The Role of the Invariant Segment in Orthodontic Diagnosis and Treatment Planning

Harold Schwartz, D.D.S.

Chester F. Wright, D.D.S.

Since its emergence as a specialty at the turn of the century, orthodontics has had as one of its chief concerns the problem of the diagnosis of aberrations of the dentofacial complex. Progress in this subject had received a tremendous stimulus when, in 1899, Dr. Angle introduced his classification of malocclusion providing a powerful means whereby the various anomalies could be simply and effectively categorized.

As the profession advanced, the effect of growth and other biologic parameters on the dentofacial complex came to be recognized and the denture came to be seen as part of a developing continuum of great complexity called the morphogenetic pattern. In their efforts to study the sequential development of this unfolding pattern under the impetus of growth and development, anthropologists had long been using the head spanner to measure the distance between points on skulls. But their methods were not very accurate until T. Wingate Todd and his associates at Western Reserve University took the head spanner and expanded it into the craniostat. This device proved very useful because, for the first time, the skull was oriented to three mutually perpendicular planes in space.

In fact, the craniostat may be said to be the precursor of the cephalometer, since the basic principles of both instruments are very similar. Both are essentially head positioners. B. Holly Broadbent, who fully described his instrument in the *Angle Orthodontist* for January 1931, superimposed successive tracings made from headplates and noted the changes in size and contour which had taken place. He later prepared the Bolton standards of normal dentofacial development for both male and female, at two year intervals. In this way he evolved a qualitative method for studying the growing head in the living. For some reason these standards were never published.

Later, Allan G. Brodie in 1941 published his studies of the growth of the face from the third month to the eighth year. Using a method of superimposition different from Broadbent, he measured angles and thereby developed a quantitative cephalometric method of measuring changes in the position of the various landmarks. One must agree that the most significant factor in the development of orthodontic research in the last quarter century was the use of roentgenographic cephalometry as an evaluative tool in case analysis and treatment planning.

But a radical change took place when, in 1948, W. B. Downs published his study of facial relationships. He applied the techniques of roentgenographic cephalometry to the study of twenty excellent occlusions and formulated the Downs' standards. The use of these standards gave a new direction to the solution of problems in orthodontic case analysis and treatment planning. In fact, this approach was markedly different from any previous uses of cephalometric material.

Heretofore, research had been di-

Read at the January, 1971 meeting of the Midwestern Component of the Angle Society.

rected toward studying growth changes. Investigators had merely recorded, painstakingly, growth patterns. Their concern was to find out "where we had been" rather than "where we were going." On the other hand, Downs' contribution to diagnosis and prognosis was predictive in its implications in that it set limits to acceptable tooth positioning and elevated the concept of an arbitrary standard to a position of pre-eminence as a diagnostic authority.

Since this standard was obtained by statistically valid methods, its applicability as a criterion was asserted. The individuality of the patient was, somehow, lost in the maze of angles, measures of central tendency, standard deviations, tables of values and other statistical adnexa. Science, it appeared, had taken over to a large extent the problem of orthodontic diagnosis. Furthermore, once the standard had been set up, it tended to roll along, sort of mindless, never stopping to think, consider balance, or judge. It had become a machine. And worse yet, its momentum tended to channelize the orthodontist's thinking into predetermined channels. The orthodontist had become part of the machine.

In reflecting on this matter, we can state that there are at present two broad avenues of approach in dealing with our problems.

1. The first, which we may call the objective or scientific approach, relies mainly on cephalometry and is the system of diagnosis most widely used today.
2. Another method of approach we may call the intuitive or subjective approach. It is this concept which we will illustrate and discuss in this paper.

It involves the appraisal of the plaster casts from a different point of view from methods heretofore employed.

