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The Prevalence of the Need for Esthetic Crown Lengthening in Post Orthodontically Treated Subjects

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THE PREVALENCE OF THE NEED FOR ESTHETIC CROWN LENGTHENING IN POST ORTHODONTICALLY TREATED SUBJECTS

A Thesis submitted in partial fulfillment of the requirements for the degree of Masters of Science at Virginia Commonwealth University.

by

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Abstract

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Prevalence information on excessive gingival display in post-orthodontic patients is limited. By studying one aspect, namely the size relationship of the clinical crowns of teeth, in an orthodontic population, we can begin to quantify their need for periodontal plastic surgery. In this two part study, 200 plaster models were used as subjects, followed by a clinical exam of 31 of those subjects. These models represented patients before and directly after orthodontic therapy, and the Part 2 clinical exams were performed at least

five years later. The lengths and widths of the six anterior teeth were measured and these values were compared to known ideals. This study revealed a significant increase in the length of the maxillary anterior teeth over the three examinations, yet these values were still approximately 1.5mm shorter than ideal. The mean tooth width-to-length ratio was 87-88% for maxillary central incisors, clearly below the accepted "ideal." As well, 61-71% of maxillary central incisors exceeded allowable tooth width-to-length ratios, and 61% of subjects displayed asymmetry in gingival architecture. Although this study only examined one aspect of excessive gingival display, it is the first study to show that in a predominantly young, post-orthodontic population, the prevalence of non-ideal width-to-length ratios is greater than 65%, and that the presence of asymmetry is greater than 60%. Therefore, close interaction between the periodontist and the orthodontist is necessary to diagnose these conditions in order to provide patients with all options for improving their smile.

Introduction

Prevalence information exists for most diseases and conditions. Clinicians understand that data regarding prevalence are helpful in that they allow a practitioner to know how often they should be observing a given condition. If they observe it more or less than the accepted prevalence data indicates, it may be useful to reevaluate their methods for diagnosing that condition. Prevalence information regarding dental esthetics is very scarce. This is largely due to the fact that a subjective field like esthetics is hard to study objectively. Past research has indicated that esthetics is not entirely a subjective field. Garber and Salama[1] have suggested, the teeth, the lip framework and the gingival scaffold determine the esthetic appearance of the smile. Within the literature there are rules and values that stay within some observed ranges and may be considered "ideal." This allows for the comparison of data gathered in new studies to these values and enables the investigator to determine how often variations from them occur.

Early research to define these "ideal" values was done by Levin[2] and Lombardi[3], who developed the notion that mathematic proportions described by the ancient Greeks many centuries ago could be used even today to define a concept of the ideal in dental esthetics. Ward[4] took this notion even further to develop a new set of proportionate values that today are generally accepted by dentists as the ideal ones. The preferred width to height ratio in his study was 78% though the acceptable range was 66% to 80%. He also found that the width relationships of the anterior teeth should be at a ratio of 70% versus the Golden Proportion (62%), as developed by the ancient Greeks. Gillen[5] validated the

existence of consistent ratios in the sizes of teeth regardless of race and gender and found them to be in the same ranges described by Ward[4]. Ahmad[6] described the Gingival Aesthetic Line which is the line connecting the apices of the gingival scallop for the maxillary anterior teeth. While the author allows for some variation in the position of the teeth, there should be symmetry in the gingival composition as it relates to this line. Touati[7] proposed that each of the anterior maxillary teeth plays a specific esthetic role. The central incisors provide stability and balance. The laterals provide charm, and the canines bring strength to the esthetic zone.

Townsend[8] reviewed many gingival aspects of the ideal smile. Canines and central incisors should be the same length and lateral incisors 1 to 2 mm shorter. The most apical part of the gingival scallop should reflect the angle of the long axis of the tooth. There should be an interdental papilla of 4.5 to 5.0 mm from the tip of the papilla to the depth of the marginal scallop. Townsend[8] also said that the tooth length for a maxillary central incisor averages 13.5 mm, 12.0 mm were average for a maxillary lateral incisor, and 13.0 mm was the average length for a maxillary canine. McGuire[9] provided a protocol for diagnosing some of the possible esthetic problems observed and studied before. It was reported that the average tooth lengths for the maxillary anterior were 11 to 13 mm, 10mm, and 11 to 13 mm for the centrals, laterals, and canines, respectively.

