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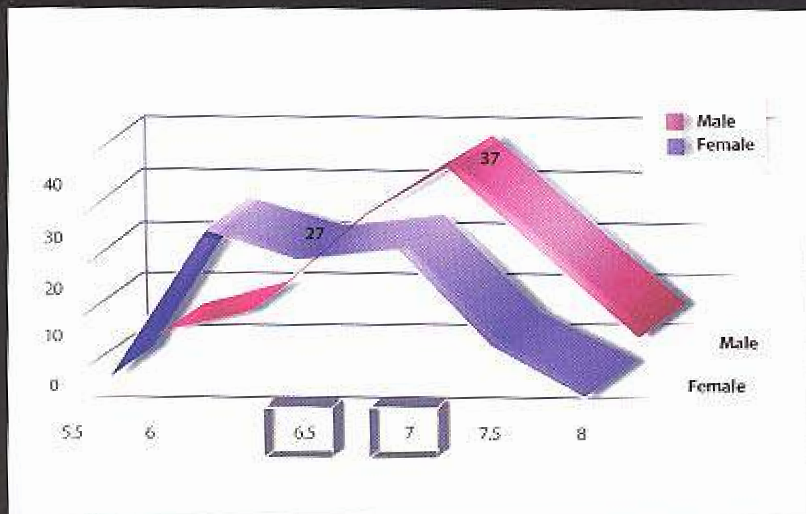

Proper diagnosis of tooth size for each patient is critical in treatment planning for aesthetic restorative dentistry. The goal of this study was to determine the clinically relevant range and mean distribution frequency of individual tooth width of the maxillary anterior dentition within a given population of patients. Mean values for restoration of tooth size were not interchangeable for the different group size of patients or respective tooth groups. The results of this study suggest that there exists a range value of maxillary anterior tooth width for both males and females. Gender differences are a critical factor in restoring an aesthetically pleasing smile.

Learning Objectives:

This article will discuss the clinical significance of tooth biometry and distribution frequency, in which size for tooth restoration may vary among patients of different age, race, or sex. Upon reading this article, the reader should:

- Become more familiar with the range of individual tooth width of the maxillary anterior dentition and their mean distribution frequencies.
- Understand that gender differences may exist affecting the width of maxillary anterior teeth.

Key Words: individual tooth width, proportion, maxillary, biometry, distribution

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Tooth size is the primary building block within the framework of a smile. Correct tooth size allows for the successful arrangement of teeth in the anterior maxilla and enables aesthetic treatment outcomes to be achieved.[1,2] Aesthetic restorative dentistry frequently entails correction of tooth size discrepancies associated with length and/or width. Consequently, tooth biometry may be an important aspect of aesthetic reconstruction, where identification of individual tooth size variations is critical to smile analysis, and correction of tooth size discrepancies are tantamount to smile design.[3,4]

There are several clinical situations that can result in dissimilar diagnoses and etiologies affecting tooth size.[5] First, hereditary factors can lead to smaller dimensions, as well as malformation (Figure 1). In addition, partial anodontia with or without transposition of teeth can occur, which can contribute to an unaesthetic smile due to a lack of tooth proportion and visual harmony. Further, insufficient incisal tooth structure with excessive gingival display due to acid erosion (eg, gastric erosive reflux disease) is now a more common disease requiring aesthetic restorative treatment (Figure 2). Lastly, with the aging process, incisal attrition with compensation eruption can lead to excessively short teeth and gingival recession can result in excessively long teeth (Figure 3).

Figure 1. Genetic factors can lead to tooth malformation where corrections are required to restore aesthetics and a stable, functional occlusal scheme.

The interdisciplinary restorative team can predictably address these aesthetic deformities associated with long or short teeth. Tooth length is frequently the variable that must be restored, as previously exemplified with the aforementioned conditions. Correction and restoration of proper tooth size and proportion are paramount to a successful aesthetic outcome. Individual tooth proportion of the maxillary anterior dentition, defined by the anatomic width/length dimensions as a percentage ratio, falls within a range of 72% to 80%, with an average of 76%.[6] Sterett et al reported a higher average proportion ratio (ie, 81%) in a population of male and female patients in reference to clinical crown dimensions where the free gingival margin is incisal to the cementoenamel junction.[7] In an effort to restore proper tooth size, proportion, and individual tooth aesthetics within the arch and smile framework, published width and length dimensions are often referenced.[7] The questions are: *What percentage of the time are these anatomic dimensions valid within a given population of patients? Is there a range and distribution frequency associated with individual tooth width of the maxillary anterior teeth that is representative of patient width variations in size, or that would be clinically relevant and applicable?* From the tooth width, clinicians can derive the desired tooth length by using the anatomic width/length percentage ratio. Thus, an additional question is: *Do these data vary based on race, sex, or age?*

