THE ANALYSIS OF OROFACIAL ESTHETIC PROPORTIONS WITH NATURAL MAXILLARY ANTERIOR TEETH AND PERCEPTION OF SMILE ATTRACTIVENESS IN PAKISTANI CITIZENS: A 2D PHOTOGRAPHIC AND 3D DIGITAL DENTAL MODELS STUDY

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LIST OF ABBREVIATIONS

GP	Golden Proportion
GM	Golden Percentage
PRP	Preston Proportion
RED	Recurring Esthetic Dental
CI	Central Incisor
LI	Lateral Incisor
Ca	Canine
RCI	Right Central Incisor
RLI	Right Lateral Incisor
RCa	Right Canine
LCI	Left Central Incisor
LLI	Left Lateral Incisor
LCa	Left Canine
CIW	Combined Central Incisor Width
FITW	Four Incisor Teeth Width
ITCD	Intercanine Distance
IPD	Interpupillary Distance
ICD	Inner intercanthal Distance
ICoD	Intercommisural Distance
IAD	Interalar Distance
IPLD	Interphiltral Distance
BZD	Bizygomatic Distance
CWHR	Crown Width Height Ratio
2D	Two Dimensional
3D	Three Dimensional

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ANALISIS PERKADARAN ESTETIK OROFACIAL DENGAN GIGI ANTERIOR MAXILLARY NATURAL DAN PERSEPSI TARIK SENYUM DALAM WARGA PAKISTANI: KAJIAN MODEL PERGIGIAN 2D FOTOGRAFI DAN DIGITAL 3D

ABSTRAK

Tujuan kajian ini adalah untuk menilai bahagian ekstraoral dan gigi hadapan maksila untuk mencadangkan nilai-nilai estetik yang sesuai untuk gigi anterior maksila dan juga untuk menilai pilihan para doktor gigi dan orang awam mengenai senyuman menarik di kalangan penduduk Pakistan. Kajian ini dilakukan dalam dua fasa. Foto-foto muka depan peserta direkodkan, termasuk senyuman penuh. Ini diikuti dengan prosedur impresi pada rahang atas. Model gigi yang dihasilkan kemudian ditukar menjadi model 3D untuk dianalisa. Kemudian, gambar dibina untuk mengumpulkan respon doktor gigi dan orang awam mengenai senyuman menawan. Data dimasukkan dalam SPSS-25. Bahagian emas klasik, peratusan keemasan, perkadaran Preston tidak mempunyai hubungan statistik yang signifikan pada lebar gigi anterior rahang atas. Jarak antara-intanthal, dengan peratusan keemas an, menunjukkan tidak ada perbezaan yang signifikan dari gabungan garis pusat. Jarak antara zygoma didapati lebih besar daripada lebar gigi anterior pada semua kumpulan yang dikaji. Jarak antara anak mata, dengan perkadaran emas, didapati selaras dengan jarak antara kanin, pada peserta wanita dan gabungan lebar insisor pusat pada kedua-dua jantina ketika dinilai dengan perkadaran Preston. Perkadaran wajah dengan 70% bahagian 70% RED menunjukkan perbezaan yang signifikan dengan lebar gigi anterior. Lebar gigi anteriormaksila yang ditentukan dengan model gigi plaster dan imbasan 3D gigi tidak menunjukkan

perbezaan yang signifikan. Jarak interpupillary, jarak antara-intercanthal dan jarak bizygomatic tidak dapat digunakan secara langsung untuk meramalkan gabungan lebar insisor pusat dan jarak antara gigi kanin. Jarak antara canthal diubah oleh peratusan keemas an, dan jarak interpupillary dengan perkadaran Preston dapat digunakan untuk meramalkan kelebaran gigi anterior maksila. Jarak interphiltral yang diubahsuai dengan perkadaran Preston adalah kaedah yang boleh diguna pakai untuk meramalkan gabungan lebar gigi sentral. Terdapat perbezaan yang ketara antara jantina sekiranya jarak interpupillari dan bizygomatic diubah dengan perkadaran gigi kecuali jika jarak intercanthal dalaman dengan peratusan keemasan. Lebih-lebih lagi, terdapat perbezaan yang signifikan dalam perbezaan jantina ketika ICD, IAD, dan IPLD diubah dengan perkadaran gigi, kecuali dalam kes IPLD oleh kumpulan PRP. Analisis perkadaran dengan perkadaran emas dan 70% pergigian estetik gigi berulang bukanlah kaedah yang boleh duguna pakai untuk menentukan gabungan lebar gigi seri dan jarak antarcanin. Doktor gigi dan orang awam lebih suka senyuman berasaskan proporsi estetik berulang, paling menarik. Gigi yang dominan dipilih ketika senyuman oleh peserta kajian ini adalah gigisentral insisor .

Susunan dan warna gigi dipilih sebagai faktor utama bagi menentukan perkadaran yang paling digemari oleh majoriti doktor gigi dan orang awam.

