EVALUATION OF CHANGES IN SMILE AESTHETICS WITH FIXED ORTHODONTIC TREATMENT

Dissertation submitted to

THE TAMILNADU DR. M.G.R.MEDICAL UNIVERSITY

In partial fulfillment for the degree of

MASTER OF DENTAL SURGERY

BRANCH V – ORTHODONTICS AND

DENTOFACIAL ORTHOPEDICS

APRIL 2012

CERTIFICATE

This is to certify that this dissertation titled **"EVALUATION OF CHANGES IN SMILE AESTHETICS WITH FIXED ORTHODONTIC TREATMENT"** is a bonafide record of work done by **Dr. Ashwin Varghese Thomas** under my guidance during his postgraduate study period between 2009–2012.

This dissertation is submitted to **THE TAMIL NADU Dr. M.G.R. MEDICAL UNIVERSITY**, in partial fulfillment for the degree of **Master of Dental Surgery** in Branch V – Orthodontics and Dentofacial Orthopedics

It has not been submitted (partially or fully) for the award of any other degree or diploma.

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Acknowledgement

Acknowledgements

Words seem less to express my deep sense of gratitude to my postgraduate teacher ***Dr. N.R. Krishnaswamy,*** *M.D.S., M.Ortho RCS. (Edin), Diplomat of Indian board of Orthodontics, Professor and Head, Department of Orthodontics, Ragas Dental College and Hospital, Chennai, for his valuable guidance and suggestions, tireless pursuit for perfection, immense and constant support, encouragement and keen surveillance for the minute details throughout this dissertation.*

I am privileged to express my extreme gratefulness to my respected Guide and Professor ***Dr. S. Venkateswaran****, M.D.S for being a constant source of support and supervision, who stimulated, enthused and encouraged me in the preparation of this main dissertation. I thank him for all the help that have been conferred upon me, without which this dissertation would not have become possible.*

I gladly utilize this opportunity to express my deep sense of gratitude and indebtedness to my respected Professor ***Dr. Ashwin George****, M.D.S, for his everlasting inspiration, incessant encouragement, constructive criticism and valuable suggestions conferred upon me without which this dissertation would not have come true.*

I am grateful and sincerely thankful to ***Dr. Shahul Hameed Faizee****, M.D.S, (Associate Professor), for his vehement personal interest, wise counsel and never ending willingness to render generous help to me in carrying out this work from its inception to its consummation.*

My sincere thanks to Professor ***Kanakaraj****, Chairman &* ***Dr. Ramachandran,*** *Principal of Ragas Dental College for providing me with an opportunity to utilize the facilities available in this institution in successful completion of this study.*

I am greatly beholden to ***Dr. Anand*** *(Reader),* ***Dr. Jayakumar*** *(Reader),* ***Dr. V. K, Shakeel Ahmed*** *(Reader),* ***Dr. Rekha*** *(Reader) and lecturers,* ***Dr. Shobana, Dr. Prabhu*** *and* ***Dr. Biju,*** *for their support, enthusiasm & professional assistance through my post graduate course.*

My heartfelt thanks to my wonderful seniors and batch mates, ***Dr. Gautham Kalladka, Dr. Amey Rati, Dr. Fayyaz Ahmed, Dr. Vashi, Dr. Ayush Sharma , Dr. Sheel Vora, Dr. Sreesan N.S. , Dr. V. Saravanan, Dr. D. Mahalakshmi****, Dr. S. Vinoth,** *and* ***Dr. Sabitha Nair*** *who were cheerfully available at all times to help me. I wish them a successful career ahead.*

I also extend my gratitude to my juniors, ***Dr. Manikandan, Dr. Deepak, Dr. Ravanth, Dr. Ashwin, Dr. Shakthi, Dr. Sivasubramanium, Dr. Aarthi, Dr. Vikram, Dr. Femin, Dr. Vishal, Dr. Murali, Dr. Saptarishi, Dr. Manali, Dr. Gayatri and Dr. Regina*** *for all their support and for cooperating with me to conduct this study.*

I would also like to thank ***Mr. Ashok*** *and* ***Mr. Rajendran*** *for helping me with the photographs for the study.*

I would like to thank ***Sister Lakshmi, Sister Rathi, Sister Kanaka, Ms. Haseena, Mr. Bhaskar, Ms. Divya and Ms. Banupriya*** *for their help during my post-graduate course.*

I also take this opportunity to pay my heartfelt gratitude to my family for being a pillar of support during my postgraduate life.

Last but not the least let me thank Almighty God for his abundant blessings that he has showered upon me.

CONTENTS

Introduction

INTRODUCTION

The face is the most important individual factor determining the physical appearance of people, in which the mouth and teeth are considered fundamental in facial aesthetics. [66,51] It is essential to enhance the aesthetic effects brought about by orthodontic treatment, which is only possible by knowing the principles that influence the balance between teeth and soft tissues during an ideal smile.[50,19] Consequently, more thorough studies are required on the details that can contribute to the aesthetic balance between teeth and soft tissues. It is also important to understand the factors influencing smile aesthetics to prevent worsening of the smile with orthodontic treatment.

Facial attractiveness plays a key role in social interaction. The fact is that in social interaction, one's attention is mainly directed towards the mouth and eyes of the speaker's face.[70] This has been demonstrated in studies with photographs, where higher intellectual and social abilities were attributed to individuals with aesthetic smiles. There is also a variation in perception of aesthetics among different ethnic populations. Therefore, the results of these studies should be viewed according to the demographic area where it was done.

As dental professionals, we must realize that this could have a great impact on the services provided to a patient because the concept of beauty might not be congruent between the patient and the doctor. Concerned with this, Wylie astutely wrote that "the layman's opinion of the human profile is every bit as good as the orthodontist's and perhaps even better since it is not conditioned by orthodontic propaganda.[59]''

An attractive smile has always been the focal point of improving a person's aesthetic appearance and thus self-esteem.[43] It is the contrast of shape, colour, line, and texture that enables us to differentiate one tooth from another, the teeth from the gums, and the smile from the face. We perceive an ideal smile as bright, vigorous, and youthful, regardless of age. From a cultural standpoint, a prominent smile with bright teeth is synonymous with youth and dynamism. This ideal smile is based on an intact and well aligned, harmonious dentition.

A smile is formed within the border of the lips. There are distinct elements contributing to a smile, including the incisal edges, the gingival embrasures, the gingival height of contour, and the inter-proximal contact areas. A consonant smile arc is more attractive than a nonconsonant one.[63] Smile arc is defined as the relationship of the curvature of the incisal edges of the maxillary teeth to the curvature of the lower lip in a social smile.[55] Other important factors in smile

appearance are the gingival display, relative gingival heights and gingival shape.

Patients smiling with their teeth entirely displayed and some gingival display (two to four millimetres), perceived their smile line as most aesthetic.[55] Proportional gingival heights are also needed to produce a normal and attractive dental appearance. Generally, the central incisor has the highest gingival level, the lateral incisor is approximately 1.5 mm lower and the canine gingival margin again is at the level of the central incisor.[55] For ideal appearance the contour of the gingiva over the maxillary central incisors and canines is a half-ellipse, with the zenith distal to the midline of the tooth. The maxillary lateral incisor, in contrast has a gingival contour of a half circle with the zenith at the mid-line of the tooth.[55]

Most orthodontic patients evaluate the treatment outcome by their smiles and overall enhancement of facial appearance.[25] Aesthetics can be defined as relating to feelings and perceptions can be defined as the organization of environmental stimuli. “Dentofacial Appearance is a significant predictor of orthodontic patient’s expectations of treatment”.[4] Traditional approaches to orthodontic diagnosis and treatment planning were based almost exclusively on models and cephalometric numbers. However, in the contemporary approach, the orthodontist focuses on the clinical examination of the patient both at

rest and smile animation and in all three physical dimensions. The emphasis is not so much on linear and angular norms but is on appropriate proportionality of facial features.

Smile analysis and smile design have become key elements of orthodontic diagnosis and treatment planning over the last decade.[42] Recent advances in technology now permit the clinician to measure the dynamic lip-tooth relationship and incorporate that information into the orthodontic problem list and biomechanical plan. Digital videography is particularly useful in both smile analysis and in doctor/patient communication. Smile design is a multi-factorial process, with clinical success determined by an understanding of the patient's soft-tissue, treatment limitations and the extent to which orthodontics or multidisciplinary treatment can satisfy the patient's and orthodontist's aesthetic goals.[2]

The aesthetics of smile is influenced by features such as the arch form, smile arc, overjet, incisor inclination, transverse cant of maxillary occlusion plane, gingival display, the shade of teeth, and co-incidence of the dental midline to facial midline. Aesthetic problems require description of parameters so that the defects can be located. When searching for the visualization of problems, several rules and assumptions are created, leading sometimes to an underestimation of defects or an overvaluing of rules, creating paradigms that are not supported by proven scientific data.

The use of simple and reliable mechanisms can improve the possibilities of success, if not eliminate performance errors. The Diagram of Facial Aesthetic References (DFAR) is an auxiliary diagnostic tool that is well suited to this purpose.

Obtaining a beautiful smile is always the main objective of any aesthetic dental treatment. However, an improvement in smile aesthetics is not always achieved as a result of orthodontic therapy. Also, there is difference in the smile aesthetics as perceived by the Orthodontists and Laymen.[15] Moreover, there were only a scant number of studies in literature that assess the change in smile aesthetics with orthodontic therapy either objectively or subjectively.

Therefore, the purpose of this study was to evaluate the improvement of smile aesthetics objectively by using the Diagram of facial aesthetic reference and to evaluate the attractiveness of the smile of orthodontic patients before and after treatment as perceived by Orthodontists, General Dentists and Laymen by means of a Visual Analogue Scale.

Review of Literature

REVIEW OF LITERATURE

Facial and dental attractiveness can significantly impact one's life. Langois[35] believed that facial attractiveness is highly correlated with a better quality of life and inter personal success. Individuals who are more attractive are perceived as more intelligent, confident and socially acceptable.

Numerous studies have shown the effect of dental attractiveness on psychosocial well being[6,19,26,36,65] and interpersonal relationships. Shaw showed that dentofacial attractiveness has a strong influence on a young adult and their preference for friends.[65] It has also been shown that when compared with less attractive people, more attractive people are seen as more popular[8,31,53,72] intelligent[9], sociable[10,31] and have greater dating potential.[36]

Peck et al[51] (1992) describes the evolution of facial aesthetic ideals from early ancient civilizations in Egypt, China, and Greece, through the Renaissance, and up until the present date. A number of different concepts have been used to quantify facial aesthetics. One of the most well-known is the Golden Proportion, a mathematical concept originally introduced by the Egyptians. It has often been used to categorize the elements of the ideal smile and facial form. While not limited to facial aesthetics, this proportion has often been noted in many classical art forms. Others have attempted to base perfect

proportionality on the square root of two and other derivatives of the Fibonacci sequence.[17,60,22]

Many of these mathematical formulas and aesthetic concepts are a pseudoscience and remain unsubstantiated. Prosthodontists and orthodontists in the 19th and 20th century based their treatment on many of these concepts but had little or no scientific basis for doing so. Ricketts[56,10] originally tried to apply such a ratio to facial aesthetics stating that the ratio of forehead to eye, and eye to menton should equal the 1:1.618, the divine proportion. Others have tried to apply such ratios to the dimensions of the maxillary anterior teeth, but this has been subsequently disproved.[54]

For the ease of understanding, the literature has been reviewed in five parts, as follows:-

1. Facial Attractiveness

Shaw W.C. et al[66] (1985) studied changes in social attractiveness based on changes in dental and facial appearance. In this study, Shaw had individuals rate photographs of attractive and unattractive males and females with dental changes such as the prominence of the incisors, missing lateral incisors, severely crowded incisors, and unilateral cleft lip. Changes in dental and facial

morphology were found to affect social attractiveness, with facial aesthetics having a greater impact than dental aesthetics.