The clinical significance of tooth biometry and distribution frequency is that size for tooth restoration may vary among patients of different age, race, or sex. Therefore, it

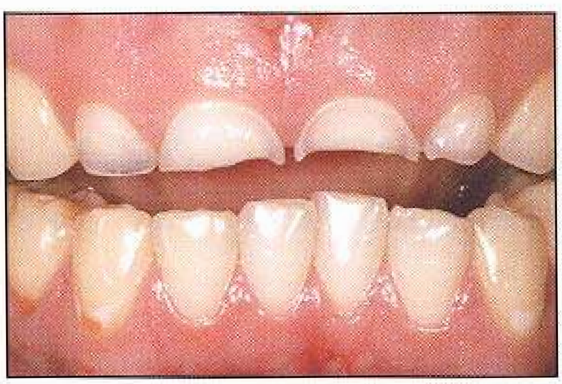

Figure 2. Accelerated loss of coronal tooth structure due to gastroesophageal reflux disease; compensatory eruption of the affected teeth and opposing dentition can occur.

Figure 3. Frequently, teeth can become short due to incisal attrition, which can result from bruxism; teeth can become long due to gingival recession.

is imperative that the proper tooth size for each individual patient be diagnosed and identified before any irreversible restorative procedures are performed. The purpose of this tooth biometry study was to find:

- The *range* of individual tooth width of the maxillary anterior dentition;
- The *mean distribution frequencies* within a given population of patients;
- Whether there were *gender differences* for the maxillary anterior teeth; and
- Whether age and *racial background* were factors in regard to tooth size.

Materials and Methods

Fifty-four gypsum model stone diagnostic casts from 36 female and 18 male patients were evaluated. The maxillary anterior dentition encompassing the central incisors (CI), lateral incisors (LI), and canines (CA) was measured. The casts were fabricated from irreversible hydrocolloid impression material that was poured immediately. The gypsum stone material was mixed with vacuum pressure.

Six-inch digital calipers with LED display SAE/Metric (ie, Graduations: 0.01 mm, Accuracy: ±0.02 mm, Repeatability: 0.01 mm) were used to measure individual tooth width at the widest mesial-distal aspect on each cast. The digital calipers were calibrated and set to "zero" prior to each measurement. One operator performed all cast measurements under 2.5× magnification via surgical loupes (ie, SurgiTel, General Scientific Corp, Ann Arbor, MI).

The criteria of the sample population consisted of nonrestored maxillary anterior teeth, nonorthodontic patients, anterior crowding of the dentition, and no visible signs of excessive incisal attrition and/or gingival recession. Cases exhibiting diastemata due to visible signs of tooth malformation were excluded. Maxillary tooth width was the only parameter measured in this study.[9] The patients ranged in age from 16 to 72 years, with a mean age of 42 years. Forty-one of 54 patients (ie, 76%) were Caucasian.

Range, mean, median, and mode values were calculated (Table 1). Distribution frequency of individual tooth width for the maxillary central, lateral, and canine teeth was calculated as well as comparative distribution frequencies according to gender. Numeric data were rounded to the nearest 0.5 mm to make the information clinically applicable (Table 2).

Results

Individual tooth width in millimeters among the 54 patients ranged in size from a minimum of 2.5 mm to a maximum of 3 mm, with the central incisors exhibiting the greatest range at 3 mm. The central incisors,

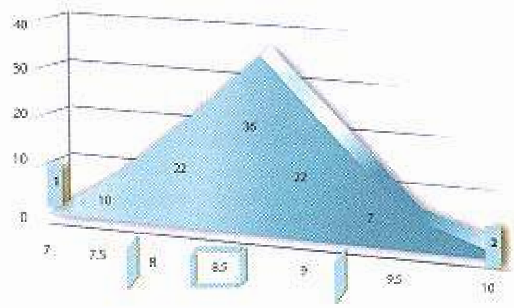

Figure 4. Combined gender width distribution for the maxillary central incisors. A 36% width distribution is noted for the mean value of 8.5 mm. The majority of patients (ie, 80%) fall within ±0.5 mm of the mean.

