Cephalometrics: A Perspective

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If one could sit on the moon and look at the activities of the 3,500 different millions of humans each trying to obtain elbow room and food on a rather small planet in a third-rate solar system and then ask himself, "What have cephalometrics contributed?", the most compelling answer is quite clear: It has humanized the orthodontist. It has helped to teach him that he doesn't have all the answers. He can't play God, even regarding occlusion and growth. Every single scientific study has underscored how little we know, and that life is complex beyond the wildest human theories of any given generation. In cephalometrics this is manifest by the gradual recognition of the normal variability among people, the variability in the way people grow, and our inability to accurately predict this variability for any single human organism. Individualism still reigns in the fight against communism and the length of time we have until 1984 depends upon how willing we are to tolerate variation from someone else's conformity, even if the program is computerized.

Of the millions of headfilms procured in the last thirty-five years, only a few thousand have been scientifically analyzed in a handful of studies. When this was done, it was suddenly found that headplates, like a photograph, were useful only for describing certain tissue relationships that exist at any one moment in time. They have proven to be of little or no value in providing valid (clinically useful) treatment goals and of absolutely no value for predicting growth. The reasons lie not with film-target distance, milliamperes, rotating anodes, computers or elaborate cephalostats. Rather they lie in the biology of the beast, malocclusion.

The line of reasoning I plan to follow hinges around an examination of malocclusion from the viewpoint of heredity and environment. It might be subtitled: Genetics versus Orthodontics. It is especially revealing to look at the push-pull of environment and heredity from a historical perspective because many advances in orthodontics have come from members of this society. Many people, Strang, Brodie, Tweed, Kloehn, Dewel, Bull and Nance —have modified the Angle concept of orthodontics with cleaner and simpler mechanics until today we have techniques such as advocated by Andrews and Klein. When these are put together, it becomes apparent that the original Angle concept of orthodontics has been completely recast and, of course, so has the use of cephalometrics. If we look at the course of this transition from a historical viewpoint, the meaning is not only more clear, but it also gives us a glimpse of the future. That is, whatever we know for absolute certainty will be recast and reinterpreted by the next decade.

Medieval thinking provides a description of idealism and the insistence of Western thinking on logic, whether the logic is good or not. It was well known among theologians at that time that God created the world perfect, but since planets traveled in elipses rather than in perfect circles, something had intervened. It was logical that since ordinary angels did not possess sufficient power, archangels (but not the higher seraphims even though they had six wings) were making elipses out of

Presented at a combined meeting of the west coast components of the Angle Society, November, 1971.

circles. A few centuries later when another theory—the theory of gravitation—became rather widely accepted, the archangel theory ceased to be logical and new theories were constructed. The new logic, Science, 18th century science, included gravitation. In the framework of this neoscience, the entire universe was recast as an intricate gear box, a lot of little parts each comprising a special niche in the total machine, from the solar system down to the earth, down to the smallest particle, the atom—the absolute fundamental particle which has been seen by no man.

It must be remembered that at the time when Angle was formulating his theories the mechanical concept of the Universe was common. The idea of evolution was not too widely held, paleontology didn't exist and there was almost no archeological evidence to document such a radical theory. Bonwell was writing on "What dentistry has to demonstrate against the hypothesis of Evolution."[1] A couple of years later Angle stated "orthodontics had long been burdened and seriously handicapped by the belief that small jaws and large teeth had in some mysterious way become mixed up through heredity, resulting in malocclusion." Instead, he held to the earlier concepts that man was created perfect and that malocclusions such as Class II were the result of faulty environment in which the ideal alignment of the teeth as intended by "the great watchmaker" did not reach "full expression." "Malocclusion is always associated with . . . perverted bone growth corresponding exactly with the degree of malocclusion." With this logic, his mechanics were aimed at re-establishing normal occlusion which would, in turn, provide "stimulus to bone cells . . . (and to) cause nature to develop bone on a large scale."[2-4] Sixty years later it is possible to re-evaluate these concepts and recast them in terms of more "modern" biology.