Hunt O et al[23] (2001) surveyed dental professionals, general dentists and orthodontists, and determined that dentists agreed that benefits of orthodontics were primarily self-esteem, physical and facial attractiveness.

Sarver D.M. et al[63] (2001) defined the smile arc as the relationship between the curvature of incisal edges of the maxillary anterior teeth and the curvature of the lower lip. He thought that ideally these two curvatures should parallel to one another. His thought was in absolute agreement with layperson's perspective from other research studies.[28, 15, 68] Sarver also proposed that a posed smile should ideally have some gingival display. His thinking was that the gingival display made the smile look more youthful.[29] Other studies that looked at smile characters from the layperson's view found that one to two millimetre of tooth coverage on a posed smile was ideal.[28, 68] It is clear from the literature that dental professionals do not view all aspects of the smile similarly to patients.[38,64]

Moore T et al[41] (2005) defined the smile as a compilation of many dental variables, such as gingival display, tooth colour, smile arc, buccal corridor and much more. Some dental variables, such as buccal corridor, smile

arc and upper midline have been studied more extensively than others. It is important to understand the influence of each variable on the smile and their optimal characteristics from the patients' perspective.

Kiekens et al[29] (2006) found that smile aesthetics contributed to 25-31% to facial attractiveness. These results were disappointing to orthodontists because the mouth did not receive as much attention as perceived. These data questioned the importance of the dentition or smile to an individual's facial attractiveness and its contribution to the quality of life to an individual.

Kiyak H.A. et al[30] (2008) reviewed the effects of a pleasing dentition on the quality of life. Kiyak thought that dental aesthetics did not enhance social acceptance. She also reported that orthodontic intervention did not contribute much to improve oral health and function. She concluded that undergoing orthodontics improved aesthetics and the psychosocial well-being of individuals. Adolescents who have completed orthodontic treatment reported less negative psychosocial influence, than those who were never treated.

Rodrigues C et al[61] (2009) had people judge an individual smiling with several digitally modified smiles. They looked at smiles with a small diastema, upper midline deviation, long axes lateral incisor discrepancy, reverse smile arc or no discrepancy. Perspectives were oral and full face views. Raters were asked to rank the images in order of attractiveness and on a

10 point scale. Non-ideal smiles received lower attractiveness ratings compared to the ideal smile. A midline diastema was most detrimental to dental and facial attractiveness than any other deviations. Obviously, some smile variables are more important to the smile and facial attractiveness than others.

Hickman L et al[21] (2010) looked at eye fixations on frontal facial images. Post-treatment orthodontic patients with skeletal class I profiles were used as models to eliminate any confounding factors that may be caused by an individual with distinct features. Adult subjects were recruited and an eye tracking device was used to follow eye movements, determine the area of interest and record the time the eye fixated on the particular area. Six categories of interest were identified - eyes, ears, mouth, nose, chin and other (forehead, cheeks, hair, throat, neck and background). Their findings revealed that the "other" category received 50% of the attention. The mouth which is area of interest to orthodontists, received only 5.1% of the attention.

Havens D.C. et al[20] (2010) showed that dental aesthetics does have an effect on facial aesthetics. Twenty orthodontists and twenty lay evaluators determined a split-line for attractive and unattractive images. The proportions of attractive patients were compared across Q-sorts using a Wilcoxon signed-rank test for paired data. The evaluators also ranked nine facial/dental characteristics at the completion of the six Q-sorts. Results showed that the pre-treatment face without the smile to be significantly more attractive than

the face with the smile or the smile-only photographs. Moreover, the two panels agreed on the proportion of ‘‘attractive’’ subjects but differed on the attractiveness level of each individual subject. They concluded that the presence of a malocclusion has a negative impact on facial attractiveness and that orthodontic correction of a malocclusion affects overall facial aesthetics positively. They also added that Laymen and Orthodontists agree on what is attractive and overall facial harmony is the most important characteristic used in deciding facial attractiveness.

2. Parameters of Smile Attractiveness

The study of smile aesthetics represents an intermediate between dental and facial aesthetics. As detailed below, the evolution of smile aesthetics took an interesting course, one which emerged from the inside out. Many of the early studies focused on the size, shape, and proportions of teeth. As these ideas developed, the focus changed to encompass the importance of symmetry as well as the periodontal architecture. In the present day, the current focus is not only on the teeth and periodontium, but their relationship to the perioral structures, specifically the extraoral soft tissues.

Williams J.L. et al[73] (1935) concluded that human teeth could be classified into three principal shapes: rectangular, triangular, and ovoid. Williams claimed that in order to produce the most harmonious reconstruction,

tooth selection should be based upon the shape of the subjects head when turned upside down.

Frush J.P. et al[16] (1955) took this idea a step further in an effort to harmonize teeth with the patient's gender, personality and age. It is here that the idea that women should have round, soft, and delicate teeth and that men should have square, angular, and rugged teeth emerged. They also try to apply similar methodology to personality and age.

Dunn W.J. et al[12] (1996) concluded that in the terms of the actual number of teeth displayed, a lay person finds having more number of teeth displayed during smiling is significantly more attractive.

Ackerman J.L. et al[1] (1998) designated the stages of smile as stage I and stage II. Stage I is posed smile, voluntary, need not be elicited or accompanied by emotion and this static smile can be sustained and reproduced. This can be natural or forced (strained). When the patient is asked to pose for a photograph he/she elicits invariably a voluntary unstrained, static yet natural smile. Stage II is un-posed smile, involuntary, induced by some kind of emotion, it is a dynamic burst, cannot be sustained.

Kokich et al[32] (1999) studied the perception of dentist and lay people to altered dental aesthetics and concluded that laypersons could not detect a midline deviation upto 4mm.

Ackerman M.B. et al[2] (2002) did Smile analysis and design in the digital era and concluded that smile analysis and smile design generally involved a compromise between two factors that are often contradictory: the aesthetic desires of the patient and orthodontist, and the patient's anatomic and physiologic limitations. Using Digital Video and Computer technology, the clinician can evaluate the patient's dynamic anterior tooth display and incorporate smile analysis into routine treatment planning. Aesthetic smile design is a multi-factorial decision making process that allows the clinician to treat patients with an individualized, interdisciplinary approach.

Kokich V.O. et al[33] (2006) expanded their previous study by evaluating more smile variables- upper midline diastema, bilateral and asymmetric discrepancies of crowns and papillary heights. The materials and methods were consistent with the previous study with the improvement of decreasing the alterable increments to 0.5mm to 1.0mm. This allowed a greater freedom of choices and a more accurate recording of the dental variables. Changing the alterable increments did not affect the conclusion that orthodontists were most sensitive to dental variables, but it did affect the

clinical values. This was clearly the case for gingival display which made the orthodontists more forgiving and laypersons less forgiving compared to the previous study. Problems with the previous studies by Kokich et al[32] were that surveys were incremental in nature and the increments were quite large and up to 2.0 mm.

Parekh S.M. et al[49] (2006) found that accentuated smile arcs were preferred over a flat smile arcs.

Ker A.J. et al[28] (2008) advanced previous studies using the slider technology to eliminate the incremental nature and created a smooth transition from one increment to the next. Each increment varied from 0.125mm to 0.5mm to improve the quantification of dental variables. It appeared that this improvement did make a difference in some smile variables and provided more precision. Results were similar when comparing a maximal gingival display and central gingival discrepancy. There was a significant difference in upper midline deviation. They concluded that that an upper midline deviation of 2.9 mm was the maximum acceptable limit for acceptable aesthetics.

3. Smile Arc and its Influence on Aesthetics

One aspect of the mini-aesthetics have recently captured the imagination of clinicians is smile arc. This is probably the case because they are

within the realm of orthodontic treatment control, and they can easily be related to other concepts of orthodontic diagnosis and treatment such as arch form and width, gnathalogic concepts of occlusal function, and the extraction/nonextraction controversy.

Hulsey C.M. et al[22] (1970) was one of the first to quantify the smile arc as a ratio to the lower lip. He used the ratio of the length of the perpendicular for the arc of the upper incisors to the length of the perpendicular arc of the lower lip. A perfect or ideal ratio equalled one. The limitation of this measurement was that it only took into account the curvature of the upper incisors and not the remaining dentition and was in fact more of a triangulation of the geometry than an arc. The results of this study showed that orthodontically treated patients had lower smile scores than those that had not been treated (i.e. a flatter smile arc). He found the smile arc to be an important contributing factor to an attractive smile and suggested that orthodontics affected the smile arc, and thus determined how attractive a smile was judged.

Eunkoo K. et al[14] (2003) studied 'Extraction Vs. Nonextraction: Arch Widths and Smile Aesthetics'. Dental casts of 30 patients treated with extraction and 30 patients without extraction of four first premolars were randomly selected to determine changes in arch width as a result of treatment. Arch widths were measured from the cusp tips of the canines, premolars, and molars. Post

treatment arch widths were also measured in the midline at a constant arch depth from the most labial surfaces of the incisors. Standardized frontal photographs of the face taken during smiling of 12 extractions and 12 non-extractions treated subjects were evaluated. Fifty laypeople judged the aesthetics of the smiles. Intercanine width increased less than 1 mm in both groups, and there was no difference between the two groups. The interpremolar and intermolar distance in both arches decreased significantly from 0.53 to 0.95 mm in the extraction sample, whereas the interpremolar and intermolar widths increased significantly from 0.81 to 2.10 mm in the nonextraction sample. When arch widths of both groups were measured from the most labial surfaces of the teeth at a constant depth, the average arch width of both arches was significantly wider in the extraction sample (1.8 mm wider in the mandible and 1.7 mm wider in the maxilla). The mean aesthetic score and the number of teeth displayed during a smile did not differ between the groups. The results indicate that the arch width is not decreased at a constant arch depth because of extraction treatment, and smile aesthetics is the same in both groups of patients.

Parekh S.M. et al[49] (2006) were one of the first to investigate the acceptability of smile with varying smile arcs. He used a similar method of presentation as previous Kokich et al[32, 33] studies and modified it to include a male and female peri-oral component. Nine different permutations were created using flat, ideal and excessive smile arcs with narrow, ideal and excessive buccal corridors determined by previous studies. The raters were

asked, “Is the smile acceptable?” They found no significant differences between the orthodontists and laypersons in evaluating acceptability of these variables. This was a significant finding because it indicated that although the different groups of raters evaluated ideal or detected deviations from the ideal differently, the ranges of acceptability were similar. A drawback to this study was that non ideal smile arcs and buccal corridors were at a set value with no freedom of manipulation. They also concluded that a flat smile arc was detrimental to the smile.

