooth values and smoking habits

1. Data for smoking patients:

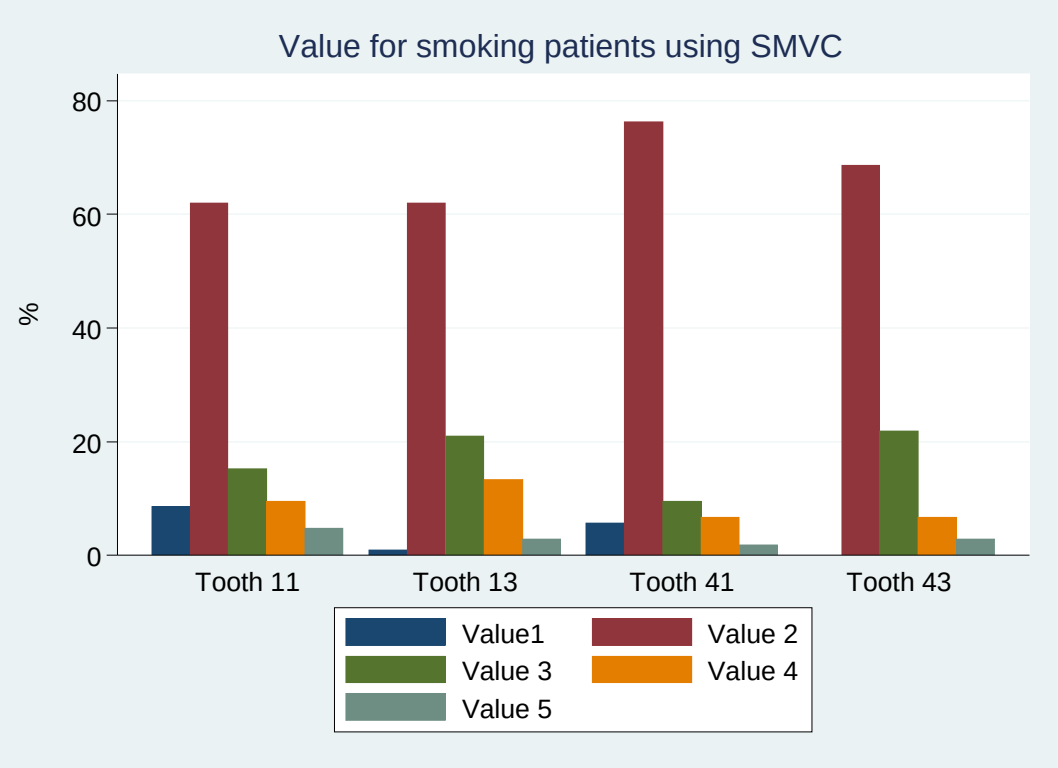

Figure 27: Values for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43) for smoker patients, using the Spectrophotometer Vita Classic (SMVC)

This figure provides an overview of the effect of smoking on the values for all the teeth examined. When compared to all the other figures, it is evident that, even though value 2 was still dominant, this was the only group that had a noteworthy representation of values 3, 4 and 5.

2. Data for non-smoking patients:

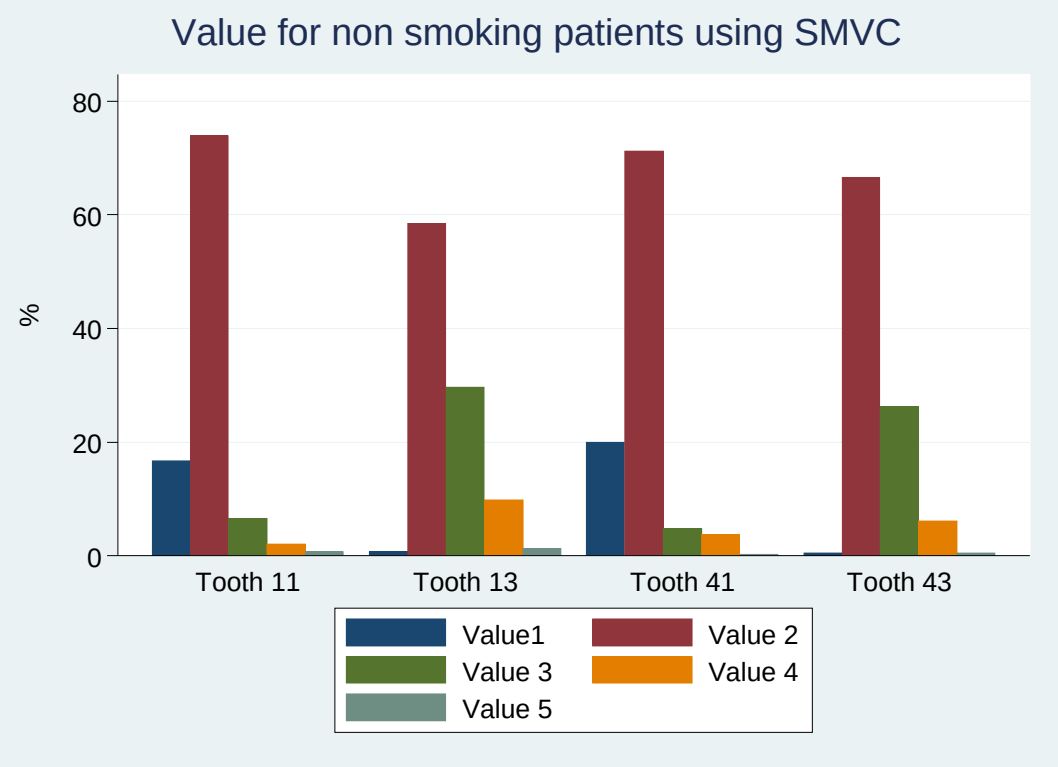

Figure 28: Values for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43) for non-smoker patients, using the Spectrophotometer (SMVC)

There were significantly lower percentages of values 3, 4 and 5 compared to smoker patients, as well as a significantly higher percentage of value 1 compared with smoker patients. It is evident that non-smoker patients are likely to exhibit lighter tooth values than smoker patients.

5.6 Comparing the hue of selected teeth with different variables: hue for the maxillary central incisor (11), the maxiillary canine (13), the mandibular central incisor (41), and the mandibular canine (43), compared with the patients' ages, sex and smoking habits

5.6.1 Comparison of age patients with hue for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43)

Table 25: Comparing age with hue for the maxillay central incisor (11)

SMVC 11	35 and younger		Older than 35	
	F	%	F	%
L	62	21.30	77	36.84
M	210	72.16	105	50.23
R	19	6.52	27	12.91
Total	291	100	209	100

For the maxillary central incisor (11), 36.84% of patients who were older than 35 had a yellow (L) hue, 50.23% a medium (M) hue and 12.91% a red (R) hue. Of the younger patients 21.30% had a yellow (L) hue, 72.16% a medium (M) hue, and 6.52% a red (R) hue. The highest percentages were found in the medium group for both younger and older patients. However, as the patients aged it would appear that the teeth tended to get more yellow as indicated in the table above. Table 26 Comparing age and hue for the maxillary canine 13.