Although plaster casts are certainly not new, in recent years they seem to have been relegated to a minor position by the orthodontist. Too often, a cursory glance is given to the molar relation, a sidelong glance at the overbite, at the overjet, at generalized crowding, and at rotations. Then the model is set aside and the modern practitioner hastens to the headplate tracing - there is where the action is. But here another difficulty arises. For having followed the many attempts to locate, infallibly, the relationship of the various parts of the denture by cephalometry and seen them fail, we are forced to agree with the anthropologists' assertion that no point, plane or angle may be employed as a point of reference. As a consequence, we do not believe that it is possible to make a tooth, a jaw, or the relationship of both to a point on the skull, the point of departure for a diagnosis. Only the reciprocal relation of both jaws as this is manifested by the tooth relation is a valid basis for diagnosis provided, of course, that the teeth occupy their correct relations to their respective jaws.

The question arises, how do you know whether any segment occupies its correct relationship to its respective jaw? The answer is that man is a product of his inheritance, hence he inherits everything about him, every relationship including the relationship of teeth to each other, to the bone that supports them and the muscles that activate them. And, these relationships prevail as long as they are not disturbed by adverse environmental forces - this is a biologic fact. When such adverse forces come into play, whether operating within or outside the denture, they seldom affect the entire relationship, and thus it is almost always possible to find a group of teeth that have taken and *maintained* their correct relation to all other anatomic structures as dictated by the morphogenetic pattern of the individual. Such a group of teeth we have termed an "invariant segment."

We define the invariant segment as follows: "The invariant segment is a group of teeth in either the maxilla or mandible or both, that has taken its correct spatial relationship to all other anatomic structures as dictated by the morphogenetic pattern of the individual."

This segment may be located by a careful scrutiny of the models. Now, our plea for a more thorough examination of the model is based on the notion that the cast as it presents itself is the record of the state of equilibrium of the forces playing on the denture. The models may thus be considered as the record of the end-result of the struggle between two contending systems of forces. On the one hand are those forces acting toward normality, directing growth and development toward an acceptable dentofacial result. Opposed to these are the disrupting and displacing forces resulting from various adverse etiologic factors; these operate to deflect the various units from their intended positions and a malocclusion results. Furthermore, this malocclusion is not only in static equilibrium, which is a condition in which opposing forces exactly counteract each other, but is, in addition, in dynamic equilibrium which is a condition of balance between varying shifting and opposing forces, a condition which is characteristic of living processes.

In this interplay of forces there may be certain invariant segments, perhaps a buccal segment or an anterior segment or even one tooth, that has reached full eruption, and taken its place in the spatial configuration without ever having been affected by any disruptive force. Such an entity could be used as a basis for planning a more rational treatment, one based not on some arbitrary standard of uneasy cephalometric lineage, but actually based on the biomechanics of the patient presenting before us. Our efforts would then be directed toward keeping these invariant elements of the denture stable and moving only the displaced portions to positions judged normal in our analysis. As a result, fewer dentures would require reduction of dental units since full use of the potentialities of the patient would be recruited in the treatment plans. Stability would be enhanced since the invariant segment would give us a nexus of stability to start with, and conceivably much less movement of teeth would be needed.

It is well to remember that what we propose is hypothetical in nature. We hypothesize that this invariance may exist and then try to find it in our close analysis of the models. We cannot press a button nor activate a distant computer nor can we display an array of standards which will relieve us from the necessity of that subjective appraisal which is at the basis of all diagnostic acumen. The ideal diagnostician does not place too much reliance on arbitrary standards. While using cephalometrics, he also considers other criteria. He weighs all factors, the history, physical examination, x-ray findings, cephalometric indications and, in addition, studies the models carefully. His procedures are not quantitative and conclusions are reached only after long and careful study.

We suggest that the method advocated here can be used to supplement and reinforce the results of cephalometric analysis and, as a consequence, the diagnostician can more easily strike a proper balance between the arbitrariness of quantitative cephalometric appraisal and the clinically oriented analysis of the models. His efforts would be tempered by an awareness of the patient as a unique entity. Even a cursory glance at modern life will show that science, once hailed as a panacea for human problems, has outstepped its boundaries. Excessive technology has created a whole host of new problems such as pollution, automation and unemployment instead of the Utopia which it originally promised.