THE ANALYSIS OF OROFACIAL ESTHETIC PROPORTIONS WITH NATURAL MAXILLARY ANTERIOR TEETH AND PERCEPTION OF SMILE ATTRACTIVENESS IN PAKISTANI CITIZENS: A 2D PHOTOGRAPHIC AND 3D DIGITAL DENTAL MODELS STUDY

ABSTRACT

This study aimed to analyse faciodental proportion and perception of an attractive smile in Pakistani citizens. Phase one consisted of 230 and phase two 286 participants. The photographs of the full face and teeth were captured in a retracted smile, followed by maxillary impression and cast construction. The cast was then converted to 3D models. In phase two the photoshoped dental pictures were used to collect responses from dentists and laypersons about a particular smile. The data were analyzed by SPSS-25. The classic theories of golden proportion, golden percentage, Preston proportion, and recurring esthetic dental proportion proposed for North American population were not found in Pakistani citizens. The study proposed a ratio of 77% for lateral and central incisors and 107% for canine and lateral incisor teeth. The inner-intercanthal distance modified by golden percentage value of 25% was similar to combined central incisor width. The modified bizygomatic distance was larger than anterior teeth width. The interpupillary distance modified by golden proportion 62% was found to be consistent with intercanine distance in female participants. The facial proportions modified with 70% RED proportion showed a significant difference with anterior teeth width. The width of maxillary anterior teeth measured on plaster and 3D dental cast showed no significant difference. The

interpupillary distance, inner-intercanthal distance, and bizygomatic distance could not be directly used to predict combined central incisors width and intercanine distance. The inner-intercanthal distance modified by golden percentage and interpupillary distance by golden proportion can be used to predict maxillary anterior teeth width. Additionally, interphiltral distance modified with Preston proportion is a reliable metric to predict combined central incisor width.

A significant difference in gender disparity was found when facial proportions were modified with dental proportions except in the case of inner-intercanthal and interphiltral distance modified by golden percentage and Preston proportion respectively. The 70% recurrent esthetic dental proportion was not a reliable method to predict maxillary anterior teeth width.

The phase two of study describes that; the dentist and layperson preferred a RED proportion-based smile, the most attractive. The dominant tooth in smile was selected to be central incisor by participants of this study. Teeth arrangement and color was selected as primary factor for deciding the preferred proportional view by most dentists and layperson.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Public awareness is increasing about dental esthetics. There is a concurrent improvement in techniques and materials. This has shifted dental treatment more towards the restoration of esthetics, in addition to its primary role in treating disease and maintaining oral health. The most influential factors contributing to harmony, symmetry, and esthetics are the size, shape, and arrangement of the maxillary anterior teeth, particularly the maxillary central incisors as viewed from the front (Baharav *et al.*, 2009).

To meet the esthetic needs of the patient, the dentist should fabricate the artificial teeth to look like the patient's natural teeth. The information about tooth norms and order may be useful when restoring missing anterior teeth. Failure to achieve the desired size and morphology may result in the patient's rejection of otherwise well-constructed and efficient prostheses. The importance of order in dental composition has been around since the ancient Greek period (Goodlin, 2011).

The concept of continuous proportion, of using repeated proportions between all teeth from the central incisor to the first premolar indicated that the most harmonious recurrent tooth-to-tooth ratio is that of the golden proportion (Levin, 1978). The golden proportion is the key principle and the basis of modern dentofacial esthetics (Ong *et al*., 2006).

According to the golden proportion concept, the perceived width of the maxillary lateral incisor should be approximately 62% of the perceived width of the central incisor, whereas that of the canine should be similarly related to the lateral incisor. Thus, it follows logically that if the perceived width of the lateral incisor is 1, the central incisor should be 1.618 times wider and the canine, 0.618 times narrower when viewed from the front. The discrepancy between the perceived width and actual width of maxillary anterior teeth exists in actuality, which is compensated by the positioning of these teeth along the curve of the maxillary arch (Ong *et al*., 2006).

The idea of a continuous proportion as described by Lombardi set off the concept of using a repeated ratio that does not limit to the 62% proportion. Ward (2015) recommended recurring esthetic dental proportion, to provide a more pleasing smile. Rather than using a single mathematical formula, he preferred using the proportion of 70% between anterior teeth moving distally in the maxillary arch. Accurate evaluation of dental proportions is possible when a person is observed smiling from the front. The frontal photographic view can be used to determine dental proportions of the widths of maxillary anterior teeth.

A study carried out in Turkish population noted a significant difference ($p<0.01$) when the mean ratios between widths of central to lateral incisors and canines to lateral incisors were compared with their ideal golden ratios of 1.618 and 0.618 respectively for both genders. The recurrent dental proportion of 70% for all anterior teeth was not found (Hasanreisoglu *et al*., 2005).