Table 26: Comparing age and hue for the upper canine (13)

SMVC 13	35 and younger		Older than 35	
	F	%	F	%
L	106	36.42	93	44.49
M	110	37.80	56	26.79
R	75	25.77	60	28.70
Total	291	100	209	100

For the maxillary canine (13), 44.49% of patients who were older than 35 had a yellow (L) hue, 26.79% had a medium (M) hue, and 28.70% had a red (R) hue. The younger group of patients exhibited a higher number of medium (M) hue: 37.80%, and almost similar percentages of yellow (L) (36.42%) hue. The percentage of younger patients with red (R) hue was 25.77%. It is evident from the table that patients older than 35 tended to have more teeth with yellowish hue. In contrast, the younger group tended to have teeth with medium to yellowish hues.

The older group had more teeth with yellow hues than the younger patients. Table 27 compares age and hue for the mandibular central incisor 41.

Table 27: Comparing age and hue for mandibular central incisor (41)

SMVC 41	35 and younger		Older than 35	
	F	%	F	%
L	46	15.80	62	29.66
M	237	81.44	116	55.50
R	8	2.74	31	14.83
Total	291	100	209	100

Table 27 shows that 29.66% of the older group of patients had a yellow (L) hue, 55.50% a medium (M) hue, and 14.83% a red (R) hue. The younger group of patients, however, exhibited half the amount of yellow hue (15.80%) and almost double the amount of medium (M) hue (81.44%). Only very few young patients 2.74% had a red (R) hue. It is evident that the older group of patients tended to have more yellowish hue for mandibular incisor 41, while the younger patients had a very high percentages of medium hue for mandibular incisor 41. Table 28: Comparing age and hue for mandibular canine 43.

Table 28: Comparing age and hue for mandibular canine (43)

SMVC 43	35 and younger		Older than 35	
	F	%	F	%
L	105	36.08	76	36.36
M	126	43.29	62	29.66
R	60	20.61	71	33.97
Total	291	100	209	100

For the mandibular canine (43), 36.36% of the older group of patients had a yellow (L) hue, 29.66% a medium (M) hue, and 33.97% a red (R) hue. The younger group of patients exhibited a 36.08% representation of yellow (L) hue, 43.29% of medium (M) hue, and 20.61% of red (R) hue.

It is evident that older patients' teeth tended to have a yellow to red hue, whereas the younger group of patients tended to have more medium to yellow hues.

5.6.2 Comparison of the sex of patients with hue for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43)

Table 29: Comparison between patients sex and hue for the maxillary central incisor (11)

SMVC 11	FEMALE		MALE	
	F	%	F	%
L	74	24.26	65	33.33
M	208	68.19	107	54.87
R	23	7.54	23	11.79
Total	305	100	195	100

For the maxillary central incisor (11), 24.26% of female patients had a yellow (L) hue, 68.19% had a medium (M) hue, and 7.54% a red (R) hue. In the male group, on the other hand, 33.33% had a yellow (L) hue, 54.87% a medium (M) hue, and 11.79% a red (R) hue.

Although it can be seen that both female and male patients had medium to yellow hues, the male patients had a higher percentage of yellow. Red was represented only in small percentages by both male and female patients. Table 30 is a comparison between patient sex and hue for the maxillarry canine (13).

Table 30: Comparison between patient sex and hue for the maxillary canine (13)

SMVC 13	FEMALE		MALE	
	F	%	F	%
L	123	40.32	76	38.97
M	103	33.77	63	32.30
R	79	25.90	56	28.71
Total	305	100	195	100

Table 30 provides information for the maxillary canine (13): 40.32% of female patients had a yellow (L) hue, 33.77% a medium (M) hue, and 25.90% a red (R) hue. Interestingly, male patients had approximately the same percentages: 38.97% had a yellow hue, 32.30% a medium (M) hue, and 28.71% a red (R) hue.

Both female and male patients therefore tended to have teeth with medium to yellow hues.

Table 31: Comparison between patients sex and hue for the mandibular central incisor 41

SMVC 41	FEMALE		MALE	
	F	%	F	%
L	64	20.98	44	22.56
M	220	72.13	133	68.20
R	21	6.88	18	9.23
Total	305	100	195	100

Table 31 shows percentages for the mandibular central incisor (41): 20.98% of females patients had a yellow (L) hue, 72.13% had a medium (M) hue, and 6.88% had a red (R) hue. In the male group 22.56% of patients fell in the yellow(L) group, 68.20% in the medium(M) hue group, and 9.23% in the red (R) hue group.

It can thus be seen that the majority of both female and male patients tended to have medium to yellow teeth.

Table 32: Comparison between patient sex and hue for the mandibular canine(43)

SMVC 43	FEMALE		MALE	
	F	%	F	%
L	115	37.70	66	33.84
M	123	40.32	65	33.33
R	67	21.96	64	32.82
Total	305	100	195	100

For the mandibular canine (43), 37.70% of female patients had a yellow (L) hue, 40.32% a medium (M) hue, and 21.96% a red (R) hue. The percentage of male patients with yellow (L) hue was 33.84%, for medium (M) hue 33.33%, and for red (R) hue 32.82%.

It is clear that female patients had higher percentages of yellow and medium hues, but lower percentages of red hues than the male patients.

5.6.3 Comparing the smoking habits of patients with hue for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43)

Table 33: Comparison between smoking and hue for the maxillary central incisor (11)

SMVC 11	Smoking		Non-smoking	
	F	%	F	%
L	34	32.38	105	26.58
M	59	56.19	256	64.81
R	12	11.42	34	8.61
Total	105	100	395	100

Table 33 shows that in the central incisor (11), 32.38% of the smoking patients exhibited a yellow (L) hue, 56.19% a medium (M) hue, and 11.42% a red (R) hue. The non-smoker patients had the following, percentages: 26.58% had a yellow (L) hue, 64.81% had a medium hue, and 8.61% had a red (R) hue.

The majority of smoker patients clearly tended to have more incisor teeth with medium to yellow hues. Table 34: Comparison between smoking and hue of the maxillary canine (13)

Table 34: Comparison between smoking and hue of the maxillary canine (13)

SMVC 13	Smoking		Non- smoking	
	F	%	F	%
L	35	33.33	164	41.51
M	33	31.42	133	33.67
R	37	35.23	98	24.30
Total	105	100	395	100

For the maxillary canine (13), 33.33% of smokeing patients had a yellow (L) hue, 31.42% a medium (M) hue, and 35.23% a red (R) hue. Non-smoking patients had a slightly higher percentage of yellow (L) hue 41.51%, practically the same percentage of medium (M) hue 33.67%, and a significantly lower percentage of red hue 24.30%.