In the world of physics the fundamentalist concept fell apart when radioactivity was discovered. This meant the basic fundamental unit, the atom, was not stable; it decayed, it changed. Rutherford, Thompson, Einstein and others followed with theories of relativity. In mathematics non-Euclidean geometry exploded the notion that mathematics could be the source of absolute truth. In biology Darwin's concepts were reinforced with the development of paleontology. Archeology added more weight. At the time Angle was writing his 7th edition, Mendel's theory of genetics was just being rediscovered. It was only twenty years ago that Watson and Crick theorized the existence of the DNA double helix and the RNA carriers. Subsequent work has reinforced their position that these genetic features are prime movers of cell division, i.e., growth. In our culture environmental factors such as disease, function and habits may have a temporary effect on growth with partial to complete recovery.

The 1940's saw a substantial revision of the original Angle logic. Brodie, Strang and Bull presented evidence and argued against bone growing. The battle of extraction to avoid arch expansion was led by Tweed. This would have been heresy to Bonwell and others who held that man, who was above nature but below the angels, had a God-given genetic potential for perfect occlusion. Strang and Bull minced no words about the fallacy of jaw growing. Kloehn, with cervical traction, made such correction of Class II possible with retraction of maxillary molars. Stainless steel and prefabricated bands took the orthodontist out of the jewelry business. The angulated brackets of Holdaway, the wide bracket, twistflex and A-lastiks simplified wire bending. The substitution of pragmatism and relativity for archangels and idealistic perfectionism may reject some of Angle's ideas but it is in keeping with his idea of progress. To title an article "The Latest and Best in Orthodontic Mechanisms" contains the idea of change and progress, not a static absolutism.

It is in this light we today can say that the orthodontist is treating biologically normal genetic variation—that variation which makes each of us a unique and distinct individual—and forcing it into one mold, one that is socially acceptable. He begins with great variation in tooth size, jaw size, muscle size and muscle strength, i.e., a so-called malocclusion, and reduces this variation to a Class I molar relationship, aligned teeth and minimal overbite. This ideal occlusion (or a reasonable facsimile minus four premolars) is socially normal in the sense that it is normal for some tribes to bind the cranium, for some to file teeth, for some to tattoo the body, while other tribes normally prefer lipstick, brassieres and straight teeth. Ideal occlusion is a man-made definition, an ideal, a description of a small part of biologic normalcy, that part that is both biologically and socially normal.

Before elaborating on why no cephalometric analysis or any set of unthinking numbers can describe a cultural ideal which is at the same time biologically stable, it is important to take an objective look at the biologic necessity of teeth, i.e., their survival value. It is obvious that one can survive in our present culture without teeth and meet adequate nutritional requirements. Many edentulous individuals attest to this, including one man whose picture was in the *ADA News* last year, age 130, who had lived for

Fig. 1 Mesa Verde Indian who had lost all maxillary and several mandibular teeth several years before his death more than 700 years ago. For background information, see the article by Osborne, "Solving the riddles of Wetherill Mesa" National Geographic Magazine, 125, No. 2, p. 155, 1964.

seventy years without a dentition, either natural or artificial.[5] It is doubtful that this Mesa Verde Indian (Fig. 1) who died before white man set foot on this continent had heard of Trubite teeth or even vulcanite dentures. Studies on digestion have indicated that mastication is of some importance for eating fried foods and green peas and of no consequence for eating potatoes, fish and bread.[6] From the standpoint of digestion teeth are a convenience to help enjoyment of good cuisine, but not a necessity for survival. Most malocclusions, aside from "open bites" or nonocclusion, do not masticate less efficiently than ideal occlusion.[7]

Teeth also facilitate, but are not essential in the articulation of a few labiodental and linguodental phones.