Often discussed in relation to this topic is the concept of altered passive eruption. The idea of two stages of eruption, one towards the occlusal plane and one where the gingival crevice moves apically (passive eruption), was first described by Gottlieb and Orban[10] in 1933. It was further reported in a study by Volchansky[11] regarding some risk

factors for Vincent's disease that 12.1% of 1,025 patients studied had some form of "delayed passive eruption." An in depth definition and description of altered passive eruption, a potential mechanism for the esthetic situation studied in this report, has been developed by Coslet et al[12]. While the protocol is extremely valuable for the practitioner, it does not include any reference to the prevalence of these problems. One article that could be found dealing with the prevalence of an esthetic compromise was written by Tjan[13]. This reported that 10.57% of their study population had a high smile line and that a further 68.94% had an average smile. Chiche[14] found that up to 3 mm of gingival tissue may show in those with high smile lines before esthetics were compromised.

In executing this study, some other definitions were required. "Ideal" tooth sizes have been described, but these may not be the sizes most often seen in patients. First, normal tooth size must be defined. Wheeler's[15] text on dental anatomy gives normal value lengths for the maxillary anterior teeth, however this is an average length measured on extracted teeth, and it does not allow for any soft tissue attachment to the crown. The reported normal values are 10.5mm, 9.0mm, and 10.0mm for central incisors, laterals, and canines, respectively. Loe's[16] description of the normal gingival attachment could be combined with this data to give an ideal clinical tooth size. It was found that there was an average of 0.5 to 2 mm of soft tissue attachment, so minimum normal length would be 8.5mm, 7mm, and 8mm, for maxillary central incisors, lateral incisors, and canines, respectively. Gargiuolo[17] described a zone of attachment measuring an average of 2.04 mm and added that 0.69 mm of sulcus depth could usually be found in the absence of inflammation. Both Gillen[4] and Pearson[18] made measurements of teeth on plaster models

with calipers. However, their study questions were distinctly different than the proposed study and were mostly concerned with tooth size from a prosthetic standpoint. A final historical note would be the concern about the age of the patient and the completion of eruption of the teeth to be studied. Volchansky[19] found that eruption of the teeth was completed by age 12 for the maxillary central incisors and canines, and that maxillary lateral incisors continued to demonstrate minor changes in gingival margin position up to 16 years of age. However, a more recent study by Morrow[20] suggests that passive eruption, resulting in increased clinical crown length, appears to continue throughout the teenage years, until at least age 19.

The purpose of this study is to apply accepted standards and determine the prevalence of the need for esthetic crown lengthening in a population of patients recently completing orthodontic therapy, and to re-evaluate those patients at least five years later for changes in marginal gingival position and their need for esthetic crown lengthening.

Methods

The study consists of two parts, with data compiled at least five years apart.

Part 1:

The first part of the study was designed to evaluate the tooth size, both length and width for subjects who have undergone orthodontic treatment at the VCU School of Dentistry. Subjects were plaster models fabricated by the VCU department of Graduate Orthodontics. Inclusion criteria were those subjects who had completed orthodontic movement of the maxillary central incisors (#8 and 9), lateral incisors (#7 and 10), and canines (#6 and 11). All teeth in the study were measured on the plaster models using digital calipers. Data obtained from these measurements will be compared to each other and to accepted "ideal" values. The ideal tooth length will be defined as indicated by McGuire[9], 11 to 13 mm for centrals, 10 mm for laterals, and 11 to 13 mm for canines, as those include a wide enough range to account for normal variation. Normal tooth length as described by Wheeler[15] was also used for comparison, including an allowance for soft tissue of 2.0 mm as indicated by Loe[16]. Tooth width-to-length ratio is analyzed as it has been found to be more consistently accepted as a standard for tooth size. Patients prefer a width-to-length ratio of 80%, while dentists seem to prefer 66%, as described by Ward[4]. This study considers a maximum of 80% width-to-length ratio to qualify as within normal limits. Ideal papillary height will be defined as 4.5 to 5.0 mm as described by Townsend[8],

and this is also the measure for depth of the gingival scallop. It was determined how many teeth had scalloping of this depth. Those values that differ by a statistically significant amount will place that tooth or smile and that subject into the group of those requiring esthetic crown lengthening. These data were then compiled to give a prevalence value for the need for esthetic crown lengthening on a subject and tooth level.