For both smoking and non-smoking patients, their teeth tended to have medium to yellow hues, while significantly more patients who smoked fell into the red hue group.

Table 35: Comparison between smoking and hue for the mandibular central incisor (41)

SMVC 41	Smoking		Non- smoking	
	F	%	F	%
L	33	31.42	75	18.98
M	59	55.23	294	74.43
R	13	12.38	26	6.58
Total	105	100	395	100

The table above provides information on the mandibular central incisor (41): 31.42% of smoking patients had a yellow (L) hue, 55.23% a medium (M) hue, and 12.38% a red (R) hue. For non-smoking patients the percentages were 18.98% for yellow (L) hue, 74.43% for medium (M) hue, and 6.58% for red (R) hue.

Both smoking and non-smoking patients tended to have medium to yellow hues with higher percentages of red hue occurring in the smoking group.

Table 36: Comparison between smoking and hue for the mandibular canine (43)

SMVC 43	Smoking		Non- smoking	
	F	%	F	%
L	32	30.47	149	37.72
M	37	35.23	151	38.23
R	36	34.82	95	24.05
Total	105	100	395	100

For the mandibular canine (43), 30.47% of smoker patients exhibited a yellow hue (L), 35.23% a medium (M) hue, and 34.82% a red (R) hue. 37.72% of non-smoker patients had a yellow (L) hue, 151 (38.23%) a medium (M) hue, and 95 (24.05%) a red (R) hue.

The smoker patients tended to have teeth with medium to reddish hues, while non-smoker patients tended to have teeth with medium to yellow hues.

5.7 Distributions of tooth values (frequency and percentage) between the maxillary central incisor (11) and the maxillary canine (13), the mandibular central incisor (41) and the mandibular canine (43), using the Vita Classical Shade Guide (Vita Lumina Vacum), the Vitapan 3D-Master Linearguide and the Spectrophotometer (Vita EasyShade Compact)

Table 37: Distributions of tooth values (frequency and percentage) between the maxillary central incisor (11) and the maxillary canine (13), the mandibular central incisor (41) and the mandibular canine (43), using the Vita Classical Shade Guide (VC)

Tooth Number	Value 1		Value 2		Value 3		Value 4		Value 5		Total	
	f	%	f	%	f	%	f	%	f	%	f	%
11	124	24.80	319	63.80	45	9	7	1.40	5	1	500	100
13	8	1.60	346	69.20	112	22.40	27	5.40	7	1.40	500	100
41	126	25.20	330	66	35	7	8	1.60	1	0.20	500	100
43	8	1.60	380	76	99	19.80	13	2.60	0	0	500	100

When examining the maxillary central incisor (11) it was found that 24.80% of patients represented value 1 whilst 63.80% of patients were value 2. For the maxillary canine (13) the majority of patients 69.20% represented value 2 whilst only 22.40% represented value 3. 25.20% of the patients represented value 1 for the mandibular central incisor (41) and 66% of the patients represented value 2. For the mandibular canine (43), 76% of patients were value 2, while 19.80% of patients were value 3. Figure 29: Distributions of tooth values between the maxillary central incisor (11) and the maxillary canine (13), the mandibular central incisor (41) and the mandibular canine (43), using the Vita Classical Shade Guide (VC)

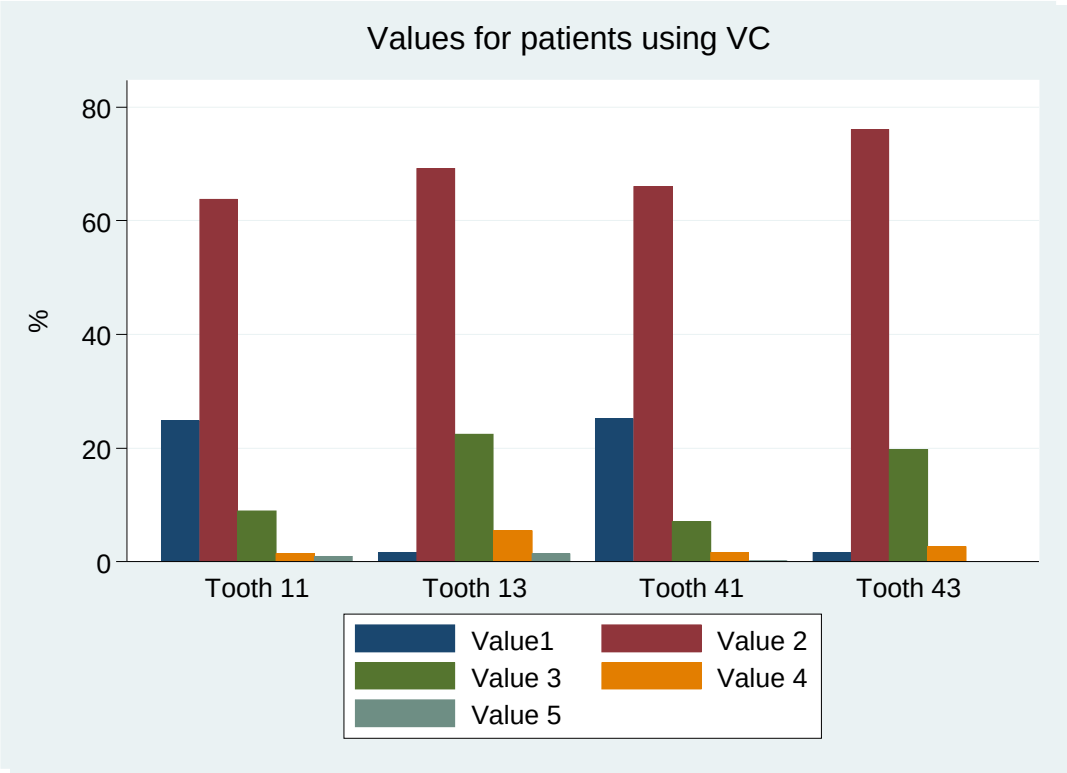

Figure 29: Distributions of tooth values between the maxillary central incisor (11) and the maxillary canine (13), the mandibular central incisor (41) and the mandibular canine (43), using the Vita Classical Shade Guide (VC)

The figure above summarizes the tooth value for all the teeth examined using the Vita Classical Shade Guide. The highest value for teeth 11 and 41 were value 1 and 2. For teeth 13 and 43, value 2 and 3 were the most dominant values. Canines had darker values when compared to the incisors with lighter values.