Table 1

Descriptive Statistics for Maxilla Width: Combined Gender Data

Tooth Number	N Statistic	Range Statistic	Minimum Statistic	Maximum Statistic	Mean Statistic	Mean Standard Error	Standard Deviation Statistic
6(13)	52	2.41	6.50	8.91	7.66	.072	.524
7(12)	52	2.00	6.00	7.00	6.63	.069	.497
8(11)	53	2.52	7.10	9.62	8.47	.075	.544
9(21)	54	2.74	7.32	10.06	8.49	.080	.590
10(22)	51	2.00	6.00	8.00	6.69	.076	.545
11(23)	53	2.55	6.34	8.89	7.61	.067	.489

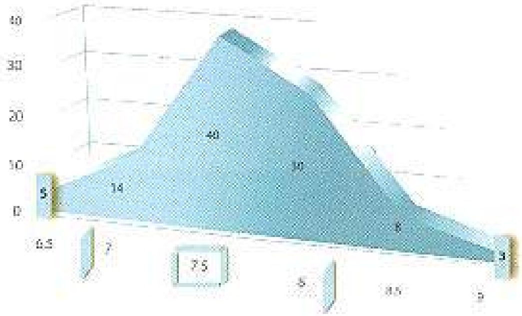

Figure 5. Combined gender width distribution for the maxillary canine teeth. A 40% mean width distribution at 7.5 mm for maxillary canines exists. Of the patients, 84% fall within ±0.5 mm of the mean with 70% at +0.5 mm of the mean.

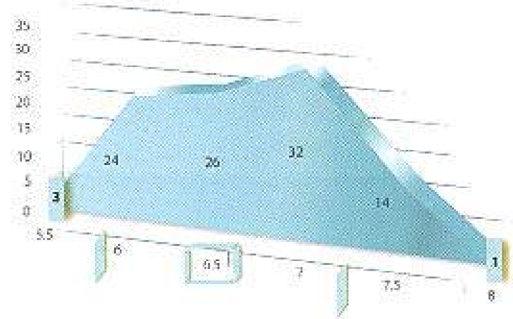

Figure 6. Combined gender width distribution is plotted for the maxillary lateral incisors. There exists a 26% mean width distribution of 6.5 mm for maxillary lateral incisors. Of the patients, 82% fall within ±0.5 mm of the mean.

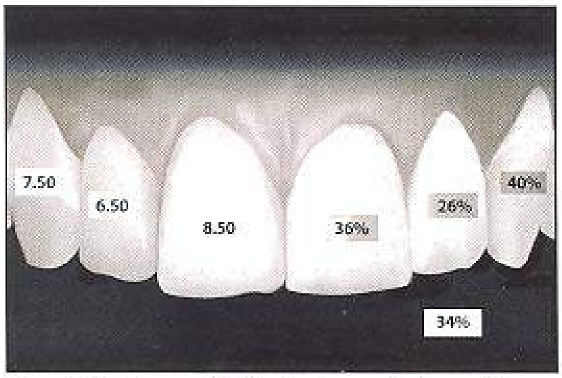

Figure 7. Total mean distribution frequencies for each tooth group (ie, CI, LI, CA), and total distribution of the maxillary anterior teeth—which is only at a 34% confidence level.

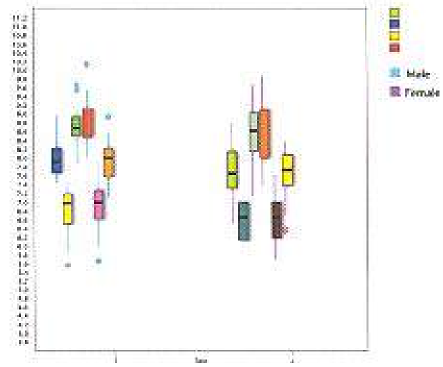

Figure 8. Blot plots for the maxillary anterior teeth. Significant gender differences exist for all tooth groups with males being larger in tooth width than females.

lateral incisors, and canines varied in range from 7 mm to 10 mm, 5.5 mm to 8 mm, and 6.5 mm to 9 mm, respectively.

Mode norms, the value with the greatest frequency within a statistical range, showed an asymmetry in the left and right dentition. Mode values (ie, rounding off to the nearest 0.5 mm) differed by 0.5 mm, implying asymmetry of tooth width between the right and left sides of the dentition—with the left side being 0.5 mm greater in width than the right side (Table 2). This is consistent with concepts of asymmetry related to parts of the human body (ie, face, hands, feet).