For science seems to have but one value which it apparently pursues regardless of the consequences. This one value is mistakenly called progress. Viewed in this light, we may well ask: "How has cephalometrics progressed?" In certain ways it would appear to have overstepped its boundaries. No longer an unalloyed blessing, it would seem to have submerged the patient in the shadows of the headplate and metamorphosed him into a geometric diagram to be compared with arbitrary standards on whose parameters no two investigators can agree. Obviously, roentgenographic cephalometry has developed a momentum of its own. But in what direction? For one thing, it has tended to express itself in a multiplicity of analyses.

Up to 1952, Krogman had described seventy-seven different systems of analysis. Commenting on the proliferation of these systems, he stated:

"The search for absolute reliability in roentgenographic cephalometry is frustrated from the very onset." . . . and we should try not to demand of it spurious accuracy and precision that is biologically impossible, and in a real sense historically improbable." Not withstanding this warning, systems of analysis are still being fabricated, the latest having been published as recently as last year. Evidently, the promised land still eludes us. As for the patient, all too frequently he is being fitted into a Procrustean bed, where the failure of his geometry to fit the pre-established parameters all too frequently results in the extraction of teeth.

I say Procrustean because there is a parallel between the way in which we lop off bicuspids and the methods of the bandit Procrustes who, in ancient Greece, waylaid travelers on the road to Athens and stretched their limbs or lopped their limbs in order to make them fit his bed.

The ultimate in the lengths to which intemperate use of cephalometrics has gone is seen in the so-called use of the computer in cephalometric diagnosis. Here the data (headplates, casts, histories, rationale of treatment) are poured into a computer. You press the button and out comes a tidy result ready for use; once again, the patient has been reduced to a series of electromagnetic impulses. He has been dehumanized.

We venture to speculate that an examination of diagnostic procedures of those practitioners who extract in a very high percentage of their cases would show too great reliance on cephalometric standards and too little on the careful study of the patient and, in particular, on a thorough analysis of the plaster casts.

In support of the foregoing assertions, let us examine several cases which illustrate the principles which we have been discussing:

Case I.D. Figure 1 illustrates the principle of invariance. Viewing the patient's left side (Fig. 1 top) in the original models, we see that the upper left cuspid and first bicuspid are in correct relation to their antagonists, while the second bicuspid is blocked out. A similar condition exists on the right side (Fig. 1 bottom).

In treatment the invariant relations were maintained and the treatment mechanics reflected this in that the maxillary first molars were moved distally to a Class I relation with the mandibular molars and then the upper incisors were aligned to correct arch form which then permitted the lower in-