When pre-extraction records are unavailable, selecting the appropriate size of the anterior teeth becomes somewhat arbitrary. Several anatomic landmarks have been

proposed to aid in determining the correct size of the anterior teeth, including such dimensions as Bizygomatic distance (BW), Interpupillary distance (IPD), Innertercanthal distance (ICD), Interalar distance (IAD), Intercommissural width (ICoD) and Intercanine distance (ITCD). The investigators on facial anthropometry felt that the bizygomatic width may not be a reliable guide for estimating the width of central incisors (House and Loop, 1939 Scandrett *et al*., 1982; Wulfman *et al*., 2010). The study by Scandrett *et al.*, (1982) also concluded that bizygomatic measurements are not a reliable means of selecting the width of maxillary central incisors. When eye measurements were evaluated, Cesario and Latta found that a factor of 1:6.6 exists between the mean interpupillary distance and the mean mesiodistal width of the maxillary central incisor (Alsaadi *et al*., 2015). According to Al Wazzan, (2001) the intercanthal distance is correlated with the mean width of two central incisors, the combined width of the central incisors, the combined width of the four incisors, and the total width of the six maxillary anterior teeth. Abdullah, (2002) found the intercanthal distance to be in “golden proportion" to the combined width of the maxillary central incisors. In a human skull study, the width of the four maxillary incisors equalled to the nasal width when measured on the skulls, however the interalar width measured on the soft tissue was correlated more to the width of the six maxillary anterior teeth (Mavroskoufis and Ritchie, 1981; Hoffman *et al*., 1986). They also found that the interalar width when multiplied by a factor of 1.31 gave the combined width of the maxillary six anterior teeth. In contrast, Smith found that neither nasal width nor interalar width correlated with the width of the six maxillary anterior teeth (Smith, 1975).

Furthermore, the intercommisural distance has been studied about facial proportions, by Clapp and Tench, 1918. They suggested that the distal surfaces of the

maxillary canines are approximated at the commissures of the mouth at rest. Whereas Silverman (1976) found that the distal surface of maxillary canines was +/- 4 mm from the oral commissures, while in another study by (Al Wazzan *et al*., 1995) found no correlation between the width of the mouth and the mesiodistal width of the maxillary six anterior teeth. Several authors (Scandrett *et al*., 1982; Latta *et al*., 1991) proposed that more than one measurement of the face may be needed to obtain the best decision for maxillary anterior teeth width. The tooth proportion of the individual tooth in the maxillary anterior dentition is defined by the anatomic width/length dimensions as a percentage ratio. It falls within a range of 72% to 80%, with an average of 76% (Wang *et al*., 2021). Sterrett *et al*., 1999 reported a higher average proportion ratio (81%) for clinical crown dimensions where the free gingival margin was incisal to the cementoenamel junction. The knowledge of racial norms for facial appearance might aid practitioners, since the treatment provided would be in balance with the facial appearance of patients of different races (Johnson, 1992).

The perception of dental esthetic parameters, dimensions of teeth, and their relation to facial esthetics vary in different populations. It has been extensively reported in studies (Al Wazzan *et al.*, 1995; Abdullah, 2002). Rosenstiel and Rashid in their web-based study that was carried out in the North American population, determined the public's preferences for esthetics with recognition of gender, country of residence, and race. The strongest preferences were recorded for midline diastema and midline shift discrepancies while the weakest preferences were for tooth whiteness and tooth proportion (Rosenstiel and Rashid, 2002). Additionally, Vig and Brundo, (1978) found the mean vertical dimension of visible maxillary central incisors in men with the lips at rest was 1.91 mm, while in women it was 3.40 mm. For the mandibular central incisors, such means were 1.23 and 0.49 mm, which is respectively a different

amount of anterior tooth exposure in Black and Asians when compared with Caucasians.

Furthermore, other studies have also reported tooth size variation between and within different racial groups. Keene reported that tooth sizes among the American Negroes are slightly larger in comparison to Caucasians (Keene, 1979). Turner and Richardson, (1989) also observed that Kenyan teeth were significantly larger than their Irish counterparts. In another multinational study comparing the mesiodistal and buccolingual crown dimensions of the permanent teeth in three ethnic groups from Egypt, Mexico, and the United States, significant differences were found in the mesiodistal dimensions between the three populations (Bishara *et al*., 1989). Apart from racial differences, authors showed other factors associated with tooth size variability including hereditary factors (Townsend and Brown, 1978) bilateral differences (Ballard, 1944) environment, and gender (Guagliardo, 1982; Lysell and Myrberg, 1982).

Therefore, a greater understanding of orofacial esthetic proportion and perception of attractive smile analysis is required from different geographical regions. As is it is proven that anterior tooth proportion differs by ethnicity and race. Proportions should be applied for optimal esthetics based on region and ethnicity. Pakistani society is a diverse mix of races and is growing at a much faster rate and relatively less scientific data in published form have reported tooth size variation between and within different racial groups i.e., Pathans, Punjabis, Sindhi, Balochi, Rajput, Balti, Kashmiri, Seraiki, Muhajirs and other smaller groups. Therefore, the

purpose of this study was to analyse orofacial esthetic proportion in maxillary anterior teeth utilizing 2D photographs and 3D digital dental models, in Pakistani citizens.