As with masticatory efficiency, the open bite or nonocclusion and sometimes anterior spacing is most telling in the production of the sibilants /s/, /z/, /f/.[8] With regard to longevity of the dentition, crowding causes some increase in dental caries of the lower anteriors (five surfaces on the average in a young adult)[7] and an increase in gingivitis.[9] What relationship exists between gingivitis and periodontal pathology is undocumented despite a popular belief that a high correlation exists.[10]

Against this background it is also worthwhile noting that some distinctly differing definitions of malocclusion are in common usage. First, it is possible to identify two distinct definitions of malocclusion:

1. Irregularities of alignment and interdigitation, i.e., "crooked" teeth, involving tooth size, dental arch size, size of mandible, muscle sizes, size of maxilla, and their relationship to one another. It is the anatomical, social, idealistic definition of an occlusion that is usually (but not always) biologically normal.
2. The dynamic intercusping associated with chewing where malocclusion refers to occlusal trauma: the so-called "T.M.J. syndrome" (of which perhaps 90% to 95% are iatrogenic). This malocclusion is painful and interferes with function.

Another problem is the definition of "normal." In dentistry the term is commonly used in at least three senses:

1. Statistical or average:
   a. Most frequent, usual, popular, the mode
   b. Typical— a statistical approximation is sometimes considered to be the mean with "normal" variation defined by ± 2 SD
2. Functional—does it work:
   Not harmful, not painful, and nonpathologic
3. Idealistic—the way it "ought" to be:
   a. Orthodontic or anatomic (Angle's Old Glory)
   b. Gnathologic
      (1) cuspid protection is normal
      (2) group function is normal
      (3) terminal hinge is normal
      (4) abrasion is abnormal
   c. Anthropologic—abrasion is normal for continuous self-equilibration.

With the advantage of fifty years of hindsight, one can now say that Angle's original concept of occlusion is static and perfectionistic (the way it "ought" to be) as opposed to a functional or natural concept (does it meet the biologic requirements for life).

Granted that straight teeth are desirable socially, the problem of orthodontic treatment can then be reduced to a choice of whether one wants to employ prolonged retention or not. If one elects to follow the original idealistic theories of Angle, to expand the dental arches to relieve crowding and attempt to release inhibited mandibular growth to "correct" a Class II molar relationship, he can expect a high percentage of relapse or "biologic rebound." Another solution is to employ a retainer for prolonged periods of time, at least until the patients tire of the retainers. He is fighting the homeostatic tendency of the muscles and the jaws to return to the original balanced position, plus the genetically determined growth changes. The semipassive teeth will accommodate by moving wherever an imbalance of pressure exists for a prolonged period of time, a circumstance we consider most fortunate when orthodontic appliances are in place and most unfortunate after they have been removed.

In this sense bone and muscle size (and their growth) are determined by Mendelian principles; the environmental forces generated by orthodontic appliances are too minute to have any long-term clinically meaningful effect on adult facial dimensions. For a dramatic example see the spontaneous recovery of face height after release of heavy orthopedic forces generated by a Milwaukee brace which Logan presented in the 1968 *Transactions of the European Orthodontic Society.*[11] On the other hand, it has been known since at least 44 B.C. that pressure on a tooth would cause it to move. Yet nowhere has anyone *ever* been able to demonstrate scientifically, i.e., to disprove the null hypothesis, that orthodontic or the so-called orthopedic forces produce a clinically meaningful (1 or 2 mm) *permanent* effect on the size of the facial bones and their supporting musculature. The concept of producing permanent change in the facial skeleton is not a clinically useful fiction.

I have chosen to treat my cases to minimize artificial retention and depend upon natural retention, i.e., to place the teeth in a position of natural balance. In my clinic at Oregon perhaps 5% of several hundred patients have received artificial retainers during the last decade. For the others we employ "natural retention" which depends upon interdigitation and the balance of the musculature (orbicularis oris-buccinator ring and the tongue). We also respect the balance of the muscles that posture the mandible vertically which will be discussed later.

