The Size Relationship Between the Maxillary and Mandibular Anterior Segments of the Dental Arch

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The combined mesiodistal widths of the maxillary teeth are greater than the same measurements of the mandibular teeth. William H. Gilpatric[1] in 1923 found the upper arch to contain eight to twelve millimeters more tooth substance than the lower arch. He noted the discussion relative to disharmony between upper and lower tooth size but felt discrepancies were rare. Today this range in size might be called a "mean deviation" and a denture would have to measure more or less than twelve or eight millimeters to contain a discrepancy in tooth size.

The natural dentition can be divided into three integral parts, the left and right buccal and the anterior segments. In occlusion these parts function as units and the loss of a tooth or under or oversizing upsets the articular balance in that particular area. The buccal segment is frequently disturbed by underfilled teeth, but more often by overfilled teeth. This is not too serious a situation from an esthetic viewpoint. However, in the anterior region if it varies with the individual denture, the size relation can control overbite, overjet, crowding and spacing. The orthodontist must get these teeth esthetically correct to satisfy the patient, so before treatment is started the correct relationship of the anterior segments should be established.

Several surveys have been made to establish the index to anterior occlusion. The author[2] (1949) with the *Anterior Coefficient,* Wayne A. Bolton[3] (1952) with his *Anterior and Posterior Ratio,* Anders R. Lundstrum[4] with his *Index to Occlusion* (1955) and Murray H. Ballard[5] (1956) with his article *A Fifth Column Within Dental Occlusions* determine how much percentagewise the segments differ. These studies revealed the lower six anterior teeth averaged from 75 to 79% as wide as the upper six anterior teeth.

The method of computation was as follows: the width of the lower six anterior teeth and the upper anterior teeth were measured with a set of dividers. The sum of the combined widths of the lower teeth was divided into the sum of the six upper teeth or visa versa. The essayist computed the amount larger the maxillary teeth were than the lower teeth, and the other authors the reverse. Since the majority of these studies divide the upper sum into the lower sum and multiply by 100, this method will be used for comparison.

The author's original article was based on the measurements of 300 malocclusions measured from models and the mouth. This was an attempt to correlate tooth size relation in the anterior region and overbite. It was definitely proved by geometric formulae and the use of the Hawley-Bonwill triangle that mechanically this is true. This was further substantiated by setting up artificial teeth that were mismated. It was

felt treated malocclusions would settle to the overbite indicated by the size of the anterior coefficient. Subsequent observation of over 600 treated cases indicates this is true, especially when the Downs' upper incisor to lower incisor angle is close to 135 degrees. In the exceptions, irregularities such as spacing, overlapping, overjet, or bad incisal plane angles were factors.

A more recent survey by the author with all the measurements taken in the mouth is more accurate. While the range is smaller, the mean is the same. The lower six anterior teeth were found to be from 73% to 85% as large as the upper six anterior teeth, with a mean of 79% (Table 1).

Wayne A. Bolton at the University of Washington conducted a survey to determine the normal range for excellent occlusions. This is an important study. A formula is used to indicate the amount of excess tooth substance present in either arch when stripping is contemplated. The range for excellent occlusions was 74.5 to 80.4. This can be compared with the mean deviation for malocclusions (Table 2) of 75.7 to 81.9. Granting the data in both studies is right this seems to indicate that undersized maxillary teeth or oversized mandibular teeth are more prevalent in malocclusions than the reverse.

Dr. Bolton found no evidence that overbite and the anterior ratio were related. This could certainly be true for excellent occlusions. A competent study by S. R. Steadman[6] on good occlusions found this to be evident. He states "The variation of 3.8 mm. between the low and high values (of overbite) indicated there was no one value of overbite that was standard or necessary for all good occlusions." There is no standard anterior ratio common to all good occlusions, and there is no incisor to incisor inclination standard to all excellent occlusions. Downs[7] found the inner angle to vary between 130 and 150.5 degrees. Many factors control the overbite; the percentage relation of the size of the anterior teeth is a mechanical factor and in some instances a deciding cause.

Anders Lundstrom measured 319 occlusions directly in the mouth. The resulting occlusal guide is called the *Anterior Index*. His range is also 73 to 85%. Since the data is given in chart form, the mean can only be guessed, but is approximately 79%.