Ker et al[28] (2008) stated that flat smile arcs were still considered acceptable to the laypersons. They conducted the survey using slider technology allowing more freedom for answers. They also expanded on previous smile aesthetic studies by focusing on laypersons only, laypersons from three different regions of the United States and including more smile variables and found a regional difference between 11 laypersons only for buccal corridor. Narrow buccal corridors were more favourable for laypersons in the west coast compared to the Midwest and east coast. Smile variables in this study included buccal corridor, smile arc, maxillary anterior gingival height discrepancy, maxillary gingival display, incisal edge discrepancy, occlusal cant, overbite, central incisor gingival margin discrepancy and maxillary midline to face and to mandibular midline to maxillary midline.

4. The Face and its influence in Smile Aesthetics

Another issue with past smile research studies is that the images focused on the lower face perspective. From a realistic standpoint, judging a smile is not limited to the lower face. It is unknown whether the full face enhances or detracts from evaluation of the smile.

From its beginning, the primary goal of orthodontics has been the development of a well-balanced face; however, most orthodontic analyses have typically examined the face from a lateral view. It has essentially been implied that if the lateral components of the face are well balanced, the frontal aspects will naturally become well balanced.

Mackley R.J. et al[37] (1993) showed that a profile photograph is not a reliable source of information to determine what a smile will look like.

Johnston C.D. et al[27] (1999) studied the difference in perception between orthodontists and laypersons on midline discrepancy using the full face. Evaluators were shown and asked to rate the attractiveness of a full face female model with different midline deviations (0, 1, 2, 4, 6 and 8mm). A 2 mm midline deviation was found to significantly reduce the attractiveness scores for 56% of the raters. Comparing these results with the lower face

image studies, [30, 31] it appears that a full face perspective made it easier to detect the midline discrepancy.

Flores-Mir et al[15] (2004) reported a difference in smile perspectives using circumoral, lower face and full face views. The results showed that the different perspectives made a difference in attractiveness. By increasing the perspective or detracting attention from the oral cavity, attractiveness rating was increased significantly. Evidently, more research is indicated to determine whether the full face magnifies or detracts smile discrepancies.

Proffit et al[55] (2006) suggested that the primary emphasis should be on facial and dental aesthetics as a starting point for treatment goals if they are in concert with the patient's concerns and priorities as long as this approach does not compromise function and stability. One can establish a hierarchy of aesthetic issues in this format.

1. The face in all three planes of space (Macro-aesthetics). Examples of problems that would be noted in that first step would be asymmetry, excessive or deficient face height, mandibular deficiency or excess, etc.
2. The smile framework (Mini-aesthetics). The smile framework is bordered by the upper and lower lips on smile animation and includes such assessments as excessive gingival display on smile, inadequate gingival display, inappropriate gingival heights, and excessive buccal corridors.

3. The teeth (Micro-aesthetics). This includes assessment of tooth proportions in height and width, gingival shape and contour, connectors and embrasures, black triangular holes, and tooth shade.

Springer et al[68] (2011) evaluated several smile variables on a full face perspective. They used average male and female model faces determined by a previous pilot survey administered in Columbus, OH. Similar to several previous smile studies, [34,21,29] their results showed no rater gender difference. The full face perspective made a difference in few of the smile variables. A maximum allowable lower midline difference on the full face perspective was more forgiving compared to the lower face view. However, the full face perspective was less forgiving with occlusal cant. A drawback this study was that smile aesthetics values were only applicable to average faces.

Several studies[48, 68, 66] in the literature have evaluated the association between facial attractiveness and smile attractiveness. It is still unknown whether facial attractiveness will enhance, detract or neutralize smile characteristics from the smile.

5. Buccal Corridor Spaces and its Influence on Smile Aesthetics

Frush J.P. et al[17] (1958) introduced the concept of buccal corridor spaces. By definition, buccal corridor spaces are the negative space created between the buccal surfaces of the posterior teeth and the inner wall of the cheek. This is a concept that has been emphasized for years in denture aesthetics - that is, having the appropriate amount of buccal corridor visible. Too much buccal corridor results in large empty spaces, while too little looks artificial and was considered the essence of bad prosthetic denture aesthetics.

Hulsey C.M. et al[22] (1970) found that buccal corridor spaces do not contribute significantly to smile aesthetics. Like the smile arc, Hulsey also determined a ratio for buccal corridor spaces, which he defined as a ratio between the lateral most points of the canines to the distance between the corners of the mouth. A limitation of this approach was that it only defined geometry of the canines to the corners of the mouth – these are not actual representative of negative buccal corridor space because other teeth can be visible in this space with the true corridor the space between these teeth and the inner cheek.

Roden-Johnson et al[60] (2003) used computer simulations of buccal corridor spaces have been done to validate Hulsey's original findings. He modified cropped smiles with three different arch forms to display absent and large buccal corridor spaces, which were then rated on a visual analogue scale. He concluded that orthodontists, general dentists, and laypeople each evaluate smiles differently. Orthodontists preferred normal to broad arch forms over untreated arch forms, while lay people demonstrated no preference between treated and untreated arch forms. More significantly, it was concluded that buccal corridor spaces did not have an effect on the smile ratings of orthodontists, general dentists, and lay people.

Moore et al[41] (2005) in contrast, recently found that laypersons could differentiate between different percentages of buccal corridor. When laypersons were shown full face colour photographs with five alterations in buccal corridor, they preferred faces with minimal buccal corridor spaces. The laypersons were able to distinguish changes in buccal corridor on all levels except when they became minimal. Laypersons preferred broad smiles significantly more than narrow smiles.

Roden-Johnson et al[59] (2005) studied 'The effects of buccal corridor spaces and arch form on smile aesthetics'. An attractive, well-balanced smile is a paramount treatment objective of modern orthodontic therapy. The purpose of

this study was to determine the effects of buccal corridor spaces (BCS) and arch form on smile aesthetics as perceived by laypeople, general dentists, and orthodontists. Material included photographs of 20 women who were treated by 2 orthodontists were collected: 1 group had narrow tapered or tapered arch forms, and the other had normal to broad arch forms. Photographs of 10 untreated women served as a control sample. All photographs showed the subjects smiling. The photographs were digitized and evaluated for BCS. Then, photographs with BCS were altered to eliminate the dark triangular areas, and those without BCS were altered by the addition of dark triangular areas at the lateral aspects of the smile. The altered photographs were randomized into a survey with the 30 original photographs. Three groups of raters (dentists, orthodontists, and laypeople) used a visual analogue scale to rate the photographs. Results showed there was no significant difference in smile scores related to BCS for all samples and for all viewers. Dentists rated broader arch forms as more aesthetic than untreated arch forms. Orthodontists rated broader arch forms as more aesthetic than narrow tapered arch forms and untreated arch forms. Lay people showed no preference of arch form. To conclude this study demonstrates that the presence of BCS does not influence smile aesthetics. However, there are differences in how dentists, orthodontists, and laypeople evaluate smiles and in what arch form each group prefers.

Moore T. et al[41] (2005) studied effect of buccal corridors on smile. The purpose of this study was to determine the influence of buccal corridors on

smile attractiveness when judged by lay people. As material, full-face colour slides of 10 randomly selected smiling subjects (5 women, 5 men) were digitized. The maxillary posterior dentitions for all subjects were digitally altered to produce a range of smile fullness: narrow (28% buccal corridor), medium-narrow (22% buccal corridor), medium (15% buccal corridor), medium-broad (10% buccal corridor), and broad (2% buccal corridor). The 5 images of each subject were paired into 11 possible combinations, and the resulting 110 pairings were randomly projected to a panel of 30 adult lay persons who compared the 2 images in each pair for smile attractiveness. Statistical analysis with the Wilcoxon signed-rank and rank-sum tests showed that (1) a broader smile (minimal buccal corridor) was judged by lay persons to be more attractive than a narrow smile (larger buccal corridors), and (2) no significant differences were found in judging between male and female subjects or between male and female judges and concluded that having minimal buccal corridors is a preferred aesthetic feature by both men and women. Large buccal corridors should be included in the problem list during orthodontic diagnosis and treatment planning.

Ackerman M.B. et al[3] (2005) wrote in relation to the article[41] on smile aesthetics would be enhanced if the authors would describe the facial types of the 10 subjects (5 men, 5 women) in their study and how this morphologic feature might influence the effect of buccal corridor change on smile macro-aesthetics. If one "extracts" a single smile characteristic from the orthodontic

problem list and examines that the feature be detached from the total face, it can lose its spatial relevance in the macro-, mini-, and even micro-aesthetic assembly of facial elements. Buccal corridor has been classified as a mini-aesthetic feature of the smile, which is influenced by the macro-aesthetic feature of facial type.

Rosenstiel S.F. et al[62] (2006) did a study on Celebrity Smile Aesthetics Assessment: Buccal Corridor and Smile Arcs. The objective was to determine if individuals identified as having a superior smile have different smile aesthetics measures than an average population. The methods included an internet search for "Best smile" and "Celebrity" identified 106 celebrities. The internet was searched for photographs of these celebrities showing a full smile from a frontal view. Photographs of dental students were used for the average group. Buccal corridor width was measured as a percentage of the inner commissure width using Adobe Photoshop and tooth and lip arcs matched to parabola. The parabolas were superimposed on the images using Photoshop. They concluded that celebrities identified as having a "best smile" had significantly smaller buccal corridors (broader smiles) than a control group and that females had significantly broader smiles, increased tooth arcs and reduced tooth/lip arc differences than males.

Ritter et al[58] (2006) studied 'Aesthetic Influence of Negative Space in the Buccal Corridor during Smiling'. The purpose of this study was to measure and verify the aesthetic influence of the bilateral spaces between maxillary teeth and lip corners, called negative space (NS), during smile. It was concluded that the NS did not influence the aesthetic evaluation of smile photographs in the sample in this study, for both orthodontists and lay people.

Geld P.V. et al[18] (2007) studied Smile Attractiveness (Self-perception and Influence on Personality), to investigate self-perception of smile attractiveness and to determine the role of the smile line and other aspects correlated with smile attractiveness and their influence on personality traits. Subjects and Methods included participants judged on their smile attractiveness with a patient-specific questionnaire. The questionnaire contained a spontaneous smiling photograph of the participant. Objective smile-line height was measured using a digital video graphic method for smile analysis. Personalities were assessed with the Dutch Personality Index. Results showed Cronbach's Alfa for the smile judgment questionnaire was 0.77. The results also showed that the size of teeth, visibility of teeth, and upper lip position were critical factors in self-perception of smile attractiveness (social dimension). The colour of teeth and gingival display were critical factors in satisfaction with smile appearance (individual dimension). Participants, smiling with their teeth entirely displayed and some gingival display (two to four millimetres), perceived their smile line as most aesthetic. Smiles with disproportional

gingival display were judged negatively and correlated with the personality characteristics of neuroticism and self-esteem. Visibility and position of teeth correlated with dominance. To conclude the results of this research underpin the psychosocial importance and the dental significance of an attractive smile.