Translated into clinical practice, this means we follow the concepts of Strang and Nance and *never* increase the width of the mandibular dental arch. There is ample evidence from several hundred cases followed several years after treatment, especially those of Reidel, to indicate that a mandibular dental arch which is expanded either laterally or anteriorly will relapse on the average.[12-16] Some cases such as seen in Figure 2 have expanded with-

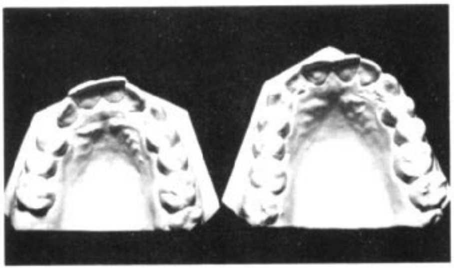

Fig. 2 Between the ages of 10 and 17 years, the blocked-out cuspid erupted with a 7 mm increase in arch width. The average increase after age 10 for the maxillary arch is about 3 mm (mandibular arch is zero) with a variation for both arches of about ± 3 mm. This extreme variation (7 mm) can thus be expected in less than one case in 100.

out treatment, but the majority will relapse to the original position or move farther lingually. In other words, on the average, nontreated cases as adults are not different from those who have been orthodontically expanded and given a chance to relapse ± normal growth change (the null hypothesis). Some recent research has shown, however, that lower incisors retracted as much as five mm remain retracted for more than five years after retention.[17] Relatively speaking, the general outline of the lower dental arch becomes the guide for treatment; if there is crowding in the lower arch, extraction is the only therapy if it is to be a stable treatment. Mechanics are then arranged to fit the upper arch to the "stable" lower arch. It has been known for decades that the lower arch does not increase in width after nine or ten years of age, on the average. We would like to predict variation of +3 mm to —3 mm around this average, but until someone has established microwave communications with the next world, we will have to admit to this degree of error. Cephalometric prediction and computers only confuse the issue.

Our treatment planning scheme to minimize artificial retention is found in SLUM:

S—(Skeleton) Since clinically meaningful changes (more than 1 mm) in the skeleton can only be produced surgically, evaluation of the face begins with the question, "Is facial surgery needed?" If so, surgery is primary. If not, crooked teeth are considered beginning with:

L—(Lower arch) Where the question becomes, "Is the crowding so severe that the extraction of teeth is preferable?"

U—(Upper arch) Is the upper arch ahead of the lower (Class II) or is it satisfactory (Class I)? How much overbite should be corrected? For Class III with severe upper arch crowding, the problem is skeletal and this scheme is not too useful.

M—(Mandibular shift) Especially with crossbite (both anterior and posterior) it is important to ascertain the balanced position of the mandible (without cuspal interference) and treat the teeth so the interdigitation is coordinated to this muscle-dominated position.

The point is that all decisions were based on the "latest and best" 1971 biology. I would point out that nowhere did archangels, cephalometrics or computers enter in. Like a photograph, cephalometrics can describe what exists, but not what "ought to be" whether defined as a biologically stable or an esthetically pleasing occlusion. This is why I argue that numbers, dumb insensitive symbols for counting, have little value in defining treatment goals. For me, the only clinical value of cephalometrics (as opposed to research value) is to make certain the lower anteriors have not been tipped forward. When students are first learning to handle torque, the tendency to procline the anteriors appears in four or five cases each year.

At this point it seems meaningful to retrace the development of cephalometrics in relation to the changes in orthodontics. The technique of cephalometrics was conceived in the 1930's when most of Angle's ideas held sway. Tweed had not yet announced he was extracting, and neither Strang nor Nance had formulated the stable mandibular arch concept. Bone growing was "in" and cervical traction was unknown. Hopes were high that Broadbent's modification of T. Wingate Todd's head spanner was the "scientific" instrument which could not only measure growth but also ultimately predict growth. Forty years later, we must admit the instrument is neither very reliable nor is its information particularly valid—at least as traditionally used for diagnosis and especially for prediction.