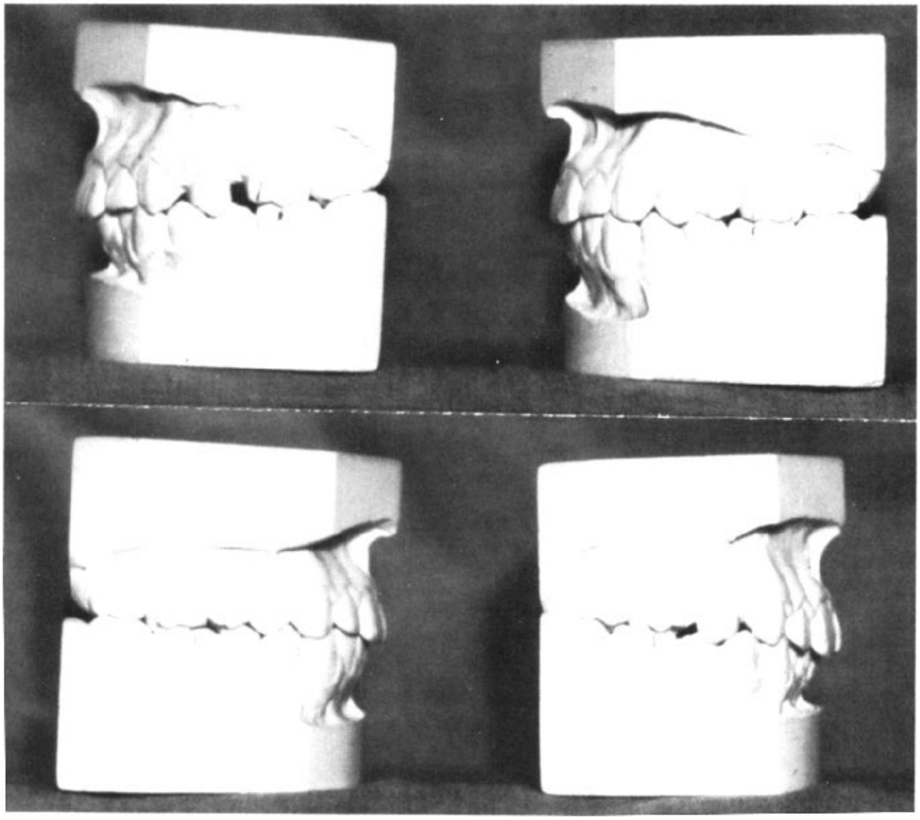

Fig. 1 Illustrates the invariant segment.

Top. Patient's left side. Notice that in the models before treatment, the maxillary cuspid and bicuspid are in correct anatomic relation to their antagonists. The models after treatment show that this relationship has been maintained.

Bottom. Patient's right side. A similar situation, involving the invariance of the maxillary right cuspid and first bicuspid, can be seen.

cisors to be placed in their correct positions. Models of the case after treatment show that the invariant segments on both sides were undisturbed during treatment.

Case D. K. (Figs. 2 and 3) is that of a female, aged 9 years 8 months, who presented with a Class I malocclusion. The original case is on the left (Fig. 2 above) and the completed case three years after active treatment is shown on the right. There was insufficient space for the unerupted maxillary lateral incisors; the mandibular anterior segment showed the central incisors and the right lateral incisor tipped lingually with the lower midline deflected to the left. The left lateral incisor had erupted lingually. In addition, the labial of the left central showed recession. There was evidently a problem in arch length and arch width in both dental arches.

Figure 2, middle, shows the invariant relation of the left buccal segments in the original untreated condition, models of which are shown on the left, while the finished case is shown on the right. Note that the original relationship is maintained throughout treatment. The before and after views of the right buc-