Murray L. Ballard first published an article entitled *Asymmetry in Tooth Size* in 1944.[8] His latest survey (1956) uses 75% as his guide because the manufacturer of the most used artificial teeth makes the anterior six teeth in a variation of sizes and selects lower anterior teeth that are 75% the size of the upper anterior teeth used as mates. In 1948 this same company furnished the author with a figure of 83%. Using a folder published by this company giving tooth dimensions, and by making the necessary divisions, a variation in relationship was found with an average re-

Material	*Range*	*Mean*
Bolton — Excellent occlusions	74.5 - 80.4	77.2%
Lundstrom — Random occlusions	73.0 - 85.0	79.0%
Ballard — Ideally treated occlusions	not given	75.0%
Neff — Malocclusions	73.0 - 85.0	79.0%

Table 1 Comparison of recent studies on tooth size relationship.

lationship of 75%. Since porcelain teeth are ground in varying amounts in the manufacture of artificial dentures, setups and finished cases were measured in dental laboratories. The range was 75 to 90% and would possibly vary more if other laboratories were visited. Some dentists have individual characteristic alignments in the anterior segment that might alter this range. Artificial teeth are apparently manufactured extra large in the upper anterior area, making allowance for variations such as overlapping the lateral incisors. Many dentures contained enough irregularities to confuse the anterior ratio. Usually there was little overbite present but often an overjet of two to three millimeters.

This figure of 83% could easily be for finished dentures. This is higher than for natural dentures because low cusp posteriors in vogue today will not balance with much anterior overlap.

Previous to these studies others published articles on this subject. Stanton[9] in an article *Engineering in Orthodontic Diagnosis* (1928) made the statement that discrepancy in tooth size is rare. He measured two thousand cases, probably from models. William H. Gilpatric[1] measured five thousand occlusions. He believed that overbite is controlled by two factors, one, the relation between upper and lower tooth substance, and two, the inclination of the premolars and molars. His measurements were of combined mesiodistal tooth widths from buccal groove to buccal groove of first molars and was not confined to the six anterior teeth. He believed if the maxillary arch was twelve millimeters longer a deep overbite resulted and, if only eight millimeters longer, there was a short overbite.

The reference to variation in tooth size in these studies has been mainly to tooth width. Tooth length and thickness must also be a factor in determining anterior tooth relationship. Discrepancies in thickness are more common than asymmetry in width. Thickness seems to increase with width, but a normal thickness per width was not apparent when samples were studied.

Steadman[10] in an article *Predetermining the Overbite and Overjet* considers both tooth width and thickness. He measures the lower six anterior teeth from distal of the cuspids and to this adds one-half the thickness of the lower incisors at the biting edge. The upper anterior teeth are measured from the lingual eminence of the cuspids, and from this measure is subtracted one-half the thickness of the upper central incisor at its incisal one-third. If these measures are the same, the overbite is considered normal. If the upper measurement is smaller, an end-to-end bite results; if the upper measure is larger, an abnormal overbite is indicated.

Here a part of a radius is added to a part of a circumference. This cannot be done accurately without the use of the mathematical figure "pi." In other studies since only division was used, pi was cancelled out. However, the error could be of minor consequence.

Steadman has been an enthusiastic and industrious investigator into the anterior tooth relationship. His first study reported in 1938 that the amount of overbite and overjet were the result of the manner in which the upper and lower occlusal curves came together. This fundamental principle was correct provided the widths of the upper teeth were correlated with the widths of the lower teeth. Other studies[6,11,12] were published from 1940 to 1952. His last survey was made on good occlusions and he gave eight factors in reference to tooth size relation. More data is to follow at a later date.

These determinants were tabulated with means and standard deviations. Many conclusions can be drawn from this report. Overbites and overjets are not related; the anatomy of the lingual surface of the upper incisors is a factor in determining the amount of the overbite; overjets can be caused by an unfavorable ratio of upper and lower bicuspid and the distal half of upper cuspid widths. The inclination of the upper incisors to the lower incisors is a factor in determining the overbite.