Table 38: Distributions of tooth values (frequency and percentage) between the maxillary central incisor (11) and the maxillary canine (13), the mandibular central incisor (41) and the mandibular canine (43), using the Vitapan 3D-Master Linearguide (3DLG)

Tooth Number	Value 1		Value 2		Value 3		Value 4		Value 5		Total	
	F	%	F	%	F	%	F	%	F	%	F	%
11	240	48	186	37.20	60	12	14	2.80	0	0	500	100
13	50	10	297	59.40	119	23.80	33	6.60	1	0.20	500	100
41	238	47.60	204	40.80	45	9	12	2.40	1	0.20	500	100
43	62	12.40	333	66.60	88	17.60	17	3.40	0	0	500	100

When examining the maxillary central incisor (11) it was found that 48% represented value 1 while 37.20% of patients represented value 2. For the maxillary canine (13), 59.40% were value 2 whilst 23.80% fell into value 3. For the mandibular central incisor (41), 47.60% of patients presented as value 1 and 40.80% presented as value 2. For the mandibular canine 66.60% of patients represented value 2, whilst 17.60% of patients represented value 3. Figure 20 distributions of tooth values between the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43), using the Vitapan 3D-Master Linearguide (3DLG).

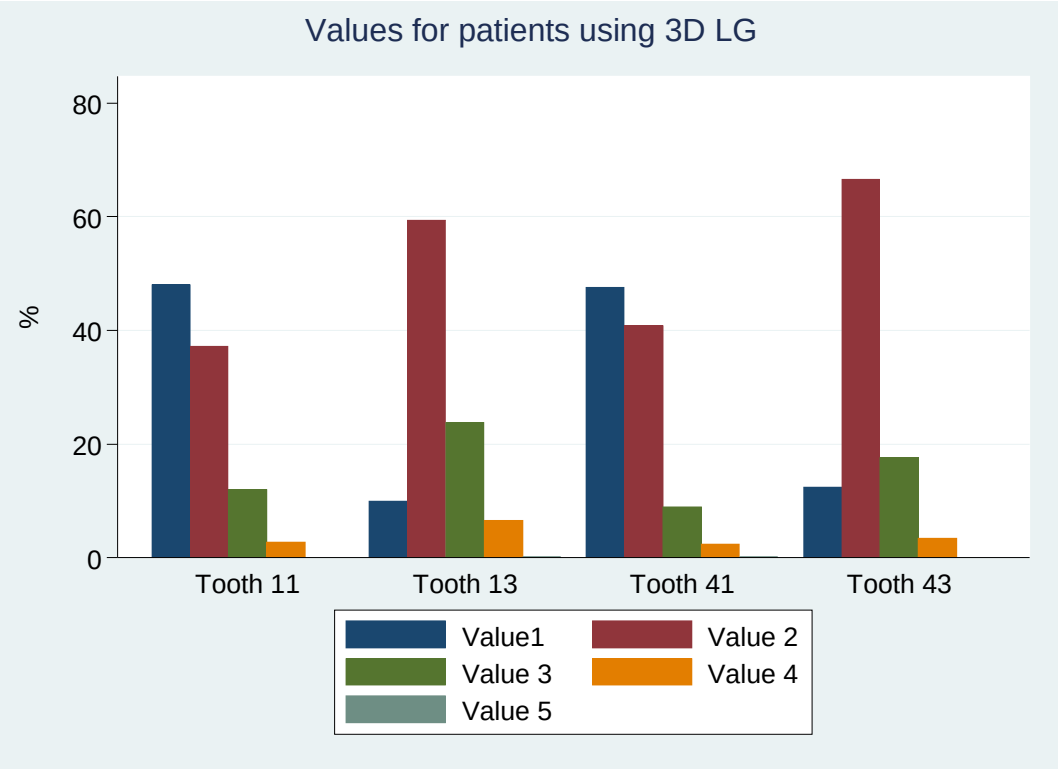

Figure 30: Distributions of tooth values between the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43), using the Vitapan 3D-Master Linearguide (3DLG).

The values for all the teeth shown in this figure were measured by the Vitapan 3D-Master Linearguide. As with the Vita Classical Shade Guide, the highest percentages of value 1 and 2 were found in the maxillary incisor (11) and the mandibular incisor (41). However, value 2 and 3 had the highest percentages in the maxillary canine (13) and mandibular canine (43).

Table 39: Distributions of tooth values (frequency and percentage) between the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43), using a Spectrophotometer Vita Classical Shade Guide (SMVC)

Tooth Number	Value 1		Value 2		Value 3		Value 4		Value 5		Total	
	No	%	No	%	No	%	No	%	No	%	No	%
11	75	15	357	71. 4	42	8.4	18	3.6	8	1.6	500	100
13	4	0.8	296	59.2	139	27.8	53	10.6	8	1.6	500	100
41	85	17	361	72.2	29	5.8	22	4.4	3	0.60	500	100
43	2	0.40	335	67	127	25.4	31	6.2	5	1	500	100

In the table above it can be seen that in 15% of the maxillary central incisors (11), the value was 1, and in 71. 4% of these incisors the value was 2. Values 2 and 3 were represented by 59.2% and 27.8% of patients' maxillary canines (13) respectively. For the mandibular central incisor (41), 17% of patients presented as value 1, while the majority (72.2%) presented as value 2. Finally, for the mandibular canine (43), 67% of patients presented as value 2, while only 25.4% showed value 3. Figure 21 distributions of tooth values between the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41) and the mandibular canine (43), using the Spectrophotometer Vita Classical Shade Guide (SMVC).

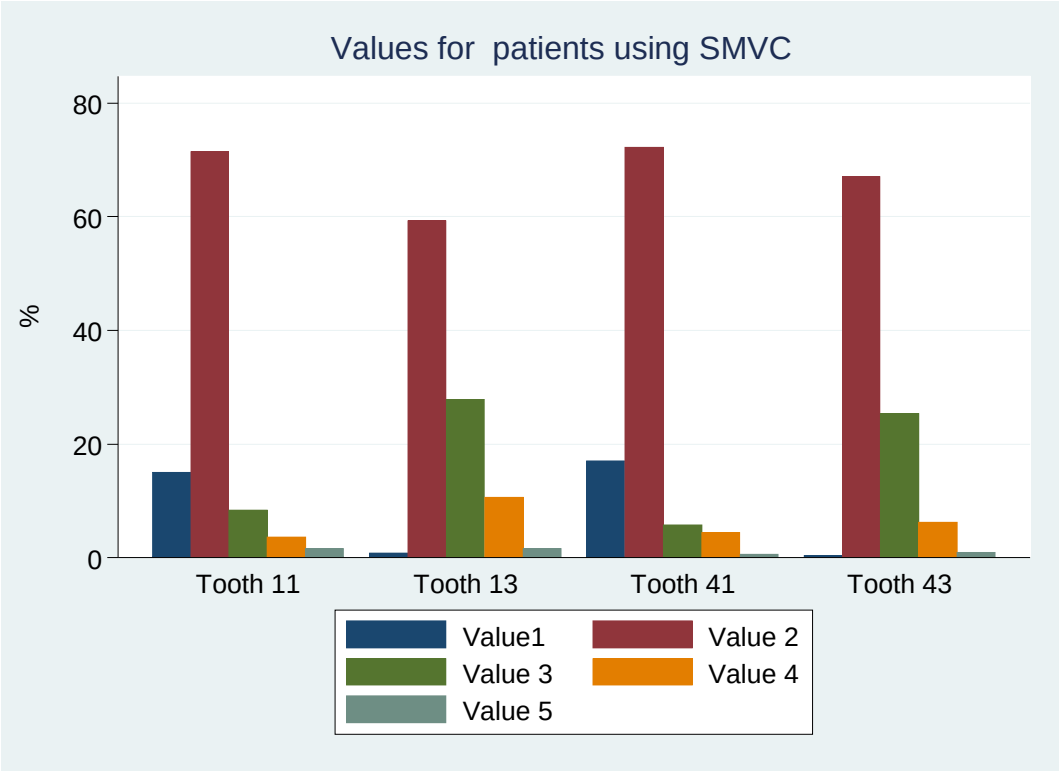

Figure 31: Distributions of tooth values between the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41) and the mandibular canine (43), using the Spectrophotometer Vita Classical Shade Guide (SMVC)