Martin A.J. et al[38] (2007) studied 'The impact of buccal corridors on smile attractiveness' to assess the impact of various sized buccal corridors (BCS) on smile attractiveness. Results showed that the Orthodontists and laypeople rated smiles with small BCs as significantly ($P < 0.05$) more attractive than those with large BCs. Orthodontists rated M1–M1 smiles as more attractive than PM2–PM2 smiles, whereas laypeople preferred PM2–PM2 smiles. Orthodontists rated only two of eight asymmetrical smiles as less attractive than would be expected for symmetrical smiles with similar arch widths; laypeople did not rate any asymmetrical smiles as less attractive than would be expected. Rater age and gender did not significantly influence the impact of BCs on smile attractiveness.

Dunn W. et al[11] (2008) studied 'Aesthetic Evaluation of Buccal Corridor Width in Top Female Models'. The purpose of this study was to document the range and variation of the width of buccal corridors in a sample of top-tier magazine models, as these models' smiles are representative of the most attractive and ideal smiles in society today. Twenty-five photographs met

these criteria and were selected for analysis. These photographs were scanned; models' faces were magnified without distortion for consistency and ease of measurement. Results indicate that the mean, standard deviation, and range of buccal corridors were 4.75%, 3.58%, and 0.0-13.73%, respectively. After removal of three outliers from the data set (13.73%, 12.82%, and 10.71%), mean buccal corridor width was 3.70% (SD=2.21%). In general, the results of this study suggest that, under most circumstances, minimal buccal corridors are associated with smile attractiveness. However, as this was a pilot study, more research is needed to further examine the contribution of buccal corridor space to aesthetic smiles in contemporary society.

II-Hyung Y. et al[24] (2008) studied 'Which Hard and Soft Tissue Factors Relate with the Amount of Buccal Corridor Space during Smiling?' The objective was to investigate which hard and soft tissue factors relate with the amount of buccal corridor area (BCA) during posed smiling. They concluded that to control of the amount of BCA for achieving a better aesthetic smile, it is necessary to observe the vertical pattern of the face, amount of upper incisor exposure and sum of the tooth material.

Nanda R. et al[44] (2008) did 'Dynamic smile analysis in young adults'. Current trends in orthodontics place greater emphasis on smile aesthetics, yet few studies provide averages and norms for an ideal smile. The purposes of this

study were to provide averages for various components of the smile and to compare some of these in orthodontically treated and untreated groups. Also, smiles of patients with and without rapid maxillary expansion (RME) were compared. The method included the use of video equipment to capture smiles in 230 subjects. Results showed the majority of subjects showed on smile flat smile arc, back to the second maxillary premolar, and an 11% buccal corridor. The orthodontically treated group showed a statistically significant more parallel smile arc compared with the untreated group. The RME group had statistically significant less buccal corridor compared with the non-expanded subjects. In conclusion this study helps to establish dynamic norms for the smile and shows that orthodontic treatment might not flatten the smile arc as previously suggested, and, furthermore, that RME appears to be associated with a decreased buccal corridor.

Materials and Methods

MATERIALS AND METHODS

The original sample consisted of selected photographic records of patients who were treated at Ragas Dental College and Hospital. A digital archive was examined to obtain one frontal photograph before treatment and one after treatment in natural head position with a posed smile.

The following inclusion criteria were strictly followed:

1. no previous history of orthodontic treatment, maxillofacial surgery or prosthetic replacements
2. complete permanent dentition except for third molars with no missing or supernumerary teeth
3. normal upper lip length (in a balanced face, the length of the upper lip [distance from subnasale to stomion] is equal to one third of lower facial height [subnasale to menton]),
4. no craniofacial anomalies or any other pathology

The final sample consisted of 70 consecutively treated patients with different malocclusions. Of the 70 patients, 52 had undergone extraction therapy. Pre-treatment and Post-treatment posed smile photograph of these patients were taken in natural head position, on the same camera (Nikon DSLR D7000, Japan), in the same environment and similar lighting conditions

by the same photographer. The photographs were checked for acceptable clarity and were then transferred to computer software (Adobe Photoshop, version 7, Adobe Systems, San Jose, Calif); then they were cropped with vertical (nose tip to soft-tissue pogonion) and transverse (perpendicular drawn down from the zygomatic prominence) limits. All images were subsequently adjusted to a standardized image size.

The photographs were evaluated in two main ways, with the use of Diagram of Facial Aesthetic References in Adobe Photoshop Software and a Visual Analogue Scale.

In the first part of this study the smile of each patient was evaluated using the diagram of facial aesthetic reference in Adobe Photoshop Software. The diagram consisted of six frames surrounding the maxillary incisors and canines, their limit are specific to each dental reference. Each frame surrounds its respective tooth, observing its limits. In its original format, DFAR makes reference to the gingival apexes, which are most apical landmarks of the gingival contour. (Figure 1) The present re-evaluation was done to add the locations of the extremities of gingival papillae (papillary tips) and emphasize the contact points. (Figure 2)

The union of these points will form lines that give evaluative references in the analysis of the smile. (Figure 3) As such, DFAR will intrinsically have four lines, formed by the following structures:

- Cervical line–gingival apexes.
- Papillary line–papillary tips.
- Contact points line–contact points.
- Incisal line–incisal edges (incisal line).

The relationship of the papillary line with the contact point's line will create a band named connector band, in a reference to the concept of dental connectors. This band, formed by the two lines (papillary and contact points), added to the cervical and incisal lines, will provide the horizontal dental references of the smile in a frontal view. Together with the contour of the upper and lower lips, six horizontal smile lines are obtained. They are:- Cervical Line (A); Papillary Line (B); Contact Points Line (C); Incisal Line (d); Upper Lip Line (e); Lower Lip Line (F).

After the diagram was established for each of the photographs, the micro aesthetics were evaluated in the form of relative consonance of smile arc, relative height of incisal edges and gingival zeniths and relative tip of individual teeth from visual examination.

In the second part of this study, a Jury consisting of five male Orthodontists, five male General Dentists and five male Laymen distinguished the attractiveness of person's smile before and after orthodontic treatment. The standardized photographs were inserted in a Microsoft Office PowerPoint 2010 slide show. All identifying features from the photographs were removed and randomly assigned numbering ranging from 1 to 140. All 140 photographs were randomly shown before the panel as a slide show to familiarize them with the photographs, before asking the panel to evaluate each one. The Visual Analogue Scale was briefly explained to the panel members, with illustrations. Each judge scored every smile on a 100mm Visual Analogue Scale between 0 (extremely unattractive) and 10 (extremely attractive). A value of 0.0 to 1.9 was considered very unattractive smile, 2.0 to 3.9 unattractive, 4.0 to 5.9 fair, 6.0 to 7.9 attractive, and 8.0 to 10.0 very attractive. (Figure 5) The judges were given 20 seconds for rating each photograph.

STATISTICAL ANALYSIS

The ratings of the Orthodontists, General Dentists and Laymen were entered and analyzed using SPSS version 16.0 (SPSS-IBM Inc., Chicago, IL, USA). Descriptive statistics included means, standard deviations, and ranges. Nonparametric Spearman's Rank Correlations were done for the 3 groups of assessors, to evaluate the agreement between members at pre-treatment and post-treatment assessment. Independent T-Test was also used to compare the mean ratings between the groups of assessors for both Pre-treatment and Post-treatment assessment. Paired Sample T-Test was used to compare the improvement of the smile aesthetics in the Pre-treatment and Post-treatment Assessment in each Assessor Group. At this level to allow for multiple comparisons, statistical significance was at the $P < 0.05$ level.

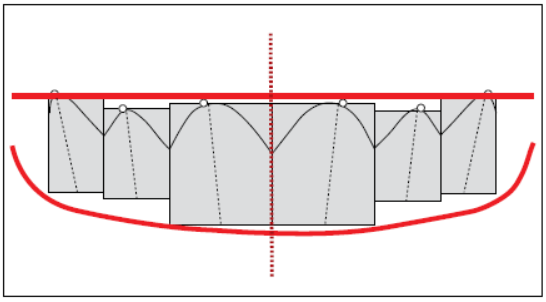


Figure 1 - Diagram of Facial Aesthetic Reference (DFAR)

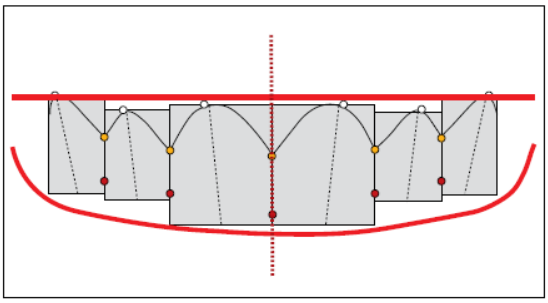


Figure 2 - DFAR with the New Reference Points

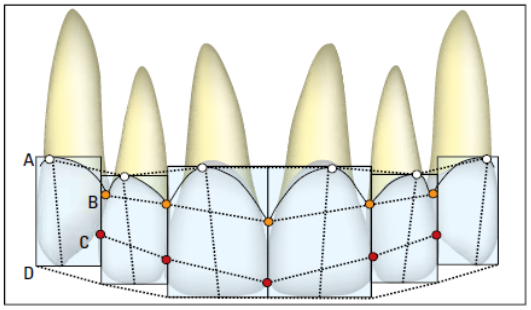


Figure 3 – DFAR with (a) Cervical line, (b)Papillary line, (c)Contact points line and (d)Incisal line

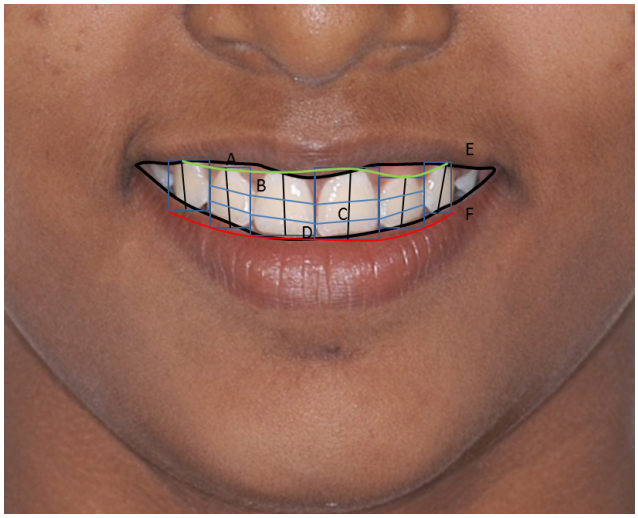


Figure 4 – DFAR with Cervical Line (A); Papillary Line (B); Contact Points Line (C); Incisal Line (d); Upper Lip Line (e); Lower Lip Line (F)

How would you rate the attractiveness of this Smile?