Fig. 2

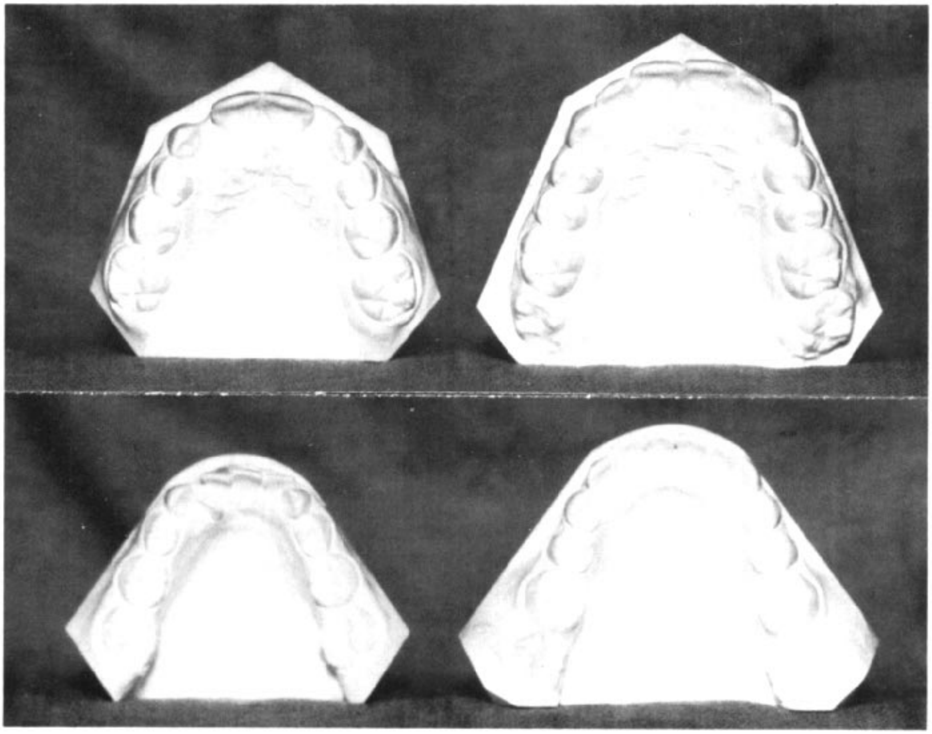

Fig. 3

cal region (Fig. 2 below) likewise show the invariant relation of the buccal segments on the right side.

At this stage of mixed dentition development, the relations of the upper permanent first molars to the lower first molars were judged normal, hence the case classified as Class I. With the shedding of the deciduous molars it was felt that the permanent molars would adjust to the proper cuspal relation. Furthermore, the relations of the right and left buccal segments of the primary denture were deemed excellent regarding cuspal interlock as well as axial inclinations. These buccal segments were, to us, the invariant segments that had emerged unscathed from the impact of the adverse forces.

With these considerations in mind, treatment was instituted as follows. Bands were placed on the maxillary deciduous molars and central incisors and an .018 archwire was placed to move the central incisors forward (Fig. 3). When the upper incisors were advanced sufficiently to permit placement of the lower appliance, bands were placed on the mandibular deciduous second molars (Fig. 3) and on the mandibular centrals and laterals. An .018 round arch was placed with the left side extended; this moved the lower incisors forward and to the right to correct the midline deviation and open space for the lingually erupted lower left lateral incisor. Eventually, the maxillary laterals were banded as they erupted and lastly, the displaced lower left lateral was banded and all incisor teeth aligned.

These relations were retained until cuspids and bicuspids had erupted when full appliances were inserted for final placement in occlusion. Retainers were then placed and at this time a lateral