Measurements were done with a digital caliper and were taken for tooth numbers 5, 6, 7, 8, 9, 10, 11, and 12, both from pre-orthodontic models and post-orthodontic models. The measurements were from the gingival margin to the incisal edge, and both above and below a line drawn between the tips of the papillae on either side of these teeth. They were also measured for the distance between the interproximal contacts as seen from the frontal view. This was accomplished by marking the mesial and distal dimension of each tooth as seen from directly in front of the model on a sheet of graphing paper. The distance as seen from the front was then measured on the paper with the digital caliper. Calculations made from the data were a ratio of the gingival versus the incisal measurements, the ratio of width-to-length, and comparison of all measurements to accepted normal values. Central incisors with a greater than 80% width-to-length ratio were placed in the group requiring esthetic crown lengthening. Teeth with at least one millimeter difference in length between symmetrical teeth, except for laterals, were also placed in this group, as were canine:central length discrepancies of greater than one millimeter. Teeth with less than four millimeters of depth of scallop were also included. Age and gender of the subjects from which the models were developed were also tested as potentially significant cofactors in excessive gingival display.

Statistical analysis was to determine the proportion, which was then converted to a percentage, of subjects whose values lie outside of the accepted normal values for tooth sizes and ratios. Tooth-to-tooth values were tested for significance by paired t-test, as were pre-and post-orthodontic measurements. Age and gender were tested by ANOVA analysis for significance.

Part 2:

The second part of the study was performed on the subject population from Part 1. An attempt was made to contact all subjects or their legal guardians at least five years following orthodontic completion. They were informed of the nature of the study and were invited to participate in a follow-up study that performed a clinical exam similar to that completed on the models. Subjects were compensated for their time monetarily, and were offered a free dental examination and prophylaxis. Subjects met with the investigator for discussion of study, informed consent, and review of medical history. All subjects signed informed consent forms acknowledging their willingness to participate in the study. The study was approved by the Institute Review Board of Virginia Commonwealth University.

Measurements were performed with the same digital caliper from Part 1 and included the distance from the zenith of the scallop to the incisal edge for teeth numbers 5, 6, 7, 8, 9, 10, 11, and 12. Because this part of the study focused on the relationship between the gingival margin and the teeth, the measurement widths of the maxillary anterior teeth were not repeated and the widths from the first part of the study were used

throughout Part 2. A series of three digital images were also taken of the subjects for future analysis.

Calculations made from the data were the ratio of tooth width-to-length from the pre- and post-orthodontic models as well as the clinical measurements. A comparison of all measurements to accepted normal values was also performed. Central incisors with a greater than 80% width-to-length ratio were placed in the group requiring esthetic crown lengthening. Teeth with at least one millimeter difference in length between symmetrical teeth were also placed in this group, as were canine-to-central length discrepancies of greater than one millimeter. Statistical analysis was a one way ANOVA by individual tooth length for all three time points.

Results

Part 1:

Two-hundred plaster models from the VCU Graduate Orthodontic Clinic were measured according to the above guidelines. At the time of model fabrication, 101 of 166 subjects for whom age data could be located were younger than 18 years old, 69 were younger than 16years old. There were 119 female subjects and 81 males, see Table 1. Age could not be determined for a large number of subjects as their records are inactive and no longer kept on file in the orthodontic department. Gender differences were not significant.