Prakash and Margolis[13] state that the vertical position of the lower incisor shows no correlation to the amount of overbite; the extent of the overbite varies with the relative vertical level of anterior teeth as related to posterior teeth.

An orthodontist correcting a malocclusion can be compared to a laboratory technician making full artificial dentures. Teeth are rearranged to fit over the ridges or bases. If there is a discrepancy between tooth size and jaw size, the technician leaves out second molars, the orthodontist extracts, usually the first premolars. The artificial tooth manufacturer makes upper and lower sets of teeth to match. Nature is not this kind to the orthodontist. He needs a method to determine if tooth masses are oversize in any dimension.

The Anterior Percentage Relation and the Radius Analysis

A suggested answer to this problem is a simplified guide called the "Anterior Percentage Relation" and the "Radius Analysis."

The Anterior Percentage Relation (A.P.R.) is a new name. This is the percentage larger the upper six anterior teeth are than their lower mates. A new survey measuring three hundred new malocclusions all directly from the mouth (Table 2) disclosed that in malocclusions the maxillary anterior segment is 18 to 36% larger than the mandibular anterior segment. 83.3% of the dentures have A.P.R.'s of 22 to 32%. This is the mean deviation, but according to Bolton does not match the range for excellent occlusions (24 to 34%). One standard deviation above is 33 to 36% and one below is 18 to 21%.

A.P.R.	*Number of cases*	
18%	3	
19	7	one S.D.
20	9	
21	8	
22	22	
23	29	
24	24	
25	41	
26	24	Mean dev.
27	23	Average
28	21	Mean 28.2%
29	18	
30	15	
31	15	
32	16	
33	7	
34	5	
35	6	one S.D.
36	7	

Table 2 Results of recent 300 malocclusion survey, showing the anterior percentage relation (A.P.R.) range and deviation. Average for all malocclusions 26.6%.

Despite being outnumbered in the method used to compute the anterior tooth relationship the A.P.R. has definite advantages. The range 18 to 36% is easy to remember as 36 is twice 18. If a slide rule is used to compute the result, the answer appears in the 1-2 area. Accuracy due to more divisions on the rule is better in this region. The best reason for using this system is that, as the anterior percentage relation increases, so does the indicated overbite. This figure can be used to determine the amount of anterior overlap needed provided other factors are normal. These would be elements such as the cant of the upper incisors in non-extrac-

tion cases, excessive tooth thickness, extremely short teeth and abnormal lingual anatomy of the upper incisors (Table 3).

A.P.R.	*% Overbite*
10%—18%	0
22%	15%
30	30
36	35
40	50
55	100

Table 3 Approximate degree of overbite as indicated by the anterior size relation.

The overbite is measured as the amount of the lower incisors covered by the upper central incisors. In a previous study through the use of the Hawley-Bonwill triangle it was found that an end-to-end bite would have an A.P.R. or coefficient of 10%. This is computed by relating the line through the incisal edges of the maxillary and mandibular anterior teeth. The tooth substance present on either side of this line would probably cause an end-to-end bite on dentures with anterior relations up to 18%. So unless spacing is present, if the upper anterior teeth are less than 18% larger than the lower anterior teeth, an end-to-end bite is indicated. A 100% overbite would have a relation of approximately 55%. A coefficient of 22% was called ideal. This was only from a treatment standpoint. Dentures with this anterior relationship will treat more easily to an end-to-end bite so often desired in finishing malocclusions which started treatment with a large overbite. This gives the face the maximum height in the lower one-third.

After doing two studies that included over six hundred natural dentures, the author agrees with Stanton and Gilpatric that, while variations in size relationships do exist, actual size discrepancies are rare. Malocclusions are constantly being treated throughout the country where the operator has paid little or no attention to the anterior relationship and the results are satisfactory. However, when a lower incisor tooth is missing or is removed, a size discrepancy may be created. It is then that the Anterior Percentage Relation should be determined to see if five, or six lower teeth (including a premolar), will be the lower segment.