1.2 Statement of the problem

The color and form of teeth are 2 of the 3 main determinants of success in an esthetic restoration; the third is dental proportion. It is also a known fact that patients are more concerned about missing anterior teeth and their replacement than about posterior ones; esthetics seems to be more important than the function of the teeth (Levin L 2007). Many factors adversely affect harmony and esthetics in a smile, like an asymmetry across the midline, anterior or central dominance, pink esthetics, improper size and shape of teeth.

However, above all, one common factor for unaesthetic prosthesis or replacement is inappropriate creation of harmonious proportions between the widths of maxillary anterior teeth and facial features when restoring or replacing them. The commonly used guidelines such as golden percentage, Preston proportion, golden proportion, recurring esthetic dental proportion, and the relationship of various facial dimensions may be misleading in different races because of distinct dentofacial specificities in different populations. The recurring esthetic dental (RED) proportion has been a benchmark for the rehabilitation of the maxillary anterior teeth of North American patients. The golden proportion, golden percentage, and Preston proportion were assessed and proposed for the Caucasian race predominantly. While the four dental proportions have been evaluated in other populations, the global application of golden proportion, golden percentage, Preston proportion, and RED proportions in the rehabilitation of maxillary anterior teeth is unclear.

Furthermore, obtaining the size of the maxillary anterior teeth when performing an esthetic smile rehabilitation can be a difficult task. The facial proportion metrics based on dental proportions to assist in the process are required. Therefore, we assume the following statement of problems in line with our study.

- ✓ Presently, there are no generally accepted standards for designing smiles using tooth proportion relationships.
- ✓ Whether the dental proportion theories proposed for the North American population are applicable to the Pakistani population need to be analyzed.
- ✓ Estimating the width of the maxillary anterior teeth when creating an esthetic smile can be challenging. Valid metrics to assist in this process are needed.
- ✓ Whether facial width proportions, width-to-length ratio, and composition of teeth revealed in a smile; affects attractiveness is yet unknown in the Pakistani population.
- ✓ Whether the width to height ratio of anterior teeth at different crown levels has a difference is yet unknown.
- ✓ Whether anterior teeth dimensions can be obtained by body height and weight in the Pakistani population is yet unknown.

1.3 Rationale of the study

This study investigated the extraoral facial proportions of maxillary anterior teeth, to determine the parameters for the extra oral-facial esthetics in the Pakistani population. The studies will contribute useful information regarding extra oral-facial aesthetics, which will be helpful for clinicians to impart a dental appearance that is pleasingly consistent with an ideal and overall facial esthetics.

Deciding on dental proportion in smile design requires knowledge of established dental ratios, but none of the proposed dental proportions for anterior teeth were found in esthetically pleasing smiles. The existing evidence indicates that racially based set values should be considered while restoring maxillary anterior teeth. Furthermore, custom dental gauges, grids, and software programs could be constructed based on scientific data from different countries to be used for a specific population.

Additionally, the modified horizontal mid and lower facial third measurements are recommended to determine the maxillary anterior teeth width. The inner-intercanthal distance modified by golden percentage and interpupillary distance by Preston proportion can be used to predict the combined width of central incisors and intercanine distance. Similarly, the Interphiltral distance modified by Preston proportion is a reliable method to predict maxillary central incisor width. The current study indicates that predicted combined width of central incisors and intercanine distance using Preston proportion and golden percentage by inner intercanthal distance, interphiltral distance, and interpupillary distance showed an exact match of maxillary anterior teeth width. This provides substantial scientific evidence of evaluation. The metric could be adopted by clinicians to construct an esthetically pleasing smile. The metrics could also be used by digital programmers in Rapid prototyping machines, computer-aided design, and computer-aided manufacturing (CAD-CAM).

1.4 Research questions

1.4.1 Phase 1 of the study

1. Is there any difference in the width of natural maxillary anterior teeth via 2Dphotographs, 3D digital models, and plaster dental cast study?
2. Is there any difference in gender and side disparities in the widths of natural maxillary anterior teeth via 2D photographs, 3D digital models, and plaster dental cast study?
3. Is there any difference in in perceived and actual widths of natural maxillary anterior teeth in Pakistani population?
4. Is there any difference in the proportions of natural maxillary anterior teeth via 2D photograph and 3D digital dental models' study?
5. Is there any difference in the norms of local proportion in maxillary anterior teeth of Pakistani population via 2D photographs, plaster and 3D digital models?
6. Is there any difference in the crown width and height ratio at different crown levels in natural maxillary anterior teeth via 2D photographs, plaster and 3D digital dental models study?
7. Is there any difference in relationship between horizontal facial proportion and widths of natural maxillary anterior teeth in Pakistani population via 2D photograph and 3D digital dental models' study?
8. Is there any difference of gender disparities in the relationship of facial proportions with the widths of natural maxillary anterior teeth via 2D photograph and 3D digital dental models' study?
9. Is there any difference in the relationship of horizontal facial proportions with the dental proportion of maxillary anterior teeth via 2D photograph and 3D digital dental models?