Age Range (years)	Number of Subjects
8 – 10	5
11 – 15	64
16 - 20	57
21 – 30	20
31 +	10
unknown	44

Table 1. – Age Distribution I

Clinical crown lengths had mean post-orthodontic values of 8.7mm for #6, 7.8mm for #7, 9.3mm for #8, 9.4mm for #9, 7.9mm for #10, and 8.7mm #11 (Table 2). Mean width for each tooth as measured from a frontal view was 4.3mm for #6, 5.6mm #7, 8.7mm #8. 8.8mm #9, 5.8mm #10, and 4.1mm #11 (Table 3)

Tooth number	Normal length (mm)	Ideal length (mm)	Mean observed pre-orthodontic length (mm)	Standard Error	Mean observed post-orthodontic length (mm)	Standard Error
6	10	11–13	7.7	+2.5	8.7	+1.5
7	9	10–12	7.4	+1.1	7.8	+1.1
8	10.5	11–13	9.3	+1.1	9.3	+1.1
9	10.5	11–13	9.4	+1.1	9.4	+1.1
10	9	10–12	7.5	+1.1	7.9	+1.1
11	10	11–13	7.7	+2.6	8.7	+1.3

Table 2. – Tooth Length Before and After Orthodontic Therapy

Tooth number	Mean post-orthodontic length (mm)	Mean post-orthodontic width (mm)	Mean observed post-orthodontic width:length (%)
7	7.8	5.6	73
8	9.3	8.7	94
9	9.4	8.8	95
10	7.9	5.8	73

Table 3. – Post-Orthodontic Width-to-Length Ratios I

Comparison of data from each tooth yielded further information. Lateral incisors and canines were significantly longer following orthodontic therapy compared to pre-treatment values ($p<0.001$). Central incisors did not have a significant increase in crown length following orthodontic therapy ($p>0.05$). Table 3 summarizes comparison of observed crown width-to-length ratios compared to ideal values. Calculated width-to-length ratios for incisors were a mean of 73% for #7, 94% for #8, 95% for #9, and 74% for #10. For tooth #7, 24% had a width-to-length ratio greater than 80%. 85% of subjects had

a ratio greater than 80% for #8, 90% for #9, and 33% for #10. By tooth, 2% of #7, 29.5% of #8, 30% of #9, and 4% of #10 had at least 100% width-to-length ratio. By subject, 36.5% of subjects had at least one central incisor with a width-to-length ratio of at least 100% (Table 4).

Tooth number	Teeth with post-orthodontic width:length >80%	Teeth with post orthodontic width:length ≥ 100%
7	24	2
8	85	30
9	90	30
10	33	4

Table 4. – Percentage of Teeth With Short Clinical Crowns Following Orthodontics I

Sixty-eight percent of subjects had an asymmetry of at least one millimeter between the tooth and its antimer, or between a maxillary canine and its ipsilateral central incisor. As can be seen in Table 5, 818(68.6%) of teeth had a scallop measuring 2 – 4mm in depth, 177(14.8%) of scallops were 0 – 2mm deep, and 197(16.5%) were greater than 4mm in depth. Table 6 summarizes results from Gingival Aesthetic Line(GAL) analysis. Of 391 lateral incisors compared to canine and central position, the gingival margin for 333 of them was found from 0 – 1mm from the GAL. Twenty-four incisors were found actually apical to this line, and 34 of them were at a distance of greater than 1mm from this line.

	Scallop depth		
Tooth Number	0-2mm	2-4mm	4+mm
6	24	130	42
7	49	137	14
8	22	132	46
9	19	142	39
10	47	135	18
11	16	142	36
Total	177	818	197

Table 5. – Scallop Depth

Lateral incisor relationship to Gingival Aesthetic Line		
Apical to GAL	0-1mm coronal to GAL	>1mm coronal to GAL
24	333	34

Table 6. – Number of Lateral Incisors and Their Relationship to GAL I

Part 2:

Of the 200 subjects whose plaster models were measured, only 31 subjects were clinically examined, due to numerous incorrect phone numbers, relocations, or lack of interest by the subjects. There were 21 female subjects and 10 male subjects, with the vast majority being between the ages of 17 and 23, see Table #7. The following reported information will include only data from those 31 subjects who were clinically examined in Part 2 of the research study.