Only 36% and 40% of the total population exhibited the mean tooth width of 8.5 mm for central incisors and 7.5 mm for canines (Table 3; Figures 4 and 5), respectively. For the lateral incisors, 26% of the population exhibited a mean tooth width of 6.5 mm (Figure 6). As a group, a central incisor with a width of 8.5 mm, a lateral incisor with a width of 6.5 mm, and a canine with a width of 7.5 mm occur only in 34% of the population (Figure 7). Some 82% of the patients, however, fell within ±0.5 mm of the mean values (Table 3; Figures 4 through 6).

The range, mean, median, and mode values were tabulated for males and females. Results of nonparametric Wilcoxon 2-sample test and parametric t-test revealed evidence for significant gender effects for the maxillary anterior teeth (Figure 8). The findings of the two tests were consistent. Male patients ranged from 0.5 mm to 1 mm greater in tooth width than female patients. The majority of males were +0.5 mm and females -0.5 mm of the mean, respectively, for all three tooth groups (Table 3). The mean distribution frequency for central incisors (Figure 9) revealed 49% for males and 31% for females, indicating greater variation of size for females. There was a significant difference in the mean lateral incisor values between males (ie, 7 mm) and females (ie, 6.5 mm) with distribution frequencies at 37% and 27%, respectively (Figure 10). The canine mean distribution frequencies (Figure 11) showed dissimilar mean values for males (ie, 8 mm) and females (ie, 7.5 mm),

Table 2

Clinical Data Accumulated for Analysis

Tooth Number	6(13)	7(12)	8(11)	9(21)	10(22)	11(23)
Total Maxilla Width	**Mean = 7.50** [N = 52]	**Mean = 6.50** [N = 52]	**Mean = 8.50** [N = 53]	**Mean = 8.50** [N = 54]	**Mean = 6.50** [N = 51]	**Mean = 7.50** [N = 53]
	Median = 7.50	Median = 6.50	Median = 8.50	Median = 8.50	Median = 6.50	Median = 7.50
	Mode = 7.50	Mode = 7.00	Mode = 8.00	Mode = 8.50	Mode = 7.50	Mode = 8.00
	StDev = 0.52	StDev = 0.49	StDev = 0.54	StDev = 0.59	StDev = 0.54	StDev = 0.49
Range	**6.5 - 8.91**	**5.55 - 7.48**	**7.1 - 9.62**	**7.32 -10.06**	**5.65 - 7.88**	**6.34 - 8.89**

*Numeric data were rounded to the nearest 0.5 mm to make the information clinically applicable. For example, the absolute mean value for central incisor #9 equals 8.4857 mm, which equals 8.5 mm when converted to the nearest 0.5 mm. Note that mode values differ by +0.5 mm, implying asymmetry of tooth side width between right and left sides of the dentition (ie, left>right).

Table 3

Total Maxilla Distribution Percentages: Combined Gender Data

Tooth Number	6(13)/11(23)	7(12)/10(22)	8(11)/9(21)
	5.0% (6.5)	3.0% (5.5)	1.0% (7.0)
	14.0% (7.0)	24.0% (6.0)	10.0% (7.5)
	40.0% (7.5)	**26.0% (6.5)**	22.0% (8.0)
	30.0% (8.0)	32.0% (7.0)	**36.0% (8.5)**
	8.0% (8.5)	14.0% (7.5)	22.0% (9.0)
	3.0% (9.0)	1 0% (8.0)	7.0% (9.5)
			2.0% (10.0)
	Mean = 7.50	**Mean = 6.50**	**Mean = 8.50**
	[N = 105]	**[N = 103]**	**[N = 107]**
	Median = 7.70	Median = 6.50	Median = 8.50
	Mode = 7.50	Mode = 7.00	Mode = 8.50
	StDev = 0.52	StDev = 0.55	StDev = 0.58
Range	**6.5 - 9.0**	**5.5 - 8.0**	**7.0 - 10.0**

*Central incisor, lateral incisor, and canine data were grouped together because mean values were equivalent for contralateral teeth. Mean, median, mode, and range values are provided as a total aggregate. Distribution percentages were calculated for each individual width within each group as a ratio of the total number of teeth. Approximately 35% of the patients were at the mean values in regards to tooth width

with distribution frequencies at 38% and 40%, respectively. The consistency in distribution frequencies indicates equal variability between gender groups.