A spectrophotometer (Vita Classical Shade Guide) was used to measure the values depicted above. The dominant values were still 1 and 2 for the maxillary central incisor (11) and mandibular central incisor (41), while the dominant values for the maxillary canine (13) and mandibular canine (43) were 2 and 3.

Table 40: Distributions of tooth values (frequency and percentage) between the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43), using the Spectrophotometer 3D-Master (SM3DM)

Tooth Number	Value 1		Value 2		Value 3		Value 4		Value 5		Total	
	No	%	No	%	No	%	No	%	No	%	No	%
11	278	55.82	138	27.71	58	11.65	18	3.61	8	1.6	500	100
13	127	25.55	189	38.03	116	23.34	53	10.66	15	3	500	100
41	301	60.44	126	25.30	57	11.45	8	1.61	8	1.6	500	100
43	165	33.13	210	42.17	88	17.67	30	6.02	7	1.2	500	100

When using a Spectrophotometer (3D-master) to measure the upper central incisor (11), the highest percentages were seen in value 1 and 2. Values 1, 2 and 3 were the highest in the maxillary canine (13), whereas in the mandibular central incisor (41) the highest values were 1 and 2. For the mandibular canine (43) values 1, 2 and 3 were dominant. Figure 22 distributions of tooth values between the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43), using the Spectrophotometer 3D-Master (SM3DM)

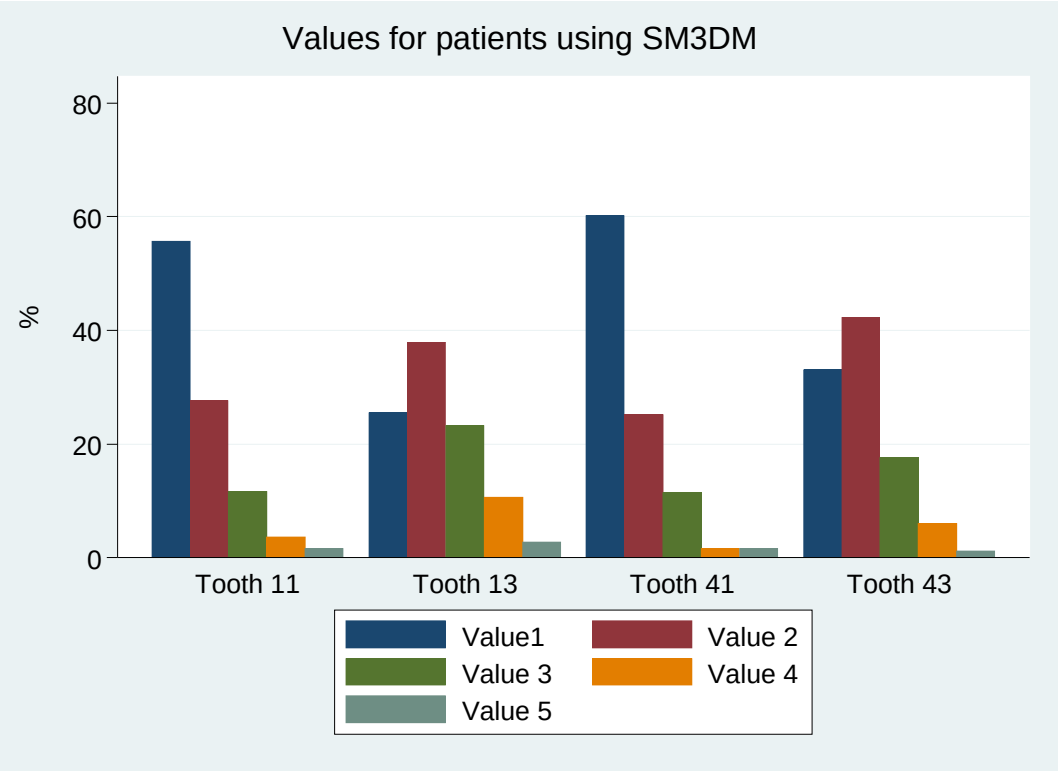

Figure 32: Distributions of tooth values between the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41), and the mandibular canine (43), using the Spectrophotometer 3D-Master (SM3DM)

The values for all the teeth measured with a spectrophotometer 3D-master. The results are different from those measured by other devices: value 1 and 2 were the dominant values for all the teeth except the maxillary canine (13) and mandibular canine (43), which had higher percentages of value 3 and 4.

5.8 Comparing the tooth values between the maxillary central incisor (11) and the maxillary canine (13), between the mandibular central incisor (41) and the mandibular canine (43), between the maxillary central incisor (11) and the mandibular central incisor (41), and between the maxillary canine (13) and the mandibular canine (43), using a Spectrophotometer (Vita Classical Shade Guide and 3D-Master)

Table 41: Comparing the tooth values between the maxillary central incisor (11) and maxillary canine (13), using a Spectrophotometer Vita Classical Shade Guide (SMVC)

Tooth value	11		13	
	F	%	F	%
1	75	15	4	0.8
2	357	71.4	296	59.2
3	42	8.4	139	27.8
4	18	3.6	53	10.6
5	8	1.6	8	1.6
Total	500	100	500	100

The maxillary central incisor (11) had higher percentages of values 1 (15%), and 2 (71.54%) (the lighter values), than the maxillary canine (13), of which only 0.80% were value 1, and 59.2% were value 2. The maxillary canine (13) however, had higher percentages of value 3 (27.86%) and 4 (10.6%), representing darker values.

Table 42: Comparing the tooth values between the mandibular central incisor (41) and the mandibular canine (43), using a Spectrophotometer Vita Classical Shade Guide (SMVC)

Tooth value	41		43	
	No	%	No	%
1	85	17	2	0.4
2	361	72.2	335	67
3	29	5.8	127	25.4
4	22	4.4	31	6.2
5	3	0.6	5	1
Total	500	100	500	100

The maxillary central incisor (41) had higher percentages of value 1 (17%), and value 2 (72.2%) than the mandibular canine (43), which had a mere 0.40% for value 1, and (67%) for value 2. However, the mandibular canine had higher percentages of value 3 (25.4%), and slightly more of value 4 (6.2%) than the lower central incisor (11), which represented values 3 and 4 with only 5.8% and 4.4% respectively.