Age Range (years)	Number of Subjects
8 – 10	0
11 – 15	2
16 – 20	16
21 – 30	10
31 +	3

Table #7 – Age distribution II

Clinical crown lengths of the examined subjects had mean values of 7.6mm for #5, 9.6mm for #6, 8.3mm for #7, 9.8mm for #8, 10.1mm for #9, 8.7mm for #10, 9.5mm #11, and 7.6mm for #12 (Table 8). Mean width for each tooth was not re-examined as widths do not change and the original data was used. (Table #9)

Tooth number	Ideal length (mm)	Mean observed pre-orthodontic length (mm)	Mean observed post-orthodontic length (mm)	Mean observed clinical exam length (mm)	P <
5		NA	6.7	7.6	.0004
6	11–13	8.0	8.6	9.6	.0022
7	10–12	7.3	7.7	8.3	.0049
8	11–13	9.2	9.3	9.8	.1558
9	11–13	9.3	9.4	10.1	.0247
10	10–12	7.4	7.9	8.7	.0003
11	11–13	7.8	8.6	9.5	.0001
12		NA	6.8	7.6	.0006

Table #8 Tooth Length Pre-Ortho, Post-Ortho, and Clinical Exam

Comparison of data from each tooth yielded further information. Of the 31 subjects from part 2, all canines, centrals and lateral incisors increased from pre-

orthodontic to post-orthodontic examinations, but not significantly. However, by the clinical examination at least five years later, all maxillary anterior teeth increased in length, and all but tooth number 8 had statistically significant increases ($p<.006$). Table 9 summarizes comparisons of observed crown width-to-length ratios compared to ideal values. From the clinical exam data, calculated width-to-length ratios for incisors were a mean of 65% for #7, 88% for #8, 87% for #9, and 67% for #10. For tooth #7, 10% had a width-to-length ratio greater than 80%. 61% of subjects had a ratio greater than 80% for #8, 71% for #9, and 10% for #10. By tooth, 0% of #7, 10% of #8, 13% of #9, and 0% of #10 had at least 100% width-to-length ratio. By subject, 32% of subjects had at least one central incisor with a width-to-length ratio of at least 100% (Table 10).

Tooth #	Ideal width:length ratio (%)	Mean post-orthodontic width (mm)	Mean post-orthodontic length (mm)	Mean observed post-orthodontic width:length (%)	Mean Clinical Exam Length (mm)	Mean observed clinical exam width:length (%)
7	66-80	5.4	7.7	70	8.3	65
8	66-80	8.6	9.3	92	9.8	88
9	66-80	8.8	9.4	94	10.1	87
10	66-80	5.8	7.9	73	8.7	67

Table #9 – Post-Orthodontic and Clinical Exam Width-to-Length Ratios

Tooth number	Teeth with post-orthodontic width:length >80%	Teeth with post-orthodontic width:length ≥ 100%	Teeth with clinical exam width:length > 80%	Teeth with clinical exam width:length ≥ 100%
7	26	3	10	0
8	74	32	61	10
9	84	26	71	13
10	35	3	10	0

Table #10 - Percentage of Teeth With Short Clinical Crowns Following Orthodontics II

Thirty-five percent of subjects had an asymmetry of at least one millimeter between a tooth and its antimer, or between a maxillary canine and its ipsilateral central incisor. Table 11 summarizes results from Gingival Aesthetic Line (GAL) analysis. Of 62 lateral incisors compared to canine and central position, the gingival margin for 28 of them was found from 0 – 1mm from the GAL. Twenty-four incisors were found actually apical to this line, and 10 of them were at a distance of greater than 1mm from this line.

Lateral incisor relationship to Gingival Aesthetic Line		
Apical to GAL	0-1mm coronal to GAL	>1mm coronal to GAL
24	28	10

Table 11 - Number of Lateral Incisors and Their Relationship to GAL II

Discussion

The harmony and flow of an esthetic smile are derived from a summation of all of its parts. This study only examined one particular aspect of the esthetic smile; that of tooth size relationships. There are rules and guidelines in the literature that aid us in creating an esthetic smile when there is a compromise. Using these guidelines, this study determined the percentage of subjects in the defined population who may benefit from esthetic crown lengthening procedures, and evaluated these subjects at least five years following the completion of their orthodontic treatment.

Upon comparing mean observed values of the maxillary anterior teeth to accepted "ideals," as presented by Townsend[8] and McGuire[9], lengths were from 1.7 to 2.3 mm short at the end of orthodontic treatment, with the canines and lateral incisors averaging more than 2 mm shorter in length than the "ideal." During the clinical examination at least five years later, the mean observed lengths of all teeth had increased, yet lengths were still from .9 to 1.5 mm shorter than "ideal." Despite these dramatic differences from the "ideal," it was determined that a proportionate comparison, that of width-to-length ratio, would be most reliable as a true indicator of ideal tooth size. Based on current esthetic philosophy as well as past research[4,5].