The Radius Analysis

A way to determine if tooth masses are oversize in thickness is to use Hawley's[14] method of drawing arch form, measurements being taken only along the radius (Fig. 1). If two circles are drawn to represent the incisal middle edges of the anterior teeth using the measure of one central incisor, one lateral incisor, and one cuspid as a radius, the distance between circles along the radius is equal to one-half the thickness of the lower incisor tooth at its incisal edge plus the thickness of the upper central incisor at its occlusal contact point. This contact point should be measured at a point up from the incisal edge of the central incisor equal

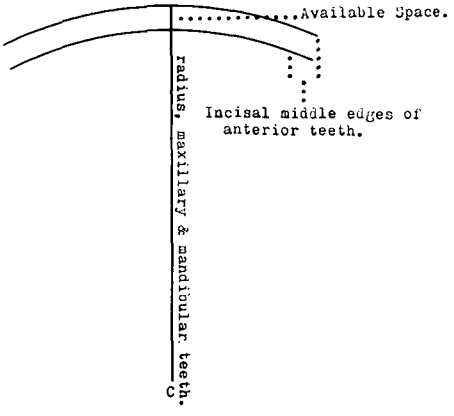

Fig. 1 Available space between the incisors in occlusion.

Upper radius	46.0
Lower radius	37.5
Available space between middle of incisal edges	8.5
Lower incisal edge	2.8
Upper incisor at occlusal contact	5.6
Total needed space	8.45

Table 4 Analysis of illustrated malocclusion.

to one-quarter the length of the lower incisor tooth crown. This space can be compared with the available space between the two circles and the anterior indicated occlusion determined (Table 4). This can be explained better by measuring an actual case.

This malocclusion (Fig. 2) after treatment will not articulate except with an end-to-end bite. With an A.P.R. of 22% it should fit nicely with a small overbite. Both the upper and lower incisor teeth are short and appear thick at the incisal edges. To determine the trouble it is necessary to measure along the radius and pit the available space