1	2	3	4	5	6	7	8	9	10
Extremely Unattractive							Extremely Attractive		

Figure 5 – Visual Analogue Scale (VAS)

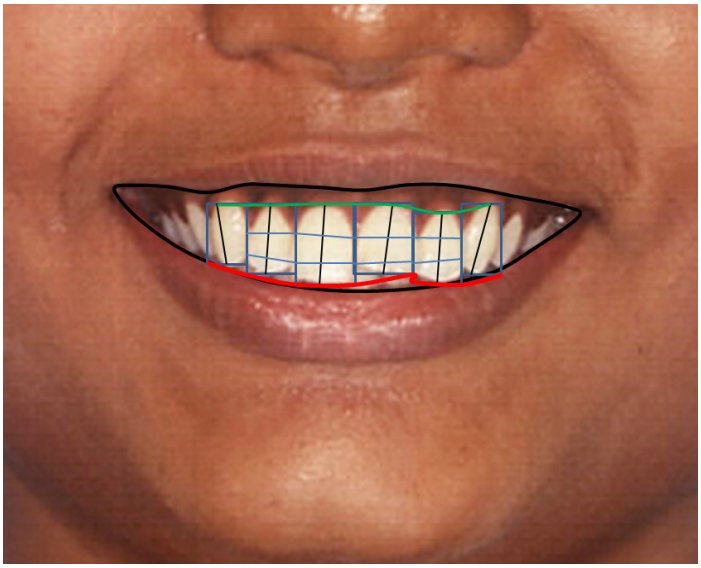


Figure 5 – Case 1 Pre-treatment Smile Evaluation with DFAR

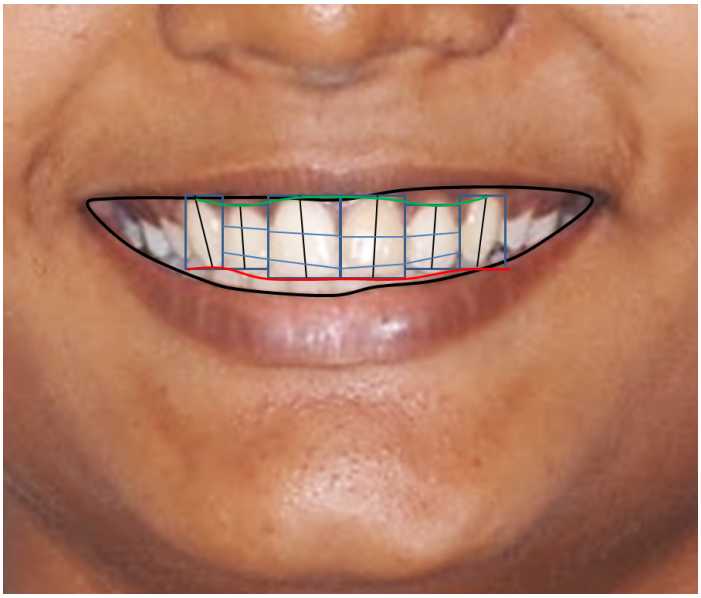


Figure 6 – Case 1 Post-treatment Smile Evaluation with DFAR

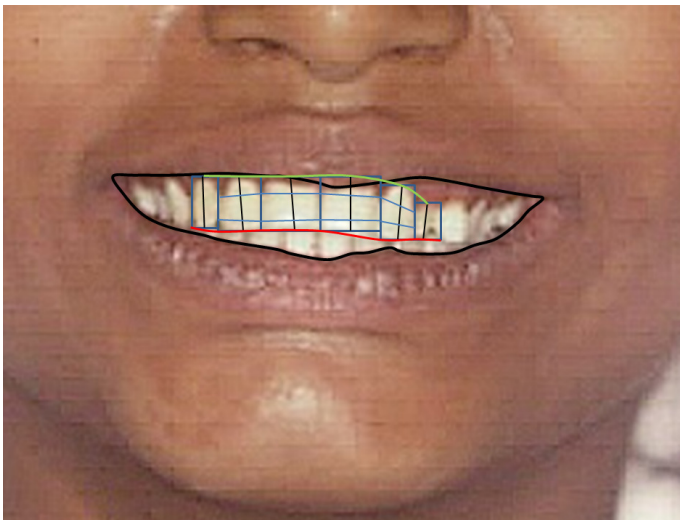


Figure 7 – Case 2 Pre-treatment Smile Evaluation with DFAR

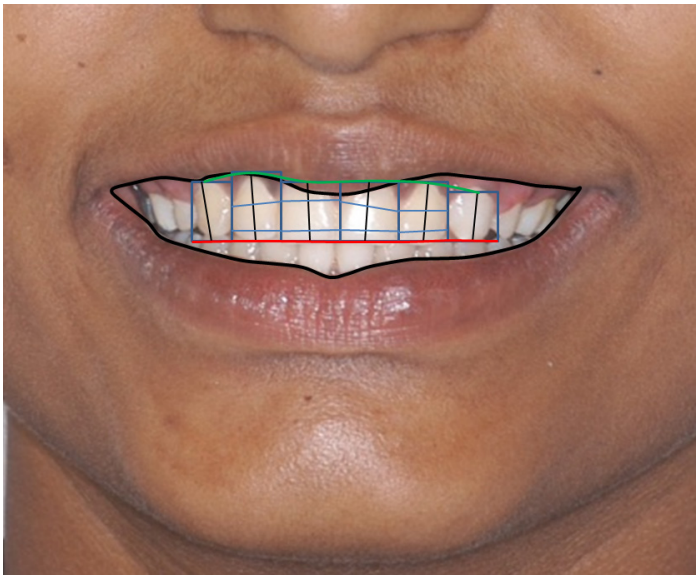


Figure 8 – Case 2 Post-treatment Smile Evaluation with DFAR

Results

RESULTS

The study comprised of 70 patients who had undergone treatment at Ragas Dental College and Hospital. Pre-treatment and Post-treatment posed smile photographs of these patients were obtained from the digital archives of Department of Orthodontics and Dentofacial Orthopaedics, Ragas Dental College. Stringent inclusion criteria were maintained for this study.

DIAGRAM OF FACIAL AESTHETIC REFERENCE:-

The parameters assessed were:-

1. Consonance of the smile arc
2. Position of the Gingival Zenith of the Anterior Teeth Relative to each other
3. Relative height of the incisal edges of the anterior teeth
4. Width of the connector band in the anterior six teeth
5. Relative Tip of the anterior teeth

Pre-treatment versus Post-treatment Smile Comparison (Table 1):

The consonance of the smile arc improved in 66 of the 70 cases, suggesting that the orthodontic treatment had improved the smile aesthetics. But the consonance remained the same in 2 cases and worsened in 2 cases. The Position of the Gingival Zenith of the Anterior Teeth Relative to each other

improved in 64 of treated cases whereas it worsened in 2 cases and no change was seen in 4 cases. The Relative height of the incisal edges of the anterior teeth improved in almost all cases except one case in which it worsened and one case where it remained the same. The Width of the connector band in the anterior six teeth improved in all the treated cases. Finally, the relative tip of the anterior six teeth improved with treatment barring one case.

VISUAL ANALOGUE SCALE:-

The parameters assessed were:-

1. The agreement between each of the members of the group at Pre-treatment Assessment
2. The agreement between each of the members of the group at Post-treatment Assessment
3. The Mean Values of Assessment between the different groups at Pre-treatment Assessment
4. The Mean Values of Assessment between the different groups at Post-treatment Assessment
5. The improvement of smile aesthetics between Pre-treatment and Post-treatment assessment as perceived by the different groups.

Evaluation of Agreement among Orthodontists in Pre-Treatment Assessment (Table 2):

Nonparametric Spearman's Rank Correlations of the Orthodontists ratings in Pre-treatment assessment showed:-

Orthodontist 1 Ratings differed with Orthodontist 2, Orthodontist 3 and Orthodontist 4 ratings. These differences were statistically significant with P–values of 0.003, 0.001 and 0.001 respectively. However, ratings of Orthodontist 1 agreed with Orthodontist 5 with a P-Value (0.718) that was not statistically significant.

Orthodontist 2 Ratings differed from Orthodontist 4 ratings with a P-Value of 0.009 which was statistically significant while his ratings agreed with Orthodontist 3 and Orthodontist 5 with P-values which were statistically not significant.

Orthodontist 3 Ratings disagreed with Orthodontist 4 with a P–Value of 0.001 which was statistically significant while his ratings agreed with Orthodontist 5 with P–Value of 0.673 which was not statistically significant.

Orthodontist 4 Ratings agreed with Orthodontist 5 with a P–Value of 0.289 which was statistically not significant.

Evaluation of Agreement among General Dentists in Pre-Treatment Assessment (Table 3):

Nonparametric Spearman's Rank Correlations of the General Dentists ratings in Pre-treatment assessment showed:-

Dentist 1 Ratings differed with Dentist 2, Dentist 3 and Dentist 5 ratings. These differences were statistically significant with P–values of 0.007, 0.001 and 0.001 respectively. However, ratings of Dentist 1 agreed with Dentist 4 with a P-Value (0.077) that was not statistically significant.

Dentist 2 Ratings differed from Dentist 3 and Dentist 5 ratings with a P-Value of 0.031 and 0.002 respectively, which were statistically significant while his ratings agreed with Dentist 4 with a P-value of 0.113 which was statistically insignificant.

Dentist 3 Ratings disagreed with Dentist 5 with a P–Value of 0.001 which was statistically significant while his ratings agreed with Dentist 4 with a P–Value of 0.173 which was not statistically significant.

Dentist 4 Ratings agreed with Dentist 5 with a P–Value of 0.192 which was statistically not significant.

Evaluation of Agreement among Laymen in Pre-Treatment Assessment (Table 4):

Nonparametric Spearman's Rank Correlations of the Laymen ratings in Pre-treatment assessment showed:-

Layman 1 Ratings differed with Layman 2, Layman 3, Layman 4 and Layman 5 ratings. These differences were statistically significant with P–value of 0.001.

Layman 2 Ratings differed from Layman 3, Layman 4 and Layman 5 ratings with P-Value of 0.001, which was statistically significant.

Layman 3 Ratings disagreed with Layman 4 and Layman 5 with P–Value 0.001, which was statistically significant.

Layman 4 Ratings disagreed with Layman 5 with a P–Value of 0.001 which was statistically significant.

Evaluation of Agreement among Orthodontists in Post-Treatment Assessment (Table 5):

Nonparametric Spearman's Rank Correlations of the Orthodontists ratings in Post-treatment assessment showed:-

Orthodontist 1 Ratings differed with Orthodontist 2, Orthodontist 3 and Orthodontist 4 ratings. These differences were of statistical significance with a P–value of 0.001, 0.001 and 0.032 respectively. However, ratings of

Orthodontist 1 agreed with Orthodontist 5 with a P-Value (0.771) that was not statistically significant.

Orthodontist 2 Ratings disagreed with Orthodontist 3, Orthodontist 4 and Orthodontist 5 with P-values of 0.001, 0.004 and 0.025 which were statistically significant.

Orthodontist 3 Ratings agreed with Orthodontist 4 and Orthodontist 5 with P–Values of 0.086 and 0.110 which was statistically not significant.

Orthodontist 4 Ratings agreed with Orthodontist 5 with a P–Value of 0.104 which was statistically not significant.

Evaluation of Agreement among General Dentists in Post-Treatment Assessment (Table 6):

Nonparametric Spearman's Rank Correlations of the General Dentists ratings in Post-treatment assessment showed:-

Dentist 1 Ratings differed with Dentist 2, Dentist 3, Dentist 4 and Dentist 5 ratings. These differences were of statistical significance with P–values of 0.001, 0.001, 0.041 and 0.001 respectively.

Dentist 2 Ratings differed from Dentist 3 and Dentist 5 ratings with a P-Value of 0.008 and 0.001 respectively, which was statistically significant while his ratings agreed with Dentist 4 with a P-value of 0.542 which was statistically not significant.