Discussion

While changes in tooth length can occur as a result of the aging process, tooth width generally remains constant.[7] Restored tooth length can be calculated with the following equation: **L = W / tooth proportion %**, where the tooth proportion ratio ranges from 72% to 81%. Anatomic values of tooth size are well established in the dental literature. The misconception is that these absolute numbers are applicable to the majority of patients. These data have found that a relatively low percentage of the sample population exhibits the mean tooth width of 36%, 26%, and 40%, for central incisors, lateral incisors, and canines, respectively. Therefore, restoring anterior teeth to the average dimensions of 8.5 mm, 6.5 mm, and 7.5 mm for the centrals, laterals, and canines in that order would be correct only 34% of the time (Figure 7).

If the range was expanded within each tooth group to ±0.5 mm of the mean value (Figures 4 through 6),

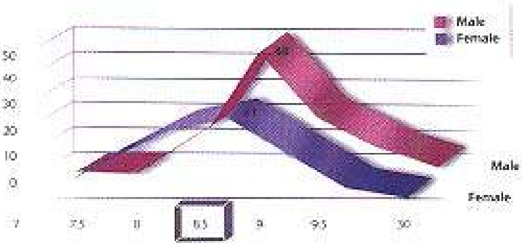

Figure 9. Comparative gender width distribution for the maxillary central incisors. Mean values are identical in both gender groups at 49% (males) and 31% (females) width distribution. The higher distribution frequency implies greater consistency of tooth size for males in regard to maxillary central incisors.

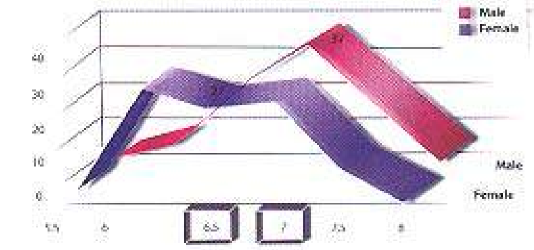

Figure 10. Comparative gender width distribution for the lateral incisors. Mean values differ by gender with males +0.5 mm wider than females. Female mean values are consistent with the total mean (ie, 6.5 mm) for lateral incisors. A 37% mean (ie, 7 mm) width distribution was exhibited in males and a 27% mean (ie, 6.5 mm) width distribution in females.

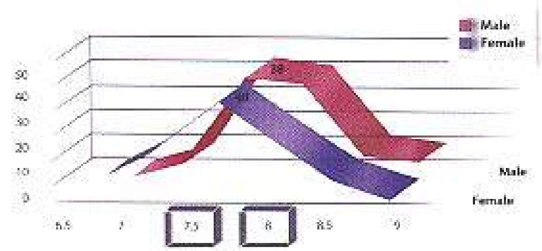

Figure 11. Comparative gender width distribution for the maxillary canines. Mean values are identical for canines in both gender groups at 40% (female) and 41% (male) width distribution. Seventy-nine percent of the males were +0.5 mm above the mean while 60% of the females were -0.5 mm of the mean.

however, then the percent of the population increased to 82% for all maxillary anterior teeth (Table 3). Thus, expanding the tooth width to ±0.5 mm of the mean increased the population percentage from 34% to 82% (Figure 12). This can also be thought of as a "confidence level." The clinical significance of these data is that there exists a range of patient tooth sizes with different confidence levels; therefore, proper diagnosis of patient tooth size is critical before any treatment is rendered. In addition, the absolute norms for the different sized groups of patients are not interchangeable.

Gender differentiation of tooth size was a major question in this study, even though gender differences in tooth shape have not been supported in the dental literature.[4] Tooth size range for males was consistently 0.5 mm larger than the mean, whereas for females it was 0.5 mm smaller. Expanding the mean value range by 0.5 mm for males increased the population from 49% to 72% for central incisors, 37% to 63% for lateral incisors, and 41% to 79% for canines, with a total average increase of 29%, from 42% to 71%. Mean values for females at -0.5 mm revealed a percentage increase from 31% to 57% for centrals, 32% to 59% for laterals, and 40% to 60% for canines with a total average increase of 26%, from 34% to 59%.

During aesthetic reconstruction, these values are very useful because they can be applied to their respective gender group with a reasonable "level of confidence" of 70% males and 60% females (Figures 13 and 14).