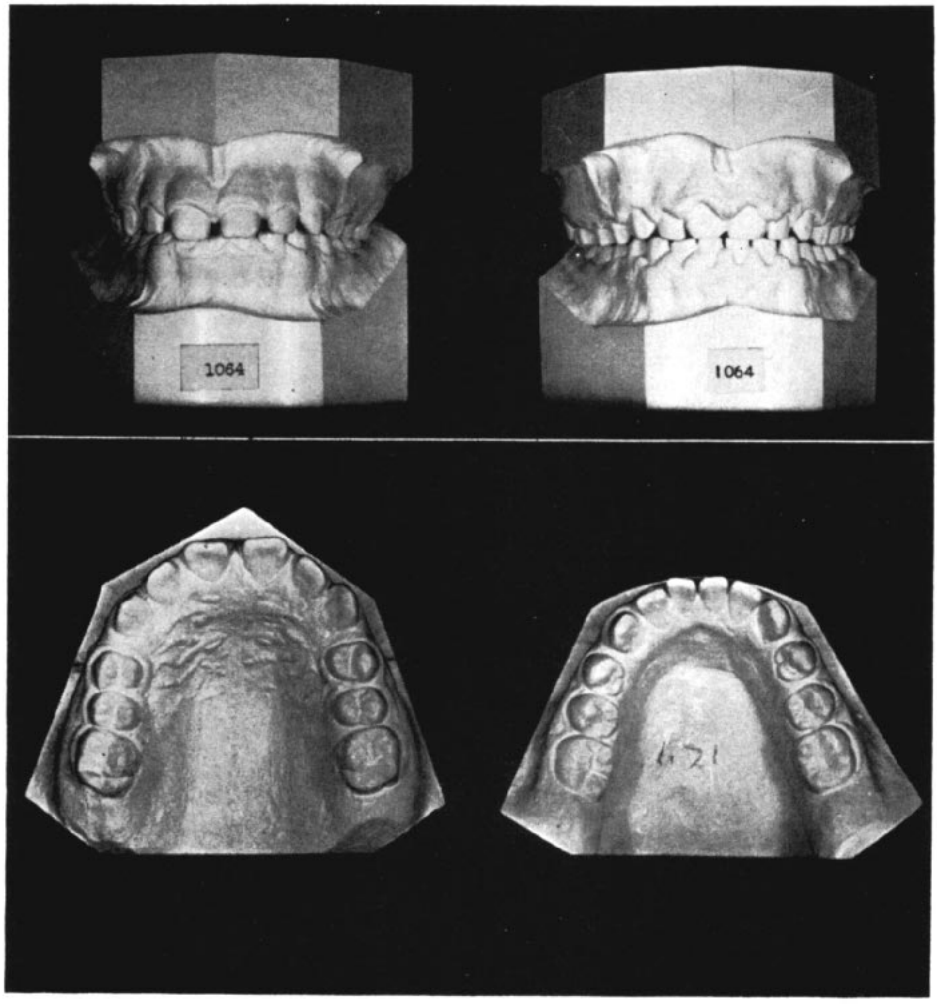

Fig. 2 Malocclusion with anterior teeth oversize in thickness.

against the needed space.

The radius for the upper arch is 46.0. For the lower arch it is 37.5. The available space is 46.0 minus 37.5 or 8.5.

The lower incisor tooth at its occlusal edge measures 5.6. The upper incisor tooth at its occlusal contact point measures 11.3. One-half of 5.6 is 2.8 and one-half of 11.3 is 5.65 a total of 8.5. The available space and the needed space are practically the same, as the result of an end-to-end bite.

Only when incisal edges appear abnormally thick is it necessary to use this analysis. Usually the amount of overbite can be calculated from the width of the anterior teeth. An A.P.R. of 22% has an indicated overbite of slightly less than 20%. A theoretical A.P.R. of 50% would have an overbite of 100%, so each increase of one percentage point in the A.P.R. is equal to 2.5 points in the overbite. Thus, the normal range of the variation in the overbite would be from 17.5% to 76% if it were not for the fact that the lingual slope of the upper incisor teeth is a compound curve. At a position where the upper incisor teeth overlap the lower incisor teeth by an amount one-third of its length the increase is mainly in overjet.

All natural dentures will not follow perfectly any geometric pattern, so as a guide to the overbite, the A.P.R. and the percentage overlap can be considered equal with some variations.

Lundstrom and Ballard suggest a correlation between tooth size disharmonies and malocclusions. There may also be a correlation between the percentage relation and arch shape. The smaller the upper six anterior teeth are in relation to the lower anterior teeth, the wider the arch at the cuspids, and the larger the A.P.R., the narrower the arch. Undeniable proof of this contention has not been established.

Dentures in the 32 to 36% range do not appear to cause disturbances that are not acceptable. Steadman found overbites of 4.3 mm. in the good occlusions he measured. This could be a 50% overbite and is more than a denture with a 36% A.P.R. would be expected to have. However, in the 18 to 22% range, spacing of the maxillary anterior teeth may occur unless the mesial ridge of the upper cuspid teeth and the distal ridge of the lower cuspid teeth are ground. When correctly done this places the lower cusp more mesial and the upper cusp more distal. The method suggested by A. C. Heimlich[15] using two colors of articulating paper is a valuable aid to better cuspid tooth balance. Beveling the incisal edges of the lower incisor teeth may help. Some cases can only be helped by the extraction of a lower incisor tooth. In other cases stripping of the interproximal surfaces of the lower anterior teeth may be sufficient.

Patient or parent resistance is encountered when reduction of the width of the anterior teeth is suggested as a remedy for asymmetry in tooth size or shape. According to Arthur L. Hudson[16] there is basis for this concern. He states, "Mesiodistal reduction of mandibular teeth does increase the hazard to caries by reducing the amount of protective enamel present. The perspective cited here is probably the least important provided the enamel removed is less than one-half of the available." He lists the important points that increase the hazard as follows:

1. Flattened surfaces that defeat the cleansing action of embrasures.
2. Roughened enamel that would tend to retain debris.
3. The removal of enough enamel to expose the inner portion that con-

tains numerous tufts and spindles in the immediate future or in the distant future when enamel wear takes place and more enamel is lost.

4. The failure to take steps to age artificially enamel that is exposed when the semimatured surface is removed.

The average thickness at the contact point is said to be 0.59 mm. for the lower central incisor, 0.66 mm. for the lateral incisor and 0.82 mm. for the cuspid tooth.