Dentist 3 Ratings disagreed with Dentist 5 with a P–Value of 0.001 which was statistically significant while his ratings agreed with Dentist 4 with a P–Value of 0.155 which was statistically not significant.

Dentist 4 Ratings agreed with Dentist 5 with a P–Value of 0.413 which was statistically not significant.

Evaluation of Agreement among Laymen in Post-Treatment Assessment (Table 7):

Nonparametric Spearman's Rank Correlations of the Laymen ratings in Post-treatment assessment showed:-

Layman 1 Ratings differed with Layman 2, Layman 3, Layman 4 and Layman 5 ratings. These differences were of statistical significance with P–values of 0.001, 0.001, 0.038 and 0.003 respectively.

Layman 2 Ratings differed from Layman 3 and Layman 5 ratings with P-Values of 0.024 and 0.020 respectively, which was statistically significant. However, he agreed with Layman 4 with a P-Value of 0.301 which was statistically not significant.

Layman 3 Ratings disagreed with Layman 4 and Layman 5 with P–Value of 0.001 and 0.001 respectively, which was statistically significant.

Layman 4 Ratings disagreed with Layman 5 with a P–Value of 0.035 which was statistically significant.

Evaluation of Agreement between the Groups of Assessors in Pre-treatment Smile Ratings (Table 8):-

Independent Samples T-Test to Compare Mean Values between Assessors in the Pre-treatment Photographs showed that the General dentists differed in their assessment from both Orthodontists and Laymen. These differences had P-Values of <0.001 and 0.025, which were statistically significant. However, Orthodontist assessment of Pre-treatment smile aesthetics agreed with Laymen.

Evaluation of Agreement between the Groups of Assessors in Post-treatment Smile Ratings (Table 9):-

Independent Samples T-Test to Compare Mean Values between Assessors in the Post-treatment Photographs showed that the Orthodontists, General Dentists and Laymen differed in assessment from each other. These differences were statistically significant with P-Values of <0.001, 0.001 and 0.001 when the ratings of Orthodontist - Dentists were compared and 0.001 when Orthodontists – Laymen and Dentist – Laymen assessment ratings were compared.

Comparison of Improvement of Smile Aesthetics in the Pre-treatment and Post-treatment Assessment in each group (Table 10):-

Paired Samples T-Test was used to compare the Improvement in the Pre-treatment and Post-treatment Assessment in each Assessor Group. The Orthodontists, General Dentists and Laymen as groups found improvement in the smile at Post-treatment evaluation as compared to the Pre-treatment evaluation. This improvement in smile aesthetics were statistically highly significant with P-Value of <0.001 in all three groups.

Tables & Graphs

Table 1 – Objective Assessment of the Smile using Diagram of Facial Aesthetic Reference

Improvement in Smile Aesthetics with Treatment					
	Consonance of the smile arc	Position of the Gingival Zenith of the Anterior Teeth Relative to each other	Relative height of the incisal edges of the anterior teeth	Width of the connector band in the anterior six teeth	Relative Tip of the teeth
Patient 1	Improved	Improved	Improved	Improved	Improved
Patient 2	Improved	Worsened	Improved	Improved	Improved
Patient 3	Improved	No change	Improved	Improved	Improved
Patient 4	Worsened	Improved	Worsened	Improved	Improved
Patient 5	Improved	Improved	Improved	Improved	Improved
Patient 6	Improved	Improved	Improved	Improved	Improved
Patient 7	Improved	Improved	Improved	Improved	Improved
Patient 8	No change	No change	No change	Improved	Improved
Patient 9	Improved	Improved	Improved	Improved	Improved
Patient 10	Improved	Improved	Improved	Improved	Improved
Patient 11	Improved	Improved	Improved	Improved	Improved
Patient 12	Improved	No change	Improved	Improved	Improved
Patient 13	Improved	Improved	Improved	Improved	Improved
Patient 14	Improved	Improved	Improved	Improved	No change
Patient 15	Improved	Improved	Improved	Improved	Improved
Patient 16	Improved	Improved	Improved	Improved	Improved
Patient 17	Improved	Improved	Improved	Improved	Improved
Patient 18	Improved	Improved	Improved	Improved	Improved
Patient 19	Improved	Improved	Improved	Improved	Improved
Patient 20	Improved	Improved	Improved	Improved	Improved
Patient 21	Improved	Improved	Improved	Improved	Improved
Patient 22	Improved	Improved	Improved	Improved	Improved
Patient 23	Improved	Improved	Improved	Improved	Improved
Patient 24	Improved	No change	Improved	Improved	Improved
Patient 25	Improved	Improved	Improved	Improved	Improved
Patient 26	Improved	Improved	Improved	Improved	Improved
Patient 27	Improved	Improved	Improved	Improved	Improved
Patient 28	Improved	Improved	Improved	Improved	Improved
Patient 29	Improved	Improved	Improved	Improved	Improved
Patient 30	No change	Improved	Improved	Improved	Improved

	Consonance of the smile arc	Position of the Gingival Zenith of the Anterior Teeth Relative to each other	Relative height of the incisal edges of the anterior teeth	Width of the connector band in the anterior six teeth	Relative Tip of the teeth
Patient 31	Improved	Improved	Improved	Improved	Improved
Patient 32	Improved	Improved	Improved	Improved	Improved
Patient 33	Improved	Improved	Improved	Improved	Improved
Patient 34	Improved	Worsened	Improved	Improved	Improved
Patient 35	Improved	Improved	Improved	Improved	Improved
Patient 36	Improved	Improved	Improved	Improved	Improved
Patient 37	Improved	Improved	Improved	Improved	Improved
Patient 38	Improved	Improved	Improved	Improved	Improved
Patient 39	Improved	Improved	Improved	Improved	Improved
Patient 40	Improved	Improved	Improved	Improved	Improved
Patient 41	Improved	Improved	Improved	Improved	Improved
Patient 42	Improved	Improved	Improved	Improved	Improved
Patient 43	Improved	Improved	Improved	Improved	Improved
Patient 44	Improved	Improved	Improved	Improved	Improved
Patient 45	Improved	Improved	Improved	Improved	Improved
Patient 46	Improved	Improved	Improved	Improved	Improved
Patient 47	Improved	Improved	Improved	Improved	Improved
Patient 48	Improved	Improved	Improved	Improved	Improved
Patient 49	Improved	Improved	Improved	Improved	Improved
Patient 50	Improved	Improved	Improved	Improved	Improved
Patient 51	Improved	Improved	Improved	Improved	Improved
Patient 52	Improved	Improved	Improved	Improved	Improved
Patient 53	Improved	Improved	Improved	Improved	Improved
Patient 54	Improved	Improved	Improved	Improved	Improved
Patient 55	Improved	Improved	Improved	Improved	Improved
Patient 56	Improved	Improved	Improved	Improved	Improved
Patient 57	Improved	Improved	Improved	Improved	Improved
Patient 58	Improved	Improved	Improved	Improved	Improved
Patient 59	Worsened	Improved	Improved	Improved	Improved
Patient 60	Improved	Improved	Improved	Improved	Improved
Patient 61	Improved	Improved	Improved	Improved	Improved
Patient 62	Improved	Improved	Improved	Improved	Improved
Patient 63	Improved	Improved	Improved	Improved	Improved
Patient 64	Improved	Improved	Improved	Improved	Improved
Patient 65	Improved	Improved	Improved	Improved	Improved
Patient 66	Improved	Improved	Improved	Improved	Improved
Patient 67	Improved	Improved	Improved	Improved	Improved
Patient 68	Improved	Improved	Improved	Improved	Improved
Patient 69	Improved	Improved	Improved	Improved	Improved
Patient 70	Improved	Improved	Improved	Improved	Improved

Table 2 - Nonparametric Spearman's Rank Correlations among Orthodontists in Pre-treatment Assessment

		Orthodontist 1	**Orthodontist 2**	**Orthodontist 3**	**Orthodontist 4**	**Orthodontist 5**
Orthodontist 1	Correlation	1	0.35	0.561	0.56	0.044
	P-Value	.	**0.003**	**0.001**	**0.001**	0.718
	N	70	70	70	70	70
Orthodontist 2	Correlation		1	0.227	0.311	0.082
	P-Value			0.059	**0.009**	0.501
	N			70	70	70
Orthodontist 3	Correlation			1	0.453	0.051
	P-Value			.	**0.001**	0.673
	N			70	70	70
Orthodontist 4	Correlation				1	0.129
	P-Value				.	0.289
	N				70	70
Orthodontist 5	Correlation					1
	P-Value					.
	N					70

Table 3 - Nonparametric Spearman's Rank Correlations among Dentists in Pre-treatment Assessment

		Dentist 1	**Dentist 2**	**Dentist 3**	**Dentist 4**	**Dentist 5**
Dentist 1	Correlation	1	0.317	0.432	0.213	0.408
	P-Value	.	**0.007**	**0.001**	0.077	**0.001**
	N	70	70	70	70	70
Dentist 2	Correlation		1	0.258	0.191	0.358
	P-Value		.	**0.031**	0.113	**0.002**
	N		70	70	70	70
Dentist 3	Correlation			1	0.165	0.422
	P-Value			.	0.173	**0.001**
	N			70	70	70
Dentist 4	Correlation				1	0.158
	P-Value				.	0.192
	N				70	70
Dentist 5	Correlation					1
	P-Value					.
	N					70

Table 4 - Nonparametric Spearman's Rank Correlations among Laymen in Pre-treatment Assessment

		Layman 1	**Layman 2**	**Layman 3**	**Layman 4**	**Layman 5**
Layman 1	Correlation	1	0.61	0.491	0.388	0.541
	P-Value	.	**0.001**	**0.001**	**0.001**	**0.001**
	N	70	70	70	70	70
Layman 2	Correlation		1	0.412	0.424	0.545
	P-Value		.	**0.001**	**0.001**	**0.001**
	N		70	70	70	70
Layman 3	Correlation			1	0.614	0.417
	P-Value			.	**0.001**	**0.001**
	N			70	70	70
Layman 4	Correlation				1	0.493
	P-Value				.	**0.001**
	N				70	70
Layman 5	Correlation					1
	P-Value					.
	N					70

Table 5 - Nonparametric Spearman's Rank Correlations among Orthodontists in Post-treatment Assessment

		Orthodontist 1	**Orthodontist 2**	**Orthodontist 3**	**Orthodontist 4**	**Orthodontist 5**
Orthodontist 1	Correlation	1	0.587	0.41	0.256	0.035
	P-Value	.	**0.001**	**0.001**	**0.032**	0.771
	N	70	70	70	70	70
Orthodontist 2	Correlation		1	0.482	0.339	0.268
	P-Value		.	**0.001**	**0.004**	**0.025**
	N		70	70	70	70
Orthodontist 3	Correlation			1	0.207	0.192
	P-Value			.	0.086	0.11
	N			70	70	70
Orthodontist 4	Correlation				1	0.196
	P-Value				.	0.104
	N				70	70
Orthodontist 5	Correlation					1
	P-Value					.
	N					70

Table 6 - Nonparametric Spearman's Rank Correlations among Dentists in Post-treatment Assessment