10. Is there any difference in the norms of human body weight and height modified by the golden and 70% RED proportion to predict the width of maxillary anterior teeth?
11. Is there any difference in the frequency of proximal contact area (PCA) and proximal contact area proportion (PCAP) between maxillary anterior teeth?

1.4.2 Phase 2 of the study

1. Is there any difference in perception of smile attractiveness utilizing 2D photographs among layperson and dentists?
2. Is there any difference in the factors affecting attractive smile utilizing 2D photographs in layperson and dentists?

1.5 Objectives of the studies

1.5.1 General objective

The primary aim of this research was to determine the proportions of extra oral-facial aesthetics with natural maxillary anterior teeth and perception of smile attractiveness in Pakistani population utilizing 2D photographs and 3D digital dental models.

1.5.2 Specific objectives

1.5.2.1 Phase 1 of the study

The specific objectives for this study were:

1. To evaluate the width of natural maxillary anterior teeth via 2D photographs, 3D digital models, and plaster dental cast study.
2. To determine gender and side disparities in the widths of natural maxillary anterior teeth via 2D photographs, 3D digital models, and plaster dental cast study.
3. To determine the difference in perceived and actual widths of natural maxillary anterior teeth in Pakistani population.
4. To determine the proportions of natural maxillary anterior teeth of Pakistani population via 2D photographs, 3D digital models, and plaster dental cast study.
5. To determine the norms of local proportion in maxillary anterior teeth of Pakistani population via 2D photographs, 3D digital models, and plaster dental cast.
6. To determine the crown width-height ratio of natural maxillary anterior teeth via 2d photographs, plaster dental cast, and 3d digital dental model's study.
7. To determine the relationship between horizontal facial proportions and natural maxillary anterior teeth width in Pakistani population via 2D photographs, plaster dental cast, and 3D digital dental models' study.
8. To determine gender disparities in the horizontal facial proportions of Pakistani population.
9. To determine and compare the modified horizontal facial proportions with natural maxillary anterior teeth via 2D photographs, plaster dental cast, and 3D digital dental models study.
10. To formulate and compare the norms of the human body weight and height modified by the golden and 70% RED proportion to predict the width of maxillary anterior teeth.
11. To determine the frequency of proximal contact area (PCA) and proximal contact area proportion (PCAP) between maxillary anterior teeth in Pakistani population.

1.5.2.2 Phase 2 of the study

1. To determine the perception of smile attractiveness utilizing 2D photographs among layperson and dentists.
2. To determine the factors affecting attractive smile utilizing 2D photographs among layperson and dentists.

1.6 Research Hypothesis

1.6.1 Phase 1 of the study

1. There is a significant difference in width of natural maxillary anterior teeth via 2D photographs, 3D digital models, and plaster dental cast study.
2. There is a significant difference gender and side disparities in the widths of natural maxillary anterior teeth via 2D photographs, 3D digital models, and plaster dental cast study.
3. There is a significant difference in perceived and actual widths of natural maxillary anterior teeth via 2D photograph, 3D digital dental model, and stone dental cast study.
4. There is a significant difference in dental proportions of natural maxillary anterior teeth via 2D photograph and 3D digital dental models study.
5. There is a significant difference in the norms of local proportion in maxillary anterior teeth of Pakistani population via 2D and 3D digital models.

6. There is a significant difference in the crown width height ratio at different levels of natural maxillary anterior teeth via 2D photographs, plaster, and 3D dental models study
7. There is a significant difference in the relationship between facial proportion and widths of natural maxillary anterior teeth in the Pakistani population via 2D photographs, plaster dental cast, and 3D digital dental models' study.
8. There is a significant difference in gender disparities in the relationship of facial proportions with the widths of natural maxillary anterior teeth via 2D photographs, plaster dental cast, and 3D digital dental models' study.
9. There is a significant difference in the modified horizontal facialproportions with natural maxillary anterior teeth via 2D photographs, plaster dental cast, and 3D digital dental models study.
10. There is a significant difference in the norms of body weight and height modified by the golden and 70% RED proportion to predict the width of maxillary anterior teeth.
11. There is a significant difference in the frequency of proximal contact area (PCA) and proximal contact area proportion (PCAP) between maxillary anterior teeth.

1.6.2 Phase 2 of the study

1. There is a significant difference in the perception of attractive smiles utilizing 2D photographs among layperson and dentists.
2. There is a significant difference in factors affecting attractive smile utilizing 2D photographs in layperson and dentists.

Chapter 2

LITERATURE REVIEW

2.1 Facial Esthetics

Beauty is a combination of qualities that gives intense pleasure and deep satisfaction to the senses or the mind, it is a philosophical concept and studied under the term esthetic which is derived from the Greek word “aisthesis” meaning “perception”. Esthetics, therefore, is the study of beauty and to a lesser extent its antonym the ugliness (Naini, 2011). Esthetics incorporates both the assimilation and assessment of beauty, proportions, and harmony (Naini and Gill, 2008).