Polishing the surfaces after stripping with fine cloth strips is mentioned as a necessary precaution in the prevention of future caries.

The average anterior percentage relationship is 26.6%. If reduction in mesiodistal tooth width is contemplated, the new A.P.R. created should not retreat from this figure, but preferably approach it.

While reduction of tooth width appears to be a controversial issue, the belief persists among dentists that if all precautions are taken it is unlikely to produce caries. Application of Gottlieb's[17] formula or topical fluoride is indicated.

Graber[18] states that during the course of treatment it may be feasible to sacrifice first premolars, second premolars, lower incisors and second or third molars. Many lower incisor teeth are diseased or stripped of labial plate and must be removed. Treatment may be very complex when only three incisor teeth are present because of the imbalance between the anterior segments. Buchner[19] remarks that "the relationship of teeth is incorrect when less than four lower incisor teeth are present." He gives the occurrence of missing lower incisor teeth as six in five hundred cases. Maxillary lateral incisor teeth were missing in the same ratio.

The removal of a single lower incisor tooth in the treatment of a Class III malocclusion is indicated when the mandible is oversize and the A.P.R. can be converted into an acceptable figure. The occlusal area of the mandible is reduced, and by replacing the extracted incisor tooth by adding a first premolar to the anterior segment, the Class III relationship does not need reducing on one side. Quite often this type malocclusion has an open or end-to-end bite. The replacement of an incisor tooth with a larger premolar will reduce the size of the A.P.R. and the indicated overbite. This should be considered before initiating this type of treatment. An anterior percentage relation of less than 18% after the extraction may produce an open bite.

Class II malocclusions frequently have a large overbite as well as overjet. If a first premolar is moved into the lower anterior segment after the extraction of a lower incisor, this will open the bite and help retain it. However, correct cuspid interdigitation seems difficult to retain as a relapse sometimes positions the maxillary cuspid directly over the lower cuspid. This relapse is also seen in Class I malocclusions treated with a lower incisor extraction and a premolar articulated in the lower anterior segment.

Other combinations involving extractions of incisors are the removal of upper lateral incisors, one lower incisor and one upper premolar, or two upper premolars and one lower incisor. In any of these combinations the relationship of the anterior segment will certainly be altered and the percentage relation should be determined before extractions and with the contemplated changes.

Correlating anterior tooth size and the overbite by the use of the anterior

relationship is a controversial subject. Malocclusions under treatment that easily develop an end-to-end bite at the end of treatment usually have a ratio in the 18 to 21% range. The correlation between the anterior percentage relation and the degree of overbite was most prevalent in four premolar extraction cases. This is evidently because this type of malocclusion is more prone to finish with a good maxillary incisal angle. This possibly explains why Bolton found no correlation between overbite and the anterior ratio. His study was confined to the examination of fifty-five selected excellent occlusions with a full complement of teeth.

Summary

1. Several surveys have determined the size relationship of the anterior teeth. Neff with malocclusions and Lundstrom with random occlusions have found that the six maxillary anterior teeth are larger than the lower six anterior teeth by 18 to 36%. Bolton determined that excellent occlusions have a smaller range, the maxillary anterior teeth being 24 to 34% larger than the lower six anterior teeth.

2. Relations that indicate reduction in tooth size of the mandibular anterior teeth is necessary occur in approximately ten percent of malocclusions. It is very rare that reduction in the size of the maxillary anterior teeth is indicated.

3. Tooth size relation of the anterior segments of the dental arches and the degree of overbite do not bear a consistent relationship in untreated malocclusions and non-orthodontic normals. However, where the orthodontist is in control of the final arrangement of the denture, the relationship is more pronounced.

Conclusion

To determine if the size relation of the teeth in the anterior segments of the dental arches is correctly correlated can be a very simple procedure. The figure 22% can be used as a dividing line between good and questionable relationships. If the maxillary six anterior teeth are 22% or more larger than the lower anterior six teeth, the relation is acceptable if it does not exceed 36%.

If the relationship figure is below 22%, a reduction in the size of the mandibular tooth masses (stripping or an extraction) may be necessary to obtain good anterior occlusion. Stripping can be done even after treatment is completed, but extraction of a lower incisor must be considered with caution.

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