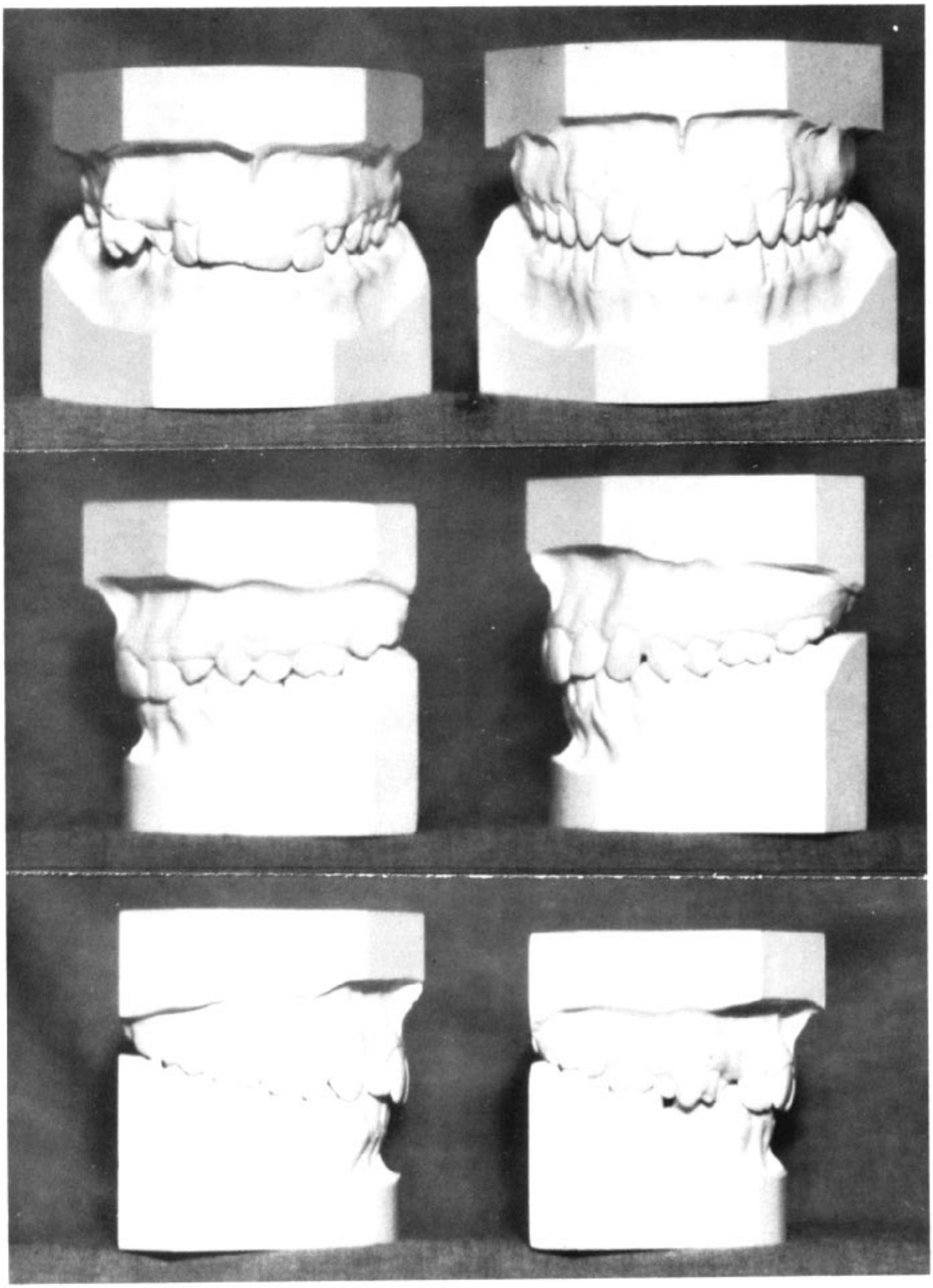

Fig. 4

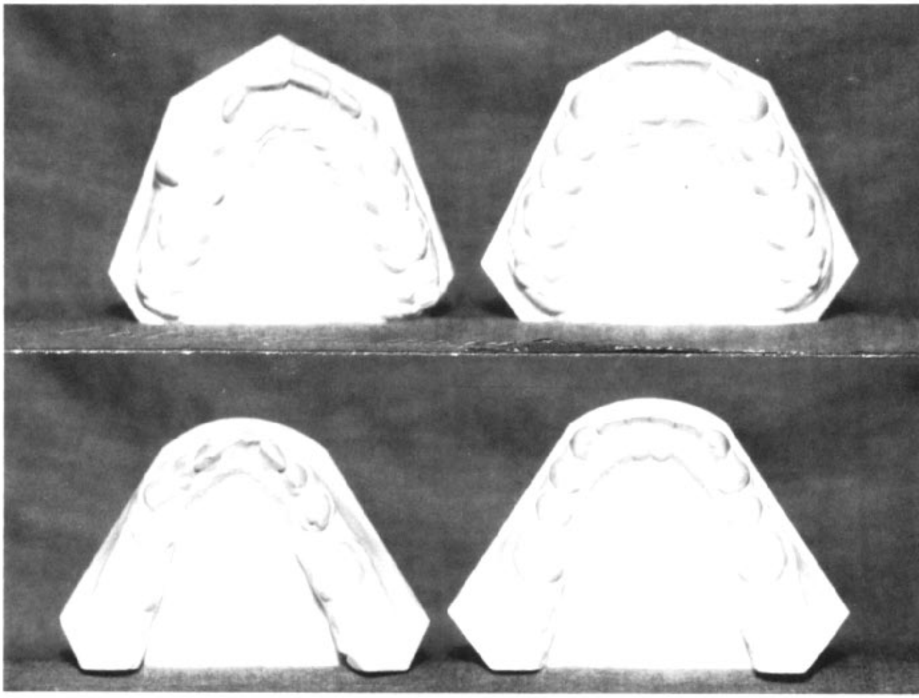

Fig. 5

pedicle graft was performed by a periodontist in the lower incisal region. The scar from this operation can be seen as a horizontal line several millimeters below the gingival margins of the lower incisors (Fig. 2 above). The upper retainer was worn for two months only; the lower retainer, however, was worn two and one half years.

Final models were taken six months after removal of the lower retainer, or three years after completion of active treatment.

Case M. W. (Figs. 4 and 5) This case is that of a male, aged 12 years 11 months, classified as a Class I malocclusion with deep overbite. There was lack of space for the maxillary right first bicuspid which had been displaced buccally. Since the upper and lower midlines coincided, it was deduced that both midlines were deviated to the right.

The front view (Fig. 4 above) shows on the left the original malocclusion with the buccally displaced right bicuspid and both midlines deviated to the right. Also shown are models of the treated case twelve years later with a stable, healthy dentition.

The buccal relations on the left side before and after treatment are shown in Figure 4, middle. In the original models shown on the left, note that the molars and first and second bicuspids are in an invariant relation. In the treated case shown on the right, one may note how these invariant relations were conserved throughout treatment. In Figure 4, below which shows the buccal relations on the patient's right side, the original models seen here on the right show the invariant relation of the upper and lower first molars; examining the models taken years later, on the left, we can see the excellent interdigitation of the buccal teeth which was achieved after space had been developed through the forward and leftward movement of the anterior segment.

Treatment in this case consisted in moving the maxillary incisors forward and to the left and moving the lower incisors forward and to the left in like manner to maintain the midline. This opened necessary space for the crowded teeth. The left buccal segments were at all times maintained in their original positions.

The maxillary occlusal views (Fig. 5) show the distorted arch form on the right side and the improved arch form obtained following treatment.