Findings regarding this proportionate comparison were even more evident in their discrepancy from ideal values than were those for tooth length alone at the completion of orthodontics. Mean ratios of 94 -95% were discovered for central incisors, and 85-90% of central incisors exceeded the allowed 80% tooth width-to-length ratio. Lateral incisors had

a mean ratio of 73%, which is allowable under both normal and ideal definitions. At the examination five years later, the width-to-length ratio of the lateral incisors had remained well within the accepted values, but the central incisors, although improved, still demonstrated a mean ratio of 87-88%, and still 61-71% of them exceeded the allowed 80% tooth width-to-length ratio. Therefore, over half of the central incisors examined exceeded the upper values of the "ideal" width-to-length ratios. Figures 1, 2 and 3 demonstrate the different types of clinical width-to-length ratios observed in this study.

Figure 1 – Tooth width-to-length ratio of 100%

Figure 2 – Tooth width-to-length ratio of 80%

Figure 3 – Tooth width-to-length ratio of 66%

From the models portion of the study, less evident differences were discovered on evaluating scallop depth. Townsend[8] stated that scallop depth should be 4.5 – 5 mm. As scallop depth is synonymous to papilla height, a common guide is for the papilla length to be one-half the height of the crown. This study revealed that 83% of the teeth examined had scallop depths less than "ideal," or less than one-half the height of the crown. Only 16.5% of teeth had a scallop depth of at least 4mm, and as average crown length for central incisors was 9.3 – 9.4 mm, even 4 mm would be too short. There are several factors at work in this category of findings. First, if soft tissue is more coronally positioned than it should be, it will be on a flatter portion of the crown and because of that will have a flatter scallop. The second may actually be the more salient in this patient population. This is the probable presence of some gingival inflammation at the time of model fabrication. Models were made at removal of orthodontic appliances and signs of inflammation are a common finding at this appointment. This inflammation could result in enlarged, bulbous papillae and even some enlargement of marginal tissues. Said enlargement would affect papillary measurements and even potentially alter length measurements. This effect was anticipated, and models that were very evidently bulbous in their papillary and marginal architecture, were not included. Notwithstanding these precautions, some measurements may have been affected, as gingivitis is impossible to diagnose on plaster models. Due to difficulty in standardizing the measurements clinically, the scallop depth measurements were not repeated on the subjects at the five year examination.

Another parameter that was difficult to quantify was that of the Gingival Aesthetic Line (GAL) relationship. Without a pupillary line for comparison, a line was simply drawn between the apical extent of canine and maxillary central incisor marginal scallops. When canines were short, which was often the case, this line would not possibly be parallel to the interpupillary line. This also created an unusual morphology to the GAL and affected the lateral incisor position relative to the other two teeth. With the acknowledged difficulties, it was found that from the first part of the study, 85.2% of lateral incisors were in a proper relationship to the GAL. Only 8.7% of lateral incisors had more than 1 mm of soft tissue between the apex of the scallop and the GAL and only 7.2% were positioned apically from this line. As stated previously, the canines had a marked effect on this relationship, and in many cases it was the canine that was responsible for the discrepancy. Using the same parameters as the part 1 measurements, it was found that at the clinical exam only 45% of lateral incisors were in a proper relationship to the GAL, and the remaining 55% were >1mm from the GAL. Although this aspect of the esthetic smile is not critical, it contributes to the potential need for correction of the discrepancies.

Another guideline that cannot be overlooked is the need for symmetry and harmony in the smile. In part 1 of the study, it was found that 68% of subjects had an asymmetry in the length of canines compared to their antimer, central incisors compared to their antimer, and central incisors compared to ipsilateral canine. As defined in this study, an asymmetry was a discrepancy of at least 1 mm between the lengths of compared teeth. Five years after completion of orthodontics, this asymmetry still existed in 61% of the subjects. This asymmetry was very evident when comparing central incisors, as they are adjacent to one

another and the dominant teeth in the smile. Surprisingly, the discrepancies in the canines were also immediately evident and were seen with regularity. It is undetermined whether these asymmetries arise from operator positioning or from some other source, but a great deal of asymmetry was observed. Figure 4 shows a subject displaying some of the typical gingival asymmetry. By examining these subjects years after the initial diagnosis of asymmetry, it becomes apparent that over time, these discrepancies of the gingival margins do not improve, and the only means to correct them is surgical intervention.