Conclusions

In the course of this study, there was a broad range of individual tooth width within the patient population, from 5.5 mm to 10 mm for the maxillary anterior teeth. Although there was a broad range of tooth width among the maxillary anterior dentition, the groups of individual teeth fell within a narrower range, with central incisors ranging from 7 mm to 10 mm, lateral incisors varying from 5.5 mm to 8 mm, and canines ranging from 6.5 mm to 9 mm. Approximately 35% of the 54 patients in the study were at mean values for centrals, laterals, and canines. The majority (80%) of the patients fell within ±0.5 mm of the mean. The data exhibited a traditional "bell curve" or "normal distribution."

Statistically significant gender differences existed for the maxillary anterior teeth, supported by Wilcoxon 2-sample test and parametric t-test. About 70% of males are 0.5 mm above the mean. Male mean values were consistently 0.5 mm greater than the overall population

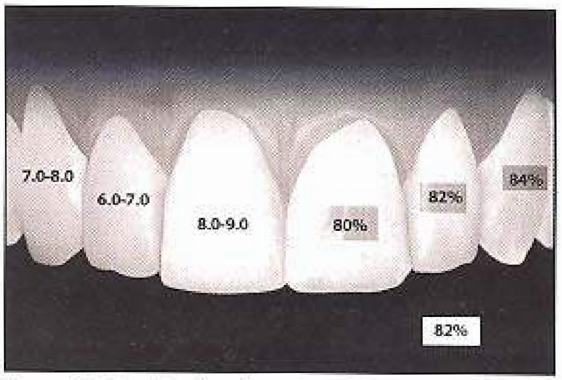

Figure 12. Combined gender mean distribution frequencies for each tooth group (ie, CI, LI, CA) and the distribution of the teeth at ±0.5 mm of the mean, which increased the confidence level to ~80%.

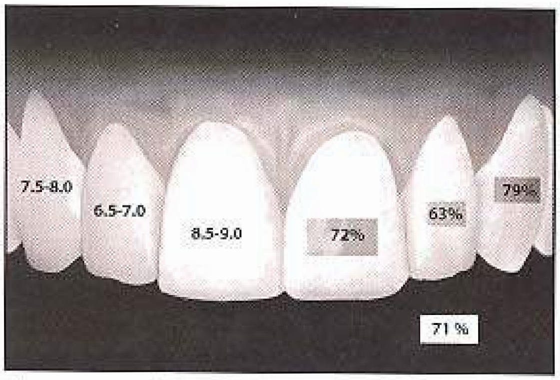

Figure 13. Distribution frequencies of male patients for each tooth group (ie, CI, LI, CA) and total distribution of the teeth. Male patients were consistently +0.5 mm of the mean.

mean for each individual tooth. Approximately 60% of females are 0.5 mm below the mean. Female mean values were consistently 0.5 mm less than the overall population mean for each individual tooth.

In summary, a normal distribution of individual tooth width exists for a given population including male and female patients. Only ~35% of the population is clustered around the mean. Expanding the range of the mean by +0.5 mm, however, will increase the occurrence within the population to about 60%. Including both +0.5 mm and -0.5 mm in the range will further increase the occurrence rate to approximately 80%. Mean values and normal distribution differed significantly between genders, with females consistently 0.5 mm to 1 mm smaller than males. Further research, however, is needed with larger population sizes to determine if race or age also affects this outcome of gender with respect to the width of the anterior teeth. These findings have significant clinical relevance in that proper tooth biometry exists for each patient; individual tooth size must therefore be identified prior to any attempt to create an aesthetic smile via dental restorations.

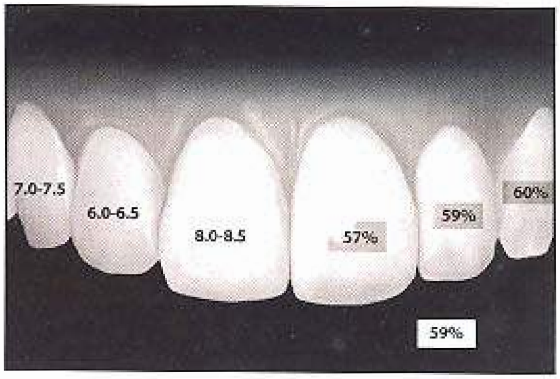

Figure 14. Distribution frequencies of female patients for each tooth group (ie, CI, LI, CA) and total distribution of the teeth. Female patients were consistently -0.5 mm of the mean.

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