Table 43: Comparing the tooth values between the maxillary central incisor (11) and the mandibular central incisor (41), using a Spectrophotometer (Vita Classical Shade Guide (SMVC)

Tooth value	11		41	
	F	%	F	%
1	75	15	85	17
2	357	71.4	361	72.2
3	42	8.4	29	5.8
4	18	3.6	22	4.4
5	8	1.6	3	0.6
Total	500	100	500	100

For the maxillary central incisor (11), 15% of patients represented value 1, and 71.4% represented value 2, compared to lower central incisor (41), for which value 1 was represented by 17% of patients, and value 2 by 72.2% of patients. Both maxillary and mandibular incisors had a similar distribution in the values.

Table 44: Comparing the tooth values between the maxillary canine (13) and the mandibular canine (43), using the Spectrophotometer Vita Classical Shade Guide (SMVC)

Tooth value	13		43	
	F	%	F	%
1	4	0.8	2	0.40
2	296	59.2	335	67
3	139	27.8	127	25.4
4	53	10.6	31	6.2
5	8	1.6	5	1
Total	500	100	500	100

The value percentages for the upper canine (13) were 0.8% at value 1, 59.2% at value 2, and 27.8% at value 3. This was more or less similar to the lower canine (43), which had a very low percentage of value 1 (0.40%), and higher percentages of value 2 (67.13%), and 3 (25.4%). The maxillary canine (13) appears to be slightly darker than the mandibular canine (43).

Table 45: Comparing the tooth values between the maxillary central incisor (11) and the maxillary canine (13), using the Spectrophotometer 3D-master (SM3DM)

Tooth value	11		13	
	F	%	F	%
1	278	55.6	127	25.4
2	138	27.6	189	37.8
3	58	11.6	116	23.2
4	18	3.6	53	10.06
5	8	1.6	15	3
Total	500	100	500	100

It can be seen from the table that 55.6% of patients' maxillary central incisors (11) were value 1, and 27.6% were value 2. The maxillary canine (13) values were quite different with 25.4% for value 1 and 37.8% for value 2. The maxillary canine (13) had higher percentages of the darker values 3 (23.2%) and 4 (10.06%) when compared to the maxillary central incisor (11).

Table 46: Comparing the tooth values between the mandibular central incisor (41) and the mandibular canine (43), using the Spectrophotometer 3D-Master (SM3DM)

Tooth value	41		43	
	F	%	F	%
1	301	60.2	165	33
2	126	25.2	210	42
3	57	11.4	88	17.6
4	8	1.6	30	6
5	8	1.6	7	1.4
Total	500	100	500	100

60.2% of the mandibular central incisors (41) were value 1, and 25.2% were value 2. The mandibular canine (43) exhibited very different values: 33% at value 1, 42% at value 2, 17.6 % at value 3, and 6% at value 4. The mandibular canine had a significantly darker value than the mandibular central incisor.

Table 47: Comparing the tooth values between the maxillary central incisor (11) and the mandibular central incisor (41), using the Spectrophotometer 3D-Master (SM3DM)

Tooth value	11		41	
	F	%	F	%
1	278	55.6	301	60.2
2	138	27.6	126	25.2
3	58	11.6	57	11.4
4	18	3.6	8	1.6
5	8	1.6	8	1.6
Total	500	100	500	100

Table 47 shows that the percentages of tooth value for the maxillary central incisor (11) and mandibular central incisor (41) were very similar. The maxillary central incisors (11) represented 55.6% of value 1, 27.6% of value 2, and 11.6% of value 3. Value 1 was represented by 60.2%, value 2 by 25.2% and value 3 by 11.4% of patients for the mandibular central incisor (41).

Table 48: Comparing the tooth values between the maxillary canine (13) and the mandibular canine (43) using the Spectrophotometer 3D-Master (SM3DM)

Tooth value	13		43	
	F	%	F	%
1	127	25.4	165	33.13
2	189	37.8	210	42
3	116	23.2	88	17.6
4	53	10.06	30	6
5	15	3	7	1.4
Total	500	100	500	100

Table 48 presents the value percentages for the maxillary canine (13): 25.4% at value 1, and 37.8% at value 2, which is slightly different from the mandibular canine (43), which had 33.13% at value 1, and 42% at value 2. This indicates however that the mandibular canine had a higher percentage of lighter values and lower percentage of darker values: the maxillay canine represented value 3 with 23.2% of patients and value 4 with 10.06% of patients.

CHAPTER 6

DISCUSSION

6.1 Overview

Only one South-African study[39]as found that links skin tone to gingival pigmentation. International studies[3,19 ,17] have included more variables. The current study compared age, sex, skin tone, gingival pigmentation and smoking habits with the shade of patients' teeth. Differences in tooth shade between the maxillary and mandibular teeth were also compared (n=500).

6.2 In vivo tooth shade analysis

Two methods exist for in vivo analysis of tooth colour. The most commonly used involves visual comparison using a shade guide in clinical dentistry (Vita Lumin Vacuum Guide and Vitapan 3D-Master Linearguide).

The second method involves the use of a spectrophotometer(Vita EasyShade Compact). Both of these methods were applied to examine the colour of the selected teeth 11, 13, 41 and 43 in 500 dental patients at the Oral and Dental Hospital, University of Pretoria .

The results obtained (Table 37 and Figure 19) using the Vita Classical Shade Guide (VC) showed that the maxillary central incisor (11), and the mandibular central incisor (41) mainly fell into the value categories 1 and 2, in other words the shade of these teeth was light in colour.

However, for the maxillary and mandibular canines (13) and (43), more patients fell into categories 2 and 3 (Table 37, Figure 29), indicating a darker shade than was seen for the incisors (11) and (41).

When patients' teeth were examined using the Vitapan 3D-Master Linearguide (3DLG), results were similar (Table 38, Figure 30) to those found when using the Vita Classical Shade Guide shade guide, as shown previously.

Using the spectrophotometer method, similar findings were obtained (Table 39, Figure 31), with a small difference that when using the SM3DM values 1 and 2 were the dominant values for all the teeth (Tables 40, Figure 32). The general finding using both methods (visual inspection and spectrophotometer) was that the maxillary incisors have a lighter value than the canines, although there is variation among patients and also some variation between the maxillary and mandibular teeth.

When the maxillary central incisor (11) was compared to the maxillary canine (13), and the mandibular central incisor (41) compared to the mandibular canine (43) using SMVC or SM3DM, the results showed that the central incisors were lighter than the canine teeth in both the maxilla and mandibles (Tables 41, 42, 45 and 46). These findings are in agreement with Goodkind et al,[28] who found that the canines are darker than the incisors.