Figure 4 – Gingival asymmetry

The final issue to be discussed is that of age and its role in tooth length. Volchansky[19] found that the marginal soft-tissue position did not change after the age of 12 in maxillary central incisors and canines in 237 patients. This was a non-longitudinal study of children up to16 years of age. The first part of the study agreed with Volchansky's findings when considering the maxillary central incisors. Tooth length in maxillary central incisors did not change from pre-orthodontic to post-orthodontic values

in this study. However, the length of maxillary lateral incisors and canines did change. What became evident from the second part of the study was that the mean tooth length of all maxillary anterior teeth, including the central incisors, increased by the five year examination. This concurs with the findings of Morrow[20] who demonstrated that there was an increase in the clinical crown length of maxillary centrals, laterals and canines of subjects up to the age of 18-19.

Regarding the etiology of what we observe in this study. We must first analyze the demographics of the subject population. The vast majority of subjects who returned for the five year examination were between the ages of 16-30, with over half of the subjects aged 16-20. Clearly, passive eruption most likely occurred from the completion of orthodontics to the clinical exam. Also, the post-orthodontic models were made the day of bracket removal. Some degree of inflammation is typically seen in subjects during this time. By the clinical examination, that inflammation could have reduced, thereby increasing the apparent length of the measured teeth.

For whatever reason, the lengths of the maxillary anterior teeth clearly increased throughout the study. Yet, despite these increases, 61-71% of the subjects had central incisors with a width-to-length ratio that exceeds the accepted ideal values. As the central incisors are the key pillars to the esthetic smile, their importance must not be overlooked.

The majority of components to the esthetic smile are unevaluated in the present study. There has been no allowance made for facial symmetry, labial curve, gingival display, position of midlines, buccal corridor display, location of the cementoenamel junction, or incisal edge position. Nor has there been any attempt to determine absolutely

the definitive therapeutic modality for each case. This study was intended to identify and define a particular piece of the esthetic puzzle. Further studies should be performed that prospectively evaluate pre-orthodontic, post-orthodontic and retention phase measurements of the maxillary anterior teeth on live subjects, with a varied age range and an even gender distribution. More importantly, photographs will aid the investigator in evaluating the total smile for a better overall assessment and determination of prevalence of the need for esthetic crown lengthening.

This study does present some important findings and issues related to esthetics. It also raises some questions regarding the use of "ideal" guidelines versus normal anatomy. The majority of subjects in this study fell within normal ranges, but many did not meet acceptable "ideal" criteria. Clearly, the need for esthetic crown lengthening to meet "ideal" values exists in the orthodontic population. Ultimately, orthodontists' treatment planning should include the possibility for esthetic crown lengthening in order to provide patients the option of a more esthetic smile. Therefore, clinicians must work side-by-side with each other and with patients to determine their goals and expectations, and perform comprehensive treatment to best achieve those desired results.

Conclusions

Part 1:

- Mean tooth length was found to be 1.7–2.3 mm shorter than ideal value
- Mean length of maxillary central incisors did not increase with orthodontic therapy
- Mean tooth width-to-length ratio was 94–95% for maxillary central incisors
- 85–90% of maxillary central incisors exceeded allowed 80% width-to-length ratio
- 29.5–30% of maxillary central incisors exceeded 100% width-to-length ratio

Part 2:

- Mean tooth length was found to be approximately 1.5mm shorter than ideal.
- Mean length of all teeth increased following orthodontic completion
- Mean tooth width-to-length ratio was 87-88% for maxillary central incisors
- 61-71% of maxillary central incisors exceeded allowed 80% width-to-length ratio
- 61 percent of subjects displayed asymmetry in gingival architecture.

Clincal Conclusions:

- Passive eruption continues with age
- If there is an indication for esthetic crown lengthening prior to orthodontics, there will most likely still be the need for crown lengthening throughout the patients life.

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