The problems of reliability (repeatability-accuracy) were first attacked twenty-five years ago by Björk;[18] Meredith, Baumrind, Solow, and Hixon[19-23] followed and have published various estimates for errors of measurement. The standard errors of measurement can be only 5-6% of the distance measured, but the rates of facial growth are so slow this 1 or 2 mm error is the same order of magnitude as the annual growth change.[23] In other words, a dull tracing pencil can almost obscure a year's growth.

Validity is a concept that is concerned with how well the cephalometric numbers or measures reflect the underlying biological features purported. The most prominent point to be noted from the implant studies is that many of the so-called "landmarks" are sites of bone resorption or deposition, i.e., they are changing. Further, a cephalogram is at best a two-dimensional abstraction of a viable three-dimensional face at one single moment of time. When measurements are derived from this silhouette, the resulting distortion (as distinct from enlargement) is seldom considered by investigators and almost never by clinicians as they talk about diagnosis and growth. The change in number values "is" growth. The clinician who doesn't have time to critically explore the research on cephalometrics must trust those who purport to be experts. Today, with Monday-morning quarterbacking, we know the anthropologists and orthodontists did not understand the tools they were using, especially statistics. The psychological security obtained from manipulating numbers (ANB, mandibular plane angle, etc.) does a disservice for the clinician. He thinks he is talking about growth and it distracts him from the soft tissue drape and the appearance of the individual; that subjective human cultural evaluation is best made by a human clinician and a human patient (and/or the parent) rather than by a cold, inert, abstract number or norm. To the patient, evaluation of his appearance is validity, not a number or some recipe for changing it. To dentists, such "scientific formulae" have appeal because they are logical. It is harder to determine if such logic is valid.

Let's turn to the latest twist, prediction. All predictions consist of extensions of the past into the future, either as a linear projection of the past or as a cyclical phenomenon such as the seasons of the year, sunspots, or a business cycle. *All* longitudinal cephalometric studies which have not misused statistics have failed to show *any* improvement in prediction over the use of the average or group change.* Of the hundreds of correlations completed which measure growth change, the highest I know of is $r = 0.4$.[24,25,26,42] This accounts for only 16% reduction of the total variability of the predicted trait. Three approaches have been tested:

(a) size/change (past growth predicts future growth) Meredith, DeKock, Carol, Björk, Knott[27-31]
(b) cephalometric angles / change (measuring bumps and landmarks predict future growth) Lande, Björk, Johnson, Balbach[25,26,30,32]
(c) gain/gain (past pattern of growth predicts future pattern of growth) Meredith, Harvold, Knott, Jones[27,31-33]

Biologically, it should be no surprise that measuring bony bumps on a two-dimensional abstraction of a three-dimensional skull should reveal nothing about the genotype, the DNA which controls cell division (growth). The cephalogram measures nothing of the musculature, tongue or connective tissue blanket. To feed cephalometric information into a computer (a counting machine which can handle millions of bits of information very rapidly) doesn't improve predictability of growth, even that small part which can be measured on two-dimensional cephalograms. To say otherwise is to insult geneticists and biologists. Statisticians use the term GIGO, garbage in, garbage out, for such simplistic solutions as found in commercially available growth forecasts.

What is more ironic is the more recent discovery that, at our 1971 level of knowledge, the prediction of facial growth as measured on a cephalogram is of little consequence to the clinician concerned with straightening teeth. First, most facial dimensions are at least 85% of their adult size by the time we treat our patients. The standard

* Prediction for an individual poses a problem somewhat analogous to that of an insurance actuary. He can predict that, on the average for each 1,000 cars insured, a dozen will be totaled while another 100 will suffer damage of more than $100. Since the specific individual cars cannot be identified, the cost of insurance is averaged "as if" each were equally liable.

deviation of 17 mm increase for the mandible is 3.8 mm (3% of the adult size) so that one can be correct within 6% approximately 95% of the time by merely adding the average to that presented by the patient. Using age 12 as the example, it doesn't require a computer to add 17 mm to the measured mandibular length.