		Dentist 1	**Dentist 2**	**Dentist 3**	**Dentist 4**	**Dentist 5**
Dentist 1	Correlation	1	0.558	0.488	0.245	0.477
	P-Value	.	**0.001**	**0.001**	**0.041**	**0.001**
	N	70	70	70	70	70
Dentist 2	Correlation		1	0.314	0.074	0.401
	P-Value		.	**0.008**	0.542	**0.001**
	N		70	70	70	70
Dentist 3	Correlation			1	0.172	0.446
	P-Value			.	0.155	**0.001**
	N			70	70	70
Dentist 4	Correlation				1	0.099
	P-Value				.	0.413
	N				70	70
Dentist 5	Correlation					1
	P-Value					.
	N					70

Table 7 - Nonparametric Spearman's Rank Correlations among Laymen in Post-treatment Assessment

		Layman 1	**Layman 2**	**Layman 3**	**Layman 4**	**Layman 5**
Layman 1	Correlation	1	0.549	0.377	0.249	0.351
	P-Value	.	**0.001**	**0.001**	**0.038**	**0.003**
	N	70	70	70	70	70
Layman 2	Correlation		1	0.269	0.125	0.278
	P-Value		.	**0.024**	0.301	**0.02**
	N		70	70	70	70
Layman 3	Correlation			1	0.507	0.473
	P-Value			.	**0.001**	**0.001**
	N			70	70	70
Layman 4	Correlation				1	0.252
	P-Value				.	**0.035**
	N				70	70
Layman 5	Correlation					1
	P-Value					.
	N					70

Table 8 - Independent Samples T-Test to Compare Mean Values between Assessors in the Pre-Treatment Assessment Comparison

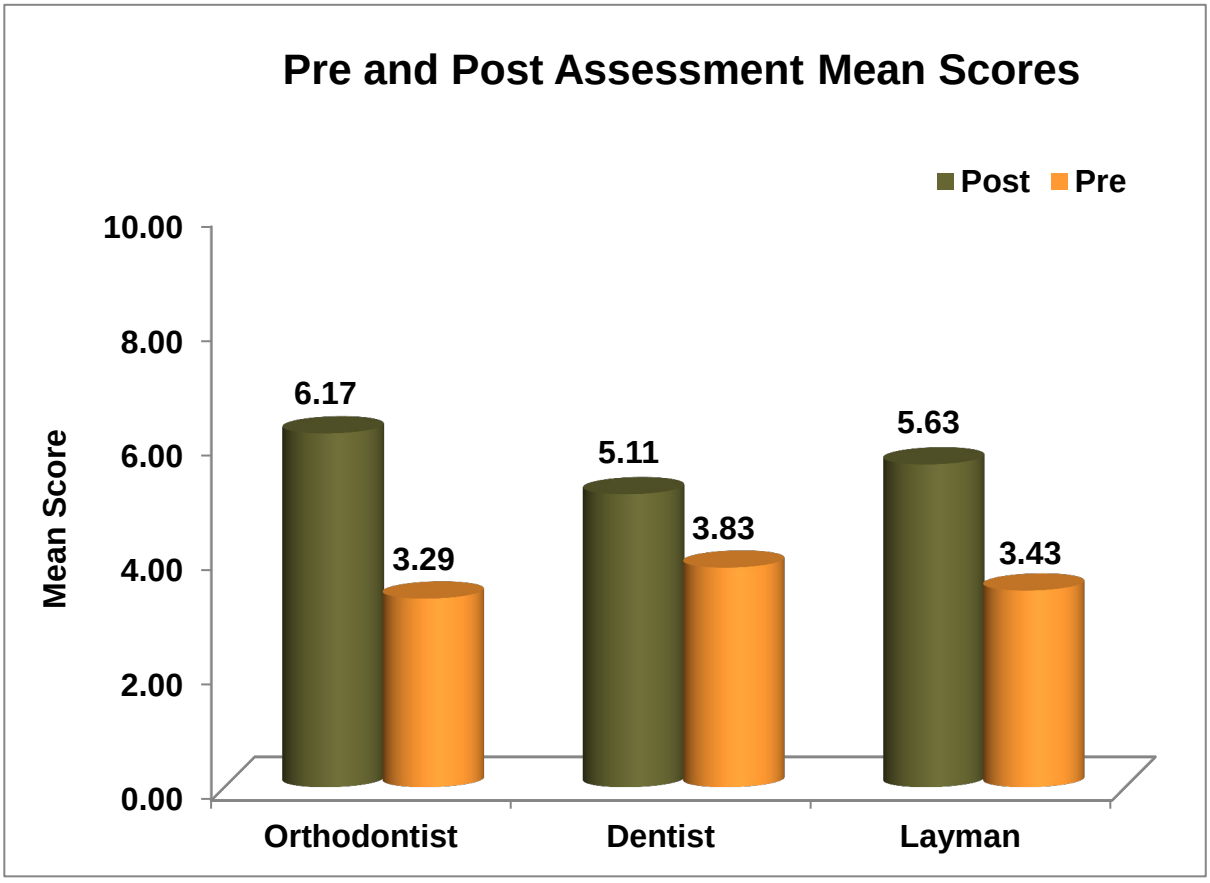
Assessors	N	Mean	Std. Dev	t-Value	P-Value
Orthodontist	70	3.29	0.94	3.683	<0.001
Dentist	70	3.83	0.8		
Orthodontist	70	3.29	0.94	0.808	0.421
Layman	70	3.43	1.22		
Dentist	70	3.83	0.8	2.266	0.025
Layman	70	3.43	1.22		

Table 9 - Independent samples T-Test to Compare Mean Values between Assessors in the Post-treatment Assessment Comparison

Assessors	N	Mean	Std. Dev	t-Value	P-Value
Orthodontist	70	6.17	1.02	6.742	<0.001
Dentist	70	5.11	0.84		
Orthodontist	70	6.17	1.02	3.244	0.001
Layman	70	5.63	0.98		
Dentist	70	5.11	0.84	3.342	0.001
Layman	70	5.63	0.98		

Table 10 - Paired Samples T-Test to Compare the Improvement in the Pre-treatment and Post-treatment Assessment in each Assessor Group.

Assessor	Assessment	N	Mean	Std. Dev	t-Value	P-Value
Orthodontist	Post-treatment	70	6.17	1.02	19.102	<0.001
	Pre-treatment	70	3.29	0.94		
Dentist	Post-treatment	70	5.11	0.84	12.284	<0.001
	Pre-treatment	70	3.83	0.8		
Layman	Post-treatment	70	5.63	0.98	14.373	<0.001
	Pre-treatment	70	3.43	1.22		



Graph 1- Comparison of Assessment's Mean Score of Orthodontists, General Dentists and Laymen

Discussion

DISCUSSION

Obtaining a beautiful smile is always the main objective of any aesthetic dental treatment. Nevertheless, in spite of its importance, the intrinsic characteristics of the smile are little discussed. These characteristics can sometimes be altered and sometimes not, as they are integral parts of the individual. As such, the field of dentistry has no reach over these characteristics, and can only make evaluations of them.

Evaluating beauty is always subjective. However, we need adequate tools to overcome the challenge of this subjectivity. In orthodontics, it is not enough only to recognize what is interfering with the smile—it requires a diagnosis of what is not normal and its aetiology, in order to establish a treatment plan.

Facial attractiveness is defined more by the smile than by soft tissue relationships at rest. According to **Proffit et al**[55], there are two main types of smiles: posed or social smile and the emotional smile. The posed smile is reproducible, and is the one presented to the world routinely and it is the social smile that is the focus of orthodontic diagnosis. Hence, in this study we used the posed smile photographs to determine the change in smile aesthetics with orthodontic treatment.

Shaw et al[65], Mackley et al[37], Moore T et al[41] and **Hunt O et al[23]** have examined the effects of various dental features on facial attractiveness using full-face photographs. However, **Shaw et al[66]** noted that the ‘‘background facial attractiveness is often more assertive than the individual dental condition.’’ This observation implies that the overall facial appearance of the patient may be more important than the smile region alone. Therefore, to avoid the influence of overall facial appearance during smile assessment, we cropped the images to include the perioral region only. The images were cropped with vertical (nose tip and soft-tissue pogonion) and transverse (perpendicular drawn down from the zygomatic prominence) limits, as advocated by **Krishnan et al[34]**.

Just as in functional problems, in which we follow conducts that lead us to a diagnosis of the anomalies, aesthetic problems also require description of parameters so that the defects can be located. When searching for the visualization of problems, several rules and assumptions are created, leading sometimes to an underestimation of defects or an overvaluing of rules, creating paradigms that are not supported by proven scientific data. The very essence of aesthetic dentistry, which involves artistic criteria, contributes to this fact. The use of simple and reliable mechanisms can improve the possibilities of success, if not eliminate performance errors. The Diagram of Facial Aesthetic References (DFAR) is an auxiliary diagnostic tool that is well suited to this purpose.

There were only a scant number of studies in orthodontic literature, done to assess the improvement in smile aesthetics with orthodontic treatment. Therefore, this study was designed and carried out to evaluate the changes in smile aesthetics by means of the Diagram of Facial Aesthetic Reference and a Visual Analogue Scale. The sample size consisted of 70 consecutive patients of all malocclusion types, who had undergone Orthodontic treatment at Ragas Dental College and Hospital. Frontal posed smile photographs of these patients before and after treatment were then obtained.

Diagram of Facial Aesthetic Reference:-

In the first part of this study, we used the Diagram of Facial Aesthetic Reference on each of the photographs, to objectively ascertain the changes in smile aesthetics with treatment. The parameters considered were the change in consonance of smile arc, amount of gingival exposure, position of the gingival zenith of the anterior teeth relative to each other, relative height of the incisal edges, width of the connector band and relative tip of the anterior teeth.

The consonance of the smile arc was defined by **Proffit et al**[55] as the contour of the incisal edges of the maxillary anterior teeth relative to the curvature of the lower lip during a social smile. The consonance of the smile arc improved in 66 of the 70 cases assessed (Table 1). An example of an ideal

result at the end of treatment can be seen in Case 1 (Figure 5, 6). Of the 4 remaining cases, two cases showed no change and two cases showed deterioration in the consonance, possibly due to faulty bracket positioning. The cases that showed no change had a good consonance at beginning treatment. However, the deterioration in two cases suggests the importance of accurate bracket positioning, the need of evaluating the smile aesthetics routinely during the finishing and detailing stages of treatment and correcting the bracket positioning errors. Alternatively, restorative treatment in the form of restorations or veneers can also be undertaken to bring consonance to the smile arc. However, this is only possible when the lower lip creates a natural curvature, with the corners of the mouth turned upwards, and incisal edges follow that curvature. Cases where the natural curvature is absent due to factors like abnormal contraction of the lower lip muscles, it may be unfeasible for smile designers to seek the consonance of the smile arc, as exceptions from the norm are a rule of nature .