The mandibular occlusal views (Fig. 5) show the greatly improved mandibular arch form in the completed case.

Discussion

The invariant segment is not an anatomic entity like a tooth or a muscle or a bone. On the contrary, it is a concept which serves the purpose of enabling us to view a malocclusion presenting for diagnosis and evaluation in a certain light, to approach it in a definite frame of mind.

This attitude helps us to view the patient in a dynamic rather than a static way. We sense the interplay of forces and their presumed resolution in the resultant malocclusion and can plan our treatment logically, instead of arbitrarily, and without extensive and often unnecessary tooth movement.

There are some cases where we cannot positively identify the invariant segment. But, a survey of one hundred cases, picked at random by one of us [C.J.W.] from his files, shows only two cases where he was in doubt of a positive identification of the invariant segment. Even in those two cases, he felt that his assessment would compare favorably with findings obtained by other methods.

In conclusion, we have sought to stimulate renewed interest in the study model as a diagnostic modality. To this end we have outlined a method of assessing cases based on the concept of the invariant segment which we have defined and described. Moreover, we have applied this concept to several selected cases and have shown how it may be employed in devising adequate treatment procedures.

We have, in addition, tried to point out that the values which cephalometry has brought to the problems of orthodontic diagnosis need to be reassessed. The patient needs to be brought out of the cathode ray shadows into full view, and the gap between him and roentgenographic cephalometry shortened by a closer analysis of models along the lines laid down in this paper. In this way the real values of cephalometric analysis can be supplemented by considerations involving the invariant segment.

Finally, we should resolutely explore all possible avenues in our endeavor to diagnose correctly, treat efficiently, attain stability and maintain health in our treated cases. For it is only by our unremitting efforts to penetrate Nature's laws that we can, in the fullness of time, attain that perfect fusion of biology with mechanics that is the mark of true progress.

1811 *St. Johns Ave.*
Highland Park, Illinois 60035