Secondly, the lower arch dimensions are close to their adult size, on the average, by the time the patient appears for treatment. As pointed out by Hunter 200 years ago, the dimensional changes of the dental arches develop early, especially in width. Moorrees more recently documented the point that after the eruption of the deciduous canines, the increase in mandibular bicanine width to adulthood is only 3 mm (1/10 of an inch).[35]

Finally, thanks to the implant studies of Björk, we know growth of the jaws doesn't usually influence the dentition by correcting Class II molar relationships as Angle postulated.[38] When the direction of mandibular growth is "horizontal," the mandible is "thrust" into the facial musculature, incisors are uprighted, and the normal reduction in arch length occurs without mesial migration of the molar. The chin develops, not from deposition of bone, but from movement of the incisors lingually. The continued reduction of arch length and anterior crowding noted in males after age 15 is probably more closely related to this adolescent "development of the chin" than to third molar eruption. If such are the consequences of horizontal mandibular growth, then what is "good" mandibular growth?

This last year we made a direct attack on the problem to see if good jaw growth (ANB and ANS/pogonion) had any relation to molar change (correction of Class II) or in reduction of overjet.[42] The results were so low (less than $r = 0.3$) that one is better off with the Björk implant results than the Angle jaw growing theory.

With muscle growth somewhat independent of bone growth and since muscle tonus as determined by various neurons is probably independent of the variables mentioned, one should not expect high relationships between occlusal changes and facial growth. To incorporate this fact into clinical concepts of treatment requires a substantial expansion of traditional concepts of facial growth and its influence on the dentition.

Examples of variable (unpredictable) changes in occlusion have been described by the literature.[36-41] Sanin et al. found that approximately one-third of the malocclusions in the deciduous dentition became good occlusions by adulthood.[41] The low, but positive, correlations (less than $r = 0.3$ to $r = 0.5$) between facial growth and dental change demonstrate that the mechanistic theories account for perhaps 10-25% of the variation in growth of the dentition. However, 75% or more of the variation in overjet change and molar change must be accounted for by changes other than anteroposterior growth of the mandible and maxilla as measured from points A and B or ANS and pogonion.[42]

If our clinical therapy is concerned with the dentition and occlusion, then the findings just mentioned challenge the efficacy for even attempting to use cephalometrics (measuring bumps on an x-ray) to predict "facial growth." Further, as seen in Table 1, there is no biologic basis for creating formulae or cephalometric measures to improve the clinician's ability to predict growth of either the face or dentition. To date, the best estimate of any individual adult facial or dental arch dimension is to use the dimension presented by the child and to add to that the remaining

Size/gain		Growth from	r	Coefficient of Determination
Stature	6 yrs.	6–18 yrs.	0.1	1%
Body weight	9 yrs.	9–18 yrs.	.2	4
Mandibular length	12 yrs.	12–20 yrs.	- .1	1
Bizygomatic diameter	5 yrs.	5–11 yrs.	.1	1
Upper face height (N-ANS)	5 yrs.	5–15 yrs.	- .1	1
Lower face height (ANS-M)	5 yrs.	5–15 yrs.	.2	4
Maxillary arch width	9 yrs.	9–15 yrs.	- .1	1
Mandibular arch width	9 yrs.	9–15 yrs.	.4	16
Overjet	12 yrs.	12–20 yrs.	- .2	4
Overbite	12 yrs.	12–20 yrs.	- .3	9
Maxillary arch length	9 yrs.	9–15 yrs.	- .1	1
Mandibular arch length	9 yrs.	9–15 yrs.	- .2	4
Cephalometric angles				
Frankfort-mandibular angle	7 yrs.	7–17 yrs.	- .1	1
S-N-Po	7 yrs.	7–17 yrs.	.4	16
Y axis - F-H	7 yrs.	7–17 yrs.	- .1	1
Incisor mandibular angle	12 yrs.	12–20 yrs.	- .1	1
S-N-A	12 yrs.	12–20 yrs.	.1	1
S-N-B	12 yrs.	12–20 yrs.	.0	0
Gain/gain				
Growth in stature	1–5 yrs.	6–18 yrs.	.1	1
Body weight	6–9 yrs.	9–18 yrs.	.2	4
Face height (N-M)	5–9 yrs.	9–15 yrs.	.2	4
Growth of mand. length	6–9 yrs.	9–12 yrs.	.1	1
Growth of max. arch width	9–11 yrs.	11–14 yrs.	.2	4
Growth of mand. arch width	9–11 yrs.	11–14 yrs.	.1	1