The relative height of the incisal edges improved in most of the cases in this study, suggesting that it is relatively easy to assess this parameter during the bonding procedure (Table 1). According to **McLaughlin et al[39],** the central incisor and canine brackets should be placed at the same distance from the incisal edge while the lateral incisor bracket should be placed 0.5mm incisal as compared to the central incisor bracket. The relative heights of the anterior teeth worsened in one case and remained the same in another case as the central incisor, lateral incisor and canine brackets were placed at the same

level. Surprisingly, the two same cases showed similar findings when the smile arc consonance was evaluated. This can be noted in Case 2 (Figure 7, 8) where the central incisor, lateral incisor and the canine have the same relative heights and thus resulted in a flat smile arc.

The position of the Gingival Zenith of the anterior teeth was evaluated by means of the Gingival Line on the Diagram of Facial Aesthetic Reference (Figure 3). The gingival line is formed from the union of the gingival zeniths of the canines, maxillary lateral and central incisors. The ideal form of the gingival line attains a convex aspect in relation to the occlusal plane as the apexes of the maxillary canines are most often higher than the lateral incisors and about the same level as the central incisors (Figure 4). In this study, the position of the gingival zenith improved to a convex form in 64 of the treated cases, but this parameter worsened in 2 cases and remained unchanged in 4 cases (Table 1). The variation in the cervical height of the teeth can depend on the periodontal conditions of each tooth, as well as on tooth size, tipping, eruption pattern, and occlusal plane tipping. Gingivoplasty and selective grinding can be under taken as adjunctive procedures to improve smile aesthetics as a concave gingival line is less attractive.

The connector band was evaluated by means of the contact point lines. However, these lines do not represent the contact points between the teeth. Rather they represent the connecting space, which denote the area the teeth

appear to touch. The best aesthetic relationship of anterior teeth is one that follows the 50-40-30 rule for the connecting space which would give a "Hand Glider" shape[64] (Figure 3). In this study, it was observed that the connector band improved with treatment in all the cases (Table 1). However, absolute measurements were not possible as magnification error of the photographs would have rendered these values inaccurate, but the appearance of the "Hand Glider" shape of the connector was considered as the benchmark for evaluating the improvement.

The relative tip of teeth was denoted by the vertical lines that extended from the apparent centre of the incisal edges to apparent centre of gingival zenith. This parameter was evaluated by assessing the increase in divergence of the vertical lines as compared the facial midline. We observed that there was improvement of this parameter in all cases included in the study (Table 1).

Visual Analogue Scale:-

In the second part of this study, the attractiveness of the smile was evaluated by 3 groups consisting of five male orthodontists, five male general dentists and five male laymen by means of visual analogue scale. The judges rated the perioral photographs on scale of 1 to 10. A score of 1 indicated that

the smile was least attractive and a score of 10 indicated a very attractive smile.

Parekh S. M. et al[49] found some differences in the way male and female orthodontists evaluated the smile aesthetics. To avoid any discrepancy between male and female evaluators, a completely male panel was used and the comparison of the evaluations between male and female panel lists was beyond the scope of this study.

Recently, the VAS gained popularity for measuring subtle differences in dental and facial attractiveness.[69] In the evaluation of dental attractiveness, moderately high correlation coefficients for reliability (0.87) have been reported with the use of the VAS.[69] Therefore, the Visual Analogue Scale was used to subjectively assess the changes in the attractiveness of smile aesthetics.

Nonparametric Spearmen's Rank Correlations was used to check the agreement of judges within each their groups (Table 2, 3, 4, 5, 6, 7). While comparing the agreement of orthodontists, general dentists and laymen with their peers during the assessment, it was observed that orthodontists had maximum agreement between themselves; the general dentists had less agreement while the laymen had no agreement within their group.

When comparing the ratings of Orthodontists, General Dentists and Laymen in the Pre-treatment Assessment (Table 2, 3, 4) the following results were obtained. Orthodontist 1 differed in his judgement from Orthodontist 2, Orthodontist 3 and Orthodontist 4. Similarly, Orthodontist 2 and Orthodontist 3 differed with Orthodontist 4 in their judgement of attractiveness of the smile (Table 2). Dentist 1 differed in judgement with Dentist 2, Dentist 3 and Dentist 5. Similarly, Dentist 2 differed with Dentist 3 and Dentist 5 and Dentist 3 differed with Dentist 5 (Table 3). In the Laymen group, each one varied in their judgement of attractiveness from their peers and this was found to be statistically significant in the study (Table 4).

When comparing the ratings of Orthodontists, General Dentists and Laymen in the Post-treatment Assessment (Table 5, 6, 7) the following results were obtained. Orthodontist 1 differed from the ratings of Orthodontist 2, Orthodontist 3 and Orthodontist 4 (Table 5). Similarly, Orthodontist 2 varied from Orthodontist 2, Orthodontist 3 and Orthodontist 5 in their judgement of smile aesthetics. While Dentist 1 disagreed with Dentist 2, Dentist 3, Dentist 4 and Dentist 5 in the ratings (Table 6). Dentist 2 disagreed with Dentist 3 and Dentist 5 and Dentist 3 also disagreed with Dentist 5. In the Laymen group, Layman 1, Layman 2, Layman 3, Layman 4 and Layman 5 varied in the ratings with their peers as in their Pre-treatment assessment except Layman 3 who agreed with Layman 4 (Table 7).

The difference in the levels of agreement can be attributed to the difference in perception, experience and training in Aesthetics that orthodontists and general dentists receive as part of their professional education. The layman, not having any training in aesthetics differed widely in their ratings as compared with their peers, whereas general dentists had more agreement with their peers and orthodontists as group had maximum agreement with among themselves. Moreover, Orthodontists showed a high level agreement while rating the attractiveness of Post-treatment smile aesthetics. This can be attributed to the knowledge of aesthetics parameters that have to be established for achieving an attractive smile, at the end of orthodontic treatment.

Nikgoo A et al[46] used a jury consisting of two dental professionals, a portrait photographer, a painter and a subject as the sixth judge. However, in this study there were differences in ratings of judges when compared to their peers. Therefore, we minimized the margin of error by using averages when comparing the ratings between the different groups of evaluators.

Independent Samples T-Test was used to compare the mean of the ratings between the various groups of Assessors for the Pre-treatment photographs (Table 7). While comparing the ratings, the Orthodontist's mean rating of the smile agreed with Laymen (P-Value = 0.421) while General Dentists disagreed with the Orthodontists (P-Value < 0.001) and Laymen (P-

Value = 0.025). This suggests that Orthodontists and Laymen perceive the smile aesthetics similarly when evaluating untreated cases whereas General Dentists differ in their assessment.

Independent Samples T-Test was also used to compare the mean of the ratings between the various groups of Assessors for the Post-treatment photographs (Table 8). While comparing the rating between orthodontists, general dentists and laymen in this study, no agreement was found between the ratings of three groups of assessors.

According to **Flores-Mir C et al**[15], the perception of aesthetics varies from person to person and is influenced by personal experiences and social environments. For the same reasons, there can be differences of opinion regarding beauty between laypersons and professionals. **Annemieke B et al**[4] pointed out an opinion difference between orthodontists and their patients when the same smiles were evaluated. Results of other recent studies by **Kokich V O et al**[32] **and Roden-Johnson D et al**[59] agree with this study, that there is a difference in aesthetic perceptions between orthodontists, general dentists, and laypersons.

Paired Samples T-Test was used to compare the improvement in smile aesthetics between the pre-treatment and post-treatment smile (Table 9). In this study, significant improvement in smile aesthetics was seen at post treatment evaluation. This improvement perceived by the Orthodontists (P-Value <0.001), General Dentists (P-Value <0.001) and Laymen (P-Value <0.001) was statistically highly significant.

In the present study, we found out that there was a significant improvement in the attractiveness of the smile with fixed orthodontic treatment and there is a difference in perception of the attractiveness of smile between Orthodontists, General Dentists and Laymen. Also, objective assessment of the smile aesthetics showed that there can be deterioration of some of the parameters like consonance of smile arc and relative height of the incisal edges.

Orthodontists as smile designers have to realise that fixed orthodontic therapy, can significantly influence the smile aesthetics. During the finishing and detailing stage of orthodontic treatment, the clinician must evaluate the smile aesthetics as a parameter to achieve an optimal result.

Further studies are required to ascertain whether smile aesthetics are influenced by the type of orthodontic therapy like extraction-nonextraction, intrusion-retraction, etc.

Summary and Conclusions

SUMMARY AND CONCLUSION

This study was done to evaluate the improvement in the smile aesthetics with fixed orthodontic treatment. The study evaluated the attractiveness of Pre-treatment and Post-treatment posed smile photographs of 70 consecutively treated cases. The evaluation of smile aesthetics in this study was done objectively using the Diagram of Facial Aesthetic Reference and subjectively using the Visual Analogue Scale.

In the first part of this study, the Diagram of Facial Aesthetic Reference was drawn on Pre-treatment and Post-treatment photographs to objectively assess the changes in the consonance of the smile arc, the position of the gingival zenith of the anterior teeth relative to each other, the relative height of the incisal edges of the anterior teeth, width of the connector band of the anterior six teeth and the relative tip of the anterior teeth. In the second part of this study, the Visual Analogue Scale was used by five male orthodontists, five male general dentists and five male laymen to subjectively assess the improvement in smile aesthetics between Pre-treatment and Post-treatment photographs.

Results of the first part of the study showed that there was improvement in all the parameters with orthodontic treatment in most of the cases. However, some of the cases showed a deterioration of some of the parameters like consonance of the smile arc, position of the gingival zenith

relative to each other and relative height of the incisal edges. Results of the second part of this study showed that Orthodontists, General Dentists and Laymen differed in their perception of the smile aesthetics. Orthodontists as a group agreed mostly with their peers on their assessment of smile aesthetics and there was a marked improvement in the smile aesthetics of patients with orthodontic treatment as perceived by Orthodontists, General Dentists and Laymen.

The results of this study agree with **Annemieke B et al[4] and Kokich V O et al[33],** that there is difference in the perception of smile between orthodontists, general dentists and laymen. In contrast to our findings, **Roden-Johnson et al[60]** did not find any difference in the perception of smile between dentists and laymen.

However, this study used only male evaluators. Further studies have to be carried out to compare the difference in the perception of smile between male and female evaluators, which was beyond the scope of this study.

Further studies can also be done correlating the type of mechanotherapy like Intrusion Retraction, Extraction-Non-extraction, etc. used during orthodontic therapy and its influence on the aesthetics of smile.

The conclusions drawn from this study are:-

1. There was improvement in the various parameters influencing smile aesthetics like the consonance of the smile arc, the relative tip of the teeth, the position of the gingival zenith relative to each other, height of the incisal edges of the anterior teeth relative to each other and the width of the connector band as result of orthodontic therapy.

2. There was a difference in the perception of Orthodontists, General Dentists and Laymen when evaluating the attractiveness of smile aesthetics.

3. Compared to their peers, Orthodontists as group had more agreement; General Dentists had less agreement whereas Laymen had the least agreement when evaluating the smile aesthetics.

4. There was substantial improvement in the attractiveness of smile with Orthodontic Therapy as perceived by Orthodontists, General Dentists and Laymen.

5. The Diagram of Facial Aesthetic Reference is a useful tool that can help clinicians to objectively assess the parameters influencing smile aesthetics and take corrective measures, as required.

6. The findings of the study suggest that there is a need to evaluate the smile aesthetics during the Finishing and Detailing stage of Orthodontic Therapy to achieve an optimal result.

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