These results are also consistent with the findings of Hessagawa et al [29] in Japanese people. When comparing the maxillary central incisor (11) with the mandibular central incisor (41) it is clear that there appears to be little

difference between SMVC and SM3DM (See Tables 43 and 47). Results were also similar when comparing the maxillary canine (13) with the mandibular canine (43) using SMVC.

However, when the maxillary canine was compared to the mandibular canine using SM3DM (Tables 48), it was found that the mandibular canine (43) was lighter than the maxillary canine (13).

This confirms the findings of Effiler et al[40], who stated that the maxillary canine exhibited a lower lightness (darker) than the mandibular canine. He also reported that no difference was observed between the maxillary incisor and the mandibular incisor which is in agreement with this study and yet different from a previous study by Goodkind et al.[28] These differences may be due to the thickness between enamel and dentine.[9]

6.3 Demographic influences on tooth shade

6.3.1 The influence of age on tooth shade

The ages of our patients ranged from 18 to 81 years. These patients were divided in two age groups simillar to the study done by Goodkind et al.[28]

. Group one consisted of 291 patients 35 and younger (176 females and 115 of males). Group two consisted of 209 patients older than 35 (129 females and 80 males), as shown in Table 1.

Our study showed that there was a significant relationship between the age of patients and the tooth value of the maxillary central incisor (11) and the maxillary canine (13), the mandibular central incisor (41) and the

mandibular canine (43). It confirmed that as people get older, tooth value generally becomes darker, as shown in (Tables 5 – 8 and Figures 17 and 18) They also tended to have more teeth with yellow hue. This significant association is consistent with the majority of other studies.[28,3,19]

In a study conducted by Hartmann and Muller [41] it was suggested that the darkening of the dentine core and flattening of surface structure by tooth surface loss in the aged probably results in a change in light reflection with altered tooth colour. Another study by Hesagawa et al[29] found that the lightness value of teeth at their centre decreases linearly with advancing age. This finding is in agreement with Goodkind et al,[28] who reported that after 35 years of age, teeth become darker and more saturated at the centre. This is owing to the formation of secondary dentine, as dentine is darker than enamel and the thickness of the enamel decreases with age. All the papers mentioned above support the findings of this study: that the age of the dental patient (those older than 35 years) influences the value of the tooth.

6.3.2 The influence of patient sex on tooth value

When considering tooth value in relation to the patients' sex, it was found that generally more female patients than male patients had teeth with lighter values (1 and 2) as can be seen in (Tables 9 – 12, Figure 19 and 20). This relationship was found to be significant for the value of the central incisor (11) (Fisher’s exact = 0.017) and not significant for the maxillary canine (13), mandibular central incisor (41) and mandibular

canine (43). The female teeth also tended to have medium to yellow hues, as seen in tables 29, 30, 31 and 32.

This finding is supported by Esan et al,[3] who examined the maxillary central incisor and reported that a significant relationship exists between gender and tooth shade. Also, men were more likely to have darker teeth. Another study by Azad et al [19]suggested a significant association with gender, in that males were found to have relatively darker tooth shade than females. It was also supported by the findings of Gazalo et al[30] ,who found that gender was a significant factor in predicting tooth colour (women have lighter teeth that are less yellow than those of men). In addition, Goodkind et al [28]concluded that there were statistically significant differences when it came to sex with regards to hue, value and chroma. Women's teeth are lighter and less saturated, with more yellow hue than men's teeth.

On the other hand, our results were not consistent with the findings of Hasegawa et al [29] and Jahangiri et al,[2] who reported that there was no significant relationship between tooth shade and sex.

6.3.3 The relationship between skin tone and tooth value

A statistically significant relationship was found between skin tone and tooth value for the maxillary central incisor (11), the maxillary canine (13), the mandibular central incisor (41) and the mandibular canine (43). In general the medium and dark skin tone patients were more likely to have lighter teeth values, while the patients with light skin tone had relatively

higher percentages of darker tooth values, as shown in Tables 13 -16, and Figures 21, 22 and 23.

The findings of this study are consistent with that of Jahangir et al,[2] who found a significant inverse relationship between tooth shade value and skin colour. They concluded that patients with medium to dark skin tone were more likely to have teeth with lighter values (lighter teeth), despite their gender or age. Furthermore, the current study findings are in agreement with that of Azad et al,[19] which concluded that tooth shade is significantly associated with skin tone. Patients with lighter skin tone tended to have darker value teeth while those with darker skin tones had lighter teeth.

The findings of this study are however not consistent with the findings of Esan et al,[3] who indicated that there is no significant relationship between facial skin colour and tooth shade. This may have been due to variation in their sampling method. They used only Nigerians and compared tooth value with different shades of dark skin, rather than contrasting the skin tones of people from different ethnic origins, as was done in our study. Dummett et al[16] also suggested that the facial complexion of patients is not significantly correlated with tooth colour. However, their shade guide did not cover the entire range of natural tooth colours and this may have resulted in bias.

6.3.4 The influence of gingival pigmentation

Dummett et al[16] indicated a significant positive correlation between facial skin complexion and gingival pigmentation using the DOPI (Dummett Oral Pigmentation Index) method. This index represented the assessment of composite numerical value compared to the total melanin pigmentation manifestation in clinical examination of various oral tissues.

The criteria are as follows:

0 = Pink tissue (no clinical pigmentation)

1 = Mild, light brown tissue (mild clinical pigmentation)

2 = Medium brown or mixed pink or brown tissue (moderate clinical pigmentation)

3 = Deep brown or blue/black tissue (heavy clinical pigmentation)

The higher the number, the darker the oral pigmentation.

This study found similar results, as can be seen in Table 3. Almost all (n=210, 98.59%) of the 213 light skin-tone patients in our study had non-pigmented gingiva, whilst the majority of medium and dark skin-tone patients had diffuse and focal gingival pigmentation.

When comparing the relationship with tooth value, gingival pigmentation was found to be significantly associated with a lighter value for tooth 13 (Fisher's exact = 0.018 in Table 18), 41 (Fisher's exact = 0.000 in Table 19), 43 (Fisher's exact = 0.010 in Table 20), but not significantly

associated with tooth 11 (Fisher's exact = 0.193 in Table 17). Only in the maxillary central incisor (11) was the result in agreement with the results published by Dummett et al,[16] who found that the DOPI (Dummett Oral Pigmentation Index) was not consistently significant with regards to tooth colour. This index was also used in another study by Mohamed and Ali,[42] who found that there was no significant relationship between tooth colour and gingival pigmentation. It is probable that the reason this study has found a significant relationship in other teeth studied (13, 41 and 43) is the fact that the clinician looked at the attached gingiva of the teeth, while the researchers using the DOPI index used it to assess the overall presence of pigmentation in the gingiva.