Table I A sample of various types of anthropologic measures and their relationship to unexpressed growth. Their contribution in reducing the total variation for aid in prediction is found in the coefficient of determination.

average growth for the group. The individual variation in growth from that age to adulthood is the error of the prediction.[24-26,43] As impressive as the numbers may be, computerization of the presently known information contributes no more to the patient's health than a reading of tea leaves.

My prediction for the future of cephalometrics is that the clinician will continue to try to use cephalometrics for predictive purposes for another generation or so in the name of security, motherhood and the archangels.

For research purposes it will continue to be useful for describing faces and for making long-term comparisons between treatments. Measurement error is too great for short-term comparisons. Because implants are seldom placed in the midsagittal plane, variation in positioning of the patient's head adds a new source of "error." Björk has devised an expensive technique to reduce this source of variability.[45] We have developed a different approach using crossing x-ray beams on the same film and an elaborate process of triangulation (which requires a computer to solve unless one can afford to spend one-half hour on each implant) to give the x, y and z coordinates of each implant with a standard error of the measure of 0.09 mm.[44] With such reliability for implants (not anatomical landmarks) it is possible to obtain some valid information regarding movement of implants or movement in relation to a plane defined by three implants. In this limited sense cephalometrics is useful for comparative purposes, like a photograph to describe where we've been, and no more.

I would recapitulate by stating that, outside of research, we employ cephalometrics only to check on changes in lower incisor position. In a teaching institution where students are particularly prone to dump lower incisors, a cephalometric check usually uncovers three or four cases each year.

For diagnosis and treatment planning, one does not need cephalometrics. The basic principles of John Hunter, Tweed, Bull, Strang and Nance and respect for the dimension of the lower arch plus the Kloehn headgear or surgical orthodontics are sufficient to fit the maxillary arch to the mandibular.

This rejection of traditional cephalometric analyses and perfectionistic concepts of malocclusion in diagnosis is not an excuse for sloppy orthodontics. Rather, because treatment is elective instead of being a biologic necessity, it calls for the very finest, most precise mechanics to produce the best work of art possible. In the business world the mode is for the buyer to beware. In a profession it is expected that the buyer may have confidence. One must consider the ethics of an expensive computerized cephalometric program which doubles the capital outlay (models, bands, etc.) to the patient without benefiting his treatment. This country spends as much on automobiles as all of health care, as much on jewelry as on all of dentistry, or as much on barbers and beauty parlors. This, the richest country in the world, rewards the orthodontists with an average income that is at the 98 percentile for all workers. This implies that the public is willing to pay well for improved dental and facial esthetics.

There is no argument that when the patient has asked for straight teeth, he deserves the best. My argument is that our objective also includes the most stable result we can provide. We owe it to the patient to respect biologic principles which govern the growth of the dentition. These are not and cannot be well described by a cephalometric analysis with any better accuracy than archangels describe the paths of the planets. A search for the biologic principles which govern the growth of the dentition will be more rewarding. As the search continues, it is important to avoid the supposition that it will be possible to understand biology sufficiently well to predict perfectly. Even archangels and seraphims don't possess such power. As a human, I would finish with a paraphrase from an old quote: To err is human; to really foul things up requires a poorly programmed computer.

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