The appraisal of facial beauty is immersed in internal thoughts and therefore inclines towards the world of art. Facial beauty can be assessed mathematically and therefore fit somewhere between art and science. Beauty occupies an important role in the daily life of a human being, it presents a standard of comparison and can cause displeasure and unhappiness when not achieved. The people who do not fit the beauty may be avoided within their communities (Naini and Gill, 2008).

2.2 History of facial beauty background

The primitive western theory of beauty can be found in the works of early Greek philosophers from the pre-Socratic period, such as Pythagoras (Atiyeh and Hayek, 2008). The Pythagorean school saw a strong connection between mathematics and beauty. In particular, they noted that objects proportioned according to the golden ratio

seemed more attractive (Gallao *et al.*, 2009). Ancient Greek architecture is based on this view of symmetry and proportion. Modern research suggests that people whose facial features are symmetric and proportioned according to the golden ratio are considered more attractive than those whose faces are not (Condon *et al.*, 2011). The modern style and fashion vary widely amongst individuals and cross-cultural research has found a variety of commonalities in people's perception of beauty (Naini *et al.*, 2008). Large eyes and a clear complexion, for example, are considered beautiful in both men and women in all cultures (Naini *et al.*, 2011). Neonatal features are inherently attractive and, in general, is associated with beauty (Condon *et al.*, 2011).

The question "What is beauty?" Has been one of the most debated and written about concepts in western literature. Margaret Wolfe Hungerford (1878) stated "Beauty is considered a mystifying quality that some faces have'' or maybe, ''in the eye of the beholder''. Plato (428−348 BC) alluded to this concept and described it as "Beholding beauty with the eye of the mind" (Mehl *et al.*, 2011). The great philosopher (Immanuel Kant 1790) stated "The beautiful is that which pleases universally without a concept". The idea that one can take after looking into all these would be, perhaps beauty as a concept can be perceived but not fully explained. This debate will no doubt linger on (Rufenacht, 1992).

The human perception of facial beauty has multifactorial foundations. The genetic evidence of facial beauty theory is supported by a change in human behaviour, that infants from newborns until two years of age, when presented simultaneously with two facial images, tend to stare longer at the face previously rated as more appealing by adults (Naini, *et al.*, 2011). The evolutionary basis is that facial beauty is a requirement for sexual selection, leading to the improved opportunity for reproduction (Johnson,

1992). Another considerable analysis confirms that there is a cross-cultural agreement regarding facial beauty (Langlois *et al.*, 1987).

2.3 Facial proportions and symmetry

The concept of harmonious proportion as a secret of beauty is perhaps an old idea regarding the nature of attractiveness (Park *et al.*, 2010). The Egyptians in the ancient era had a great interest in art and beauty. The famous painted figure of Queen Nefertiti with her harmonious facial proportions and symmetry is an example of how the Egyptians immortalized the beauty of their kings and queens by depicting them with "ideal" facial proportions (Peck and Peck, 1970).

The Egyptian proportional standards in this regard used grids with meshes of equal-sized squares (Levin, 1964). This was an attempt to bring a change with the age of Greek sculptures which focused on the harmonious proportion between the parts of the human figure. In this course, a Greek mathematician Pythagoras (6^{th} century BC) postulated that beauty could be explained through mathematical laws and laws of proportion. He described an explanation of beauty through a significant finding that plucking taut strings of proportionately different lengths produces harmonious notes (Pierce, 2005). The difference in the proportionate lengths of the strings followed mathematical laws, and hence his explanation of laws of proportion. The Pythagoras uses the cosmos to describe beauty, as he felt that beauty was part of the mathematical order of the universe, from which the term the word "cosmetic" originates (Levin, 1964; Pierce, 2005). Many painters and sculptors have attempted to establish ideal proportions for the human form; in this regard, the most famous amongst all about ideal proportions is the rule of golden proportion (Preston, 1993).

2.4 Golden proportion

The geometrical proportion in which a line AB is divided at a point C in such a way that AB/AC = AC/CB. That is, the ratio of the shorter section to the longer section of the line is equal to the ratio of the longer section to the whole line. This gives AC/AB the value 0.618, termed the Golden Number. The point at which the line is divided is known as the Golden Section and is represented by the symbol (Phi), derived from Phidias the name of the Greek sculptor (Kapusta, 2004).

The great mathematician (Luca Pacioli, 1509) has re-named the Golden proportion the "Divine proportion" he felt that the concept was not fully explained, and started using it with a new name, using this name Leonardo da Vinci drew figures of symmetrical and proportionate faces and bodies (Kapusta, 2004). Another concept, which gives reliance to the Golden Proportion, is the Fibonacci sequence, Leonardo of Pisa (1170−1240), also known as Leonardo Fibonacci, described a number sequence in which each number is the sum of the two preceding numbers, i.e. 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, etc (Koshelev, 1997). In the 19th century, the mathematician Edouard Lucas coined the term Fibonacci sequence, and scientists began to discover the numbers in nature, such as in the spirals of sunflower heads, the logarithmic spiral in snail shells, and animal horns figures (Peck and Peck, 1970; Koshelev, 1997). As the numbers increase in magnitude, the ratio between succeeding numbers approaches the Golden Proportion (Levin, 1978). Attempts have been made by researchers to date in applying the concept of the golden proportion to dental esthetics (Rosenstiel and Rashid, 2002). In smile design, the golden proportion is applied in the apparent mesiodistal width of the anterior teeth when viewed from the frontal aspect (Spear *et al.*, 2006).