6.3.5 The influence of smoking

One hundred and five people in our sample size were smokers. No significant differences were found for teeth value in smokers (Table 22 and 24) except with teeth 11 and 41 (Table 21 and 23). This may look contradictory, as the upper and lower canines were in any case darker than the incisors in most patients. A factor that should be kept in mind is that cigarettes are normally positioned closer to the incisors than the canines by smokers. Smoker patients' teeth were also found to have a more yellowish hue in the incisors (11) and (41) (Tables 33 and 35) and a more reddish hue for the canines (13) and (43) (Tables 34 and 36). This finding has not been recorded in other publications and is therefore a new observation.

CHAPTER 7

7.1 Conclusion

It was concluded that the central incisors is lighter than the canines in both jaws. The lower canine (43) was, however, lighter than the upper canine (13). Patients older than 35 had significantly darker and more yellow teeth and females in both age groups had significantly lighter, less reddish teeth than males. Those with darker skin tones had significantly lighter teeth values and were more likely to have diffuse or focal gingival pigmentation. Gingival pigmentation did not appear to be significantly associated with the value of the central incisor, but was however significantly associated with lighter values in the other teeth studied. Although smoking made all teeth more yellow, it did not significantly change the value of the canines but the incisors were a darker shade.

7.2 Clinical implications

Recognition of the relationship between skin tone, age and tooth value could assist dentists in the construction of removable dentures for older people. The relationship between darker skin tone and gingival pigmentation will assist in selecting the right shade for the labial flange in a denture. Understanding the relationship between the canines and incisors in the upper and lower jaws, will help the dentist to select artificial teeth with a more natural colour. All of the above findings will improve the aesthetic value of dentures and result in better patient satisfaction.

7.3 Limitations of the study

Although the research included a relatively large group of both female and male subjects, across a wide range of ages there are certain limitations inherent to the study.

Firstly, subjects were recruited only at the Oral and Dental Hospital. Patients that go there for treatment all share a certain background, income bracket and profile of health. Patients with extremely low income that might have poor health education or patients above the average income bracket who are well educated in oral health might have exhibited a different set of data than those treated at the Pretoria Oral and Dental Hospital.

The second limitation is the fact that it was not possible to use day light for shade selection. Since all patients are to be treated within the physical premises, a light corrector had to be used to perform the examinations.

Furthermore, the skin tone guide used in the study was designed by a dental technician. There are other skin shade guides available that were designed by professionals in the field of dermatology that might have classified the different shades (light, medium and dark) in a slightly different manner.

Laslty, the shade of only the middle third section of every tooth was measured. The incisal and gingival thirds of the teeth were not taken into consideration.

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Appendix:

PATIENT / PARTICIPANT'S INFORMATION LEAFLET & INFORMED CONSENT FORM FOR A NON-INTERVENTION STUDY

STUDY TITLE: Evaluation of Tooth Shade in a Selected Sample of Patients visiting the Oral and Dental Hospital

SPONSOR: Department of Prosthodontics, University of Pretoria

Principal Investigators: Dr Asma MZ Amari.

Institution: Department of Prosthodontics, School of Dentistry, University of Pretoria

DAYTIME AND AFTER HOURS TELEPHONE NUMBER(S):

Daytime numbers: 0123192446

Afterhours: 072 869 6257

DATE AND TIME OF FIRST INFORMED CONSENT DISCUSSION:

dd	**mmm**	**ivy**

:
Time

1) INTRODUCTION

You are invited to volunteer for a research study. This information leaflet is to help you to decide if you would like to participate. Before you agree to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this leaflet, do not hesitate to ask me.

2) THE NATURE AND PURPOSE OF THIS STUDY

We would like to learn more about tooth colours and how it is related to skin color. We need your help so as to understand this better.

.

3) EXPLANATION OF PROCEDURES TO BE FOLLOWED

The study will involve checking the colour of your front teeth, the colour of your gums and how it is related to your skin colour using a colour guides. No pain will be caused during the examination!

4) RISK AND DISCOMFORT INVOLVED.

There will be no risk or discomfort involved during the examination

5) POSSIBLE BENEFITS OF THIS STUDY.

It will allow dentist to improve shade matching and selection of teeth .

6) I understand that if I do not want to participate in this study, I will still be treated at the hospital without prejudice.

7) I may at any time withdraw from this study.

8) HAS THE STUDY RECEIVED ETHICAL APPROVAL?

This Protocol was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, telephone numbers 012 3541677 / 012 3541330 and written approval has been granted by that committee. The study has been structured in accordance with the Declaration of Helsinki (last update: October 2008), which deals with the recommendations guiding doctors in biomedical research involving human/subjects. A copy of the Declaration may be obtained from the investigator should you wish to review it.

9) INFORMATION

If I have any questions concerning this study, I should contact:

Dr A Amari tel :0123192446 or cell: 0728696257

10) CONFIDENTIALITY

All records obtained whilst in this study will be regarded as confidential. Results will be published or presented in such a fashion that patients remain unidentifiable.

11) CONSENT TO PARTICIPATE IN THIS STUDY.

I have read or had read to me in a language that I understand the above information before signing this consent form. The content and meaning of this information have been explained to me. I have been given the opportunity to ask questions and am satisfied that they have been answered satisfactorily. I understand that if I do not participate it will not alter my management in any way. I hereby volunteer to take part in this study.

I have received a signed copy of this informed consent agreement.

....

Patient name Date

.....	.....
Patient signature	Date
.....	.....
Investigator's name	Date
.....	.....
Investigator's signature	Date
.....	.....
Witness name and signature	Date

VERBAL PATIENT INFORMED CONSENT (applicable when patients cannot read or write)

I, the undersigned, Dr ……..…, have read and have explained fully to the patient, named …….. and/or his/her relative, the patient information leaflet, which has indicated the nature and purpose of the study in which I have asked the patient to participate. The explanation I have given has mentioned both the possible risks and benefits of the study and the alternative treatments available for his/her illness. The patient indicated that he/she understands that he/she will be free to withdraw from the study at any time for any reason and without jeopardizing his/her treatment.

I hereby certify that the patient has agreed to participate in this study.

Patient's Name _____

(Please print)

Patient's Signature _____ Date _____

Investigator's Name _____

(Please print)

Investigator's Signature _____ Date _____

Witness's Name _____ Witness's Signature _____ Date _____

(Please print)

(Witness - sign that he/she has witnessed the process of informed consent)

Appendix 2:

PATIENT CODE								
AGE								
SEX								
SKIN TONE	Dark		Medium		Light			
GINGIVAL PIGMENTATION	Non Pigmented		Focal		Diffuse			
SMOKER	Smoker		Non Smoker		Number of cigarettes per day			
TOOTH NUMBER	11	13	41	43	21	23	31	33
VITA CLASSICAL								
LINEAR GUIDE 3D MASTER								
SPECTROPHOTO – METER								