2.5 Standards/canons of proportion

The standards of proportions are in practice since 5th century. It is based on esthetic parameters that deals with beauty of overall body stature. It underwent revolution extensively with the advancing world. The following text is based on successive changes that have occurred with advancement in the field of esthetics.

2.5.1 Greek sculptors (5th century BC)

The Greeks discussed ideal mathematical proportions for the parts of the human body. The mathematical proportions and laws described by Polycleitus are based on the work described by Pythagoras, Roman copies of one of his most famous statues, the "Doryphorus" ('Spear Bearer') still exist. The statue is itself often referred to as the 'Canon' because it embodies Polycleitus' views on the correct proportions of the ideal male form (Demus and Forlati, 1960).

2.5.2 Galen (2nd century AD)

The renowned Greek physician and philosopher said, "Beauty does not lie in the individual parts, but the harmonious proportion of all the parts to each other". During the same period, Polycleitus described the importance of symmetry concept in the human form combined with ideal proportions, which he referred to as symmetric (Gross, 1998).

2.5.3 Marcus Vitruvius Pollio (1st century BC)

The Roman architect was legendary for describing the facial beauty and proportional division of the human body, especially well known for introducing facial trisections. He described the “symmetrical harmony” of the “ideal “human body and compared this to perfect buildings (Levin, 1964).

2.5.4 Leonardo da Vinci (1452−1519 BC)

The famous figurine artist and mathematician stated proportion as the ratio between the respective parts and to the whole (Levin, 1964). His work produced studies on the proportions of the human head, and combinations of various forms of foreheads, chin, nose, and mouth (Rosenstiel and Rashid, 2002).

The figure of the Vitruvian man, which Leonardo based on guidelines described by Vitruvius, represents “ideal” male proportions based on man’s navel as the centre of a circle enclosing man with outstretched arms. This reflects the importance of proportions in the human form. The distance from the hairline to the inferior aspect of the chin (soft tissue menton) is one-tenth of a man’s height. The distance from the top of the head to soft tissue menton is one-eighth of a man’s height.

2.5.5 Albrecht Durer (1471−1528 BC)

The famous German artist highlighted the importance of facial and dental proportions. He said that disproportionate human faces are unaesthetic, whereas proportionate features are acceptable if not always beautiful; today the guidelines used by dentists are based on those initially described in art and sculpture, with some

modification from the original. The changes made in the initial standards or guidelines used by dentists currently are based on population averages, which comes from studies using radiographic anthropometry, photography, and individual teeth analysis (Goodlin, 2011).

2.6 Dental Esthetics

Dental esthetics comprised of overall harmony between dental and facial parameters of esthetics, such as microesthetics, macroesthetics, and miniesthetics. Esthetic dentistry is a branch of restorative dentistry which deals with the knowledge, application and evaluation of dental esthetics.

2.6.1 Esthetic dentistry

Esthetic or cosmetic dentistry is an emerging and advancing part of the modern-day dental practice, the terms esthetic and cosmetic is synonymously used in dental nomenclature, cosmetic means to do something superficial to cover a defect or deficiency (Hugo and Denner, 2009). Esthetic dentistry itself refers to those skills and techniques used to improve the art and symmetry of the teeth and face to improve the appearance as well as the function of the teeth in the mouth, and face. Esthetic dentistry is an imitation of nature and mimicking the lost state of harmony to rehabilitate the lost or congenitally missing parts (Rifkin, 2000). The beauty of esthetics lies in its concealment, ideal and perfect beauty may not fulfil esthetic demands.

One of the important aspects of esthetic dentistry is designing smiles (Soares *et al.*, 2016). The smile design in restoring esthetics is a collection of artistic work needed

for patients seeking restoration in the anterior zone or esthetic zone (Hugo and Denner, 2009). This comprises dentofacial elements in a specific sequence (Soares *et al.*, 2016).

2.6.2 Facial, and dental midline relationship

In smile design, the starting point of the esthetic assessment is the facial midline. Clinicians use the maxillary central incisors as their esthetic baseline and then move laterally to the lateral incisors and canines to the premolars and beyond. Prominent facial anatomy including the eyes, nose, and chin can be deceptive in locating the midline. Anatomically, people's eyes are found at slightly different levels or different depths within the orbital sockets (Ahmad, 1998).

Many patients have their noses or chins that deviate from the centre, which undermines these landmarks as indicators of the facial midline (McLaren and Rifkin, 2002). Anatomical landmarks like nasion at the bridge of the nose and cupid's bow in the centre of the upper lip, when connected in a straight line can be the best indicator of midline (Arnett and Bergman, 1993). The dental midline i.e., the midline between the maxillary central incisors should coincide with the facial midline. If the visual junction of maxillary central incisors is at an angle to the facial midline, it is referred to as a canted midline (Arnett and Bergman, 1993; Ahmad, 1998).

Canting is a major design flaw in any natural or restored dentition. The alignment of the maxillary and mandibular dental midlines is desirable in dentistry, but the mandibular midline may become a lesser issue in esthetics as mostly anterior teeth are covered with lower lip during smiling. The narrowness and uniform sizes of mandibular incisors make visualization of their middle point more difficult,

particularly when seen in relationship to lips and other soft-tissue landmarks (Chiche and Pinault, 1994).

The study by (Kokich Jr *et al*., 1999) showed that the public could not tell that the dental midline was off from the facial midlines of up to 4 mm. As long as the midline is parallel with the long axis of the face midline discrepancies of up to 4 mm will generally not be perceived as unesthetic, slight corrections of midlines can be corrected utilizing esthetic dentistry parameters as long as the maxillary central are made symmetrical and correct intertooth relationships are maintained. Ideally, the dental midline should end up linear with the facial midline, but this is not the case. The minute discrepancy in the midline is accepted within functional limits because midline abnormalities are the least noticed by patients and dental personnel.

2.6.3 Dentolabial relationship (the relationship of the teeth to the lips)

The relationship of the lips to the teeth or visual tooth display both statically and dynamically is directly related to lip length and teeth length. The research in this regard has shown that the average 30-year-old woman displays about 3.5 mm of maxillary central incisor tooth structure when the lips are at rest (Vig and Brundo, 1978; Connor and Moshiri, 1985).

In replacement of lost anterior teeth, this is generally recommended that 2 mm of tooth structure is displayed at rest. The 2mm exposure at rest is generally less than desired by esthetically driven patients, for most patients who have improved esthetics as their primary treatment goal, between 3 mm and 4 mm displayed at rest will be esthetically ideal (Frush and Fisher, 1958).

Another parameter for the esthetic position of the maxillary anterior incisal edges applies when the patient smiles. In an esthetic composition, the tips of the maxillary anterior teeth should ideally come very close to touch the lower lip up to a maximum of 3 mm away. The esthetic results can be obtained by positioning the incisal edges of the maxillary anterior teeth within these two dentolabial esthetic zones (McLaren and Rifkin, 2002).

Teeth length, width and position, lip length, and lip mobility greatly affect maxillary tooth display both statically and dynamically. The average lip length is found to be between 20 mm to 24 mm, measured from the base of the nose to the edge of the upper lip (Arnett and Bergman, 1993). Average lip mobility in a normal esthetic smile is 7 mm to 8 mm as measured according to the Centre for Esthetic Dentistry (CED) (Rifkin, 2000). In a study by (Kokich Jr *et al*., 1999) it was demonstrated by photographs that it is still appealing if 2 mm of gingival shows in a full smile.

This was opposed by (Marcel, 2001a) according to them it is still in the esthetic zone to show up to 3 mm of gingiva in a full smile, especially if there is slightly more than 8 mm lip movement during a smile. In an esthetic smile, the edges of the maxillary anterior teeth follow a convex course matching the curvature of the lower lip and there must be a negative space, which is a small space between the maxillary posterior teeth and the inside of the cheek. A broad smile with a minimal buccal corridor is deemed most esthetic by lay people (Kokich Jr *et al.*, 1999; Moore *et al.*, 2005). However, a broad smile without a buccal corridor could also be perceived as fake.

2.6.4 Dento-gingival analysis (the relationship of the teeth to the gingiva)

The lips frame the teeth and gingival, the ratio of tooth structure to the amount of gingival and labial tissue should be harmonized to prevent an over-dominance of any one element. Gingival margin placement is based on lip mobility, and to a certain extent on the desired tooth length. The other factors to consider in designing esthetic gingival relationships are the gingival line (the relationships of free gingival margins of the maxillary teeth), gingival scalloping and contour, papillary tip positioning, and gingival colour. The gingival line, with slight discrepancies like dental midline, is least noticed by the general public and dental professionals. In an esthetic smile, the gingival line for the anterior teeth should be relatively horizontal to the horizon and relatively symmetric on both sides of the midline (Marcel, 2001a).

It may radiate up slightly as it goes posterior, this is not critical that the lateral incisor gingival line fall incisal to the central as this is not obvious when a person is smiling. Positioning the lateral to the central incisor within 0.5 mm gingivally and 1 mm incisally is generally perceived as eye-catching as long as horizontal symmetry is maintained. The contour of the gingiva or the gingival scallop to the tip of the papilla should be between 4 mm or 5 mm, the tips of the papillae should have the same radiating symmetry as the incisal edges and the free gingival margins. In an esthetic smile, the volume of the gingiva from the apical aspect of the free gingival margin to the tip of the papilla is about 40% to 50% of the length of the maxillary anterior tooth and fills the gingival embrasure. Gingival color should appear pink and healthy or consistent with the healthy colour of individual race variations (Wheeler, 1958; Marcel, 2001a).