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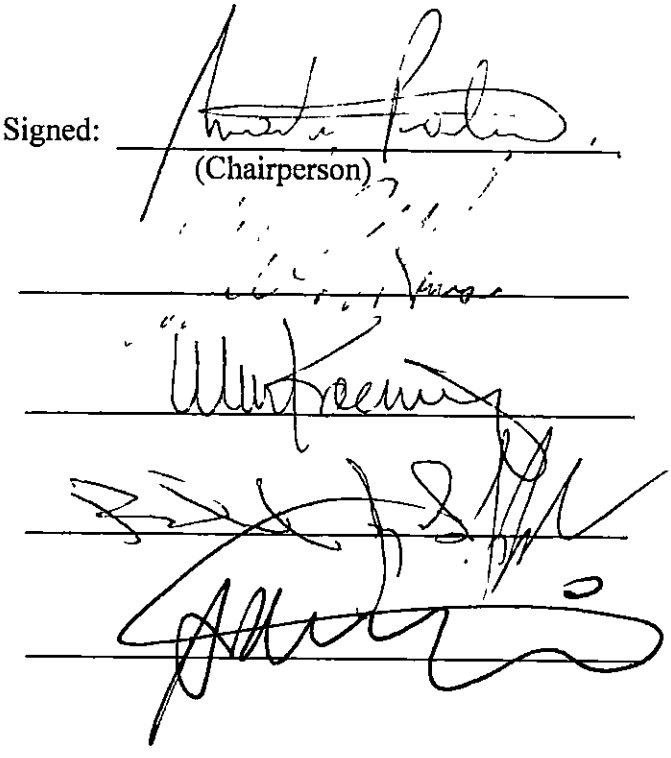
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EVALUATION OF CEPHALOMETRIC CHANGES IN CLASS II VERSUS CLASS III MALOCCLUSIONS

by

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Submitted in partial fulfillment of the requirements

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EVALUATION OF CEPHALOMETRIC CHANGES IN CLASS II VERSUS CLASS III MALOCCLUSIONS

Abstract

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The purpose of this study was to examine the change in cephalometric points over time for class II and class III subjects. Lateral cephalogram series of twenty-one untreated class II and class III subjects were compared.

Overall superimpositions were done as described by Elmajian (1959). Cephalometric analysis of each series was completed using an analysis of position change over time (mm/year) of Point A, Point B, pogonion, menton and gonion, in relation to a vertical and horizontal reference plane, using a method similar to that described by Kim et al.(2002). Changes over time in ANB, Wits, and SN-MP as well as measurements of corpus length, ramus height, and total mandibular length were also recorded.

Regression means of the change of each cephalometric point over time within each series were used to calculate

average change for purposes of direct comparison between the two groups. The level of significance between the two groups was set at $p < 0.05$.

There was no statistically significant difference in the rate of change between class II and class III subjects in the vertical direction. In the horizontal direction, there was a statistically significant difference in the rate of change in Wits for class III subjects, which showed a greater change over time than did class II subjects. ANB increased significantly more for class III than for class II. Future study of class I subjects relative to class II and class III subjects might be helpful in the development of a clear understanding of the differences in growth between the three classes of malocclusion.

DEDICATION

This thesis is dedicated to:

My mom and dad for believing that their children should not settle for less than they can be.

My brothers whom I idolize and attempt to emulate in so many ways.

My friends, Allen, Bryan, Cliff, Ekapon, Jed, Jiten, Raf, Rupin, Victoria, and Zain, for keeping me straight.

And to Wendy.

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My dysfunctional orthodontic family, Victoria Wan, Moe Razavi, and Tasha Woodson who traveled this road with me.

My fellow residents, Jed Hildebrand, Cliff Lowdenback, Mike Paulus, Gabrielle Chan, Nadia Lyotard, Sebastian Baumgaertal, Alika Crew, Reid Wenger and Jeff Kwong.

To the faculty and staff of the Department of Orthodontics at Case Western Reserve University.

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LITERATURE REVIEW

"Growth measurement is always relative and never absolute." -Elmajian

Introduction

Understanding the growth and development of the human facial skeleton is critical to the field of orthodontics. At opposite ends of the malocclusion spectrum, class II and class III malocclusions are poorly understood with regard to the distinctions in their growth patterns.

Cephalometry

The advent of cephalometric radiography in the early twentieth century opened new doors for the orthodontist in the realm of diagnosis. Beyond the clinical exam, the birth of cephalometrics allowed visualization of the underlying causes of the various malocclusions. The relationships of the soft and hard tissues of the face were made visible for evaluation. Its contribution to orthodontics for treatment planning, research, education and growth evaluation is immeasurable.

With the gaining popularity of cephalometrics as a diagnostic tool in orthodontics, key questions arose from the practical application of cephalometry. What could cephalometrics do for the individual patient? How can cephalometrics help the clinician to give the most optimal treatment? In 1960, Ricketts discussed the "four Cs" as the uses for cephalometric analysis in orthodontics. These were (1) to characterize or describe the conditions that exist, (2) to compare one individual with another or the same individual with himself at a later time, (3) to classify certain descriptions into various categories and (4) to communicate all of these aspects to the clinician, to a fellow research worker or to the parent.

Innumerable cephalometric analyses exist today using linear and angular, even radial measurements as the method of evaluation to describe the form of the face before, during and after treatment. For comparison of cephalograms of an individual patient taken at various stages, superimposition techniques are employed. In his discussion of pattern in craniofacial growth, Moyers (1979) wrote that craniofacial complex changes can be described and quantified by the identification of

craniofacial constants which are measures that are relatively invariant. Superimposition allows the clinician to evaluate changes within an individual over time using stable cranial landmarks as reference points.

Elmajian (1959) studied the skeletal morphology of the cranial base with respect to the determination of its relative unchanging or non-growing segments. Elmajian found that the plane of the sphenoid bone, the cribriform plate of the ethmoid bone and the curvature of the great wings of the sphenoid bone had a relatively unchanging relationship to one another, and appeared to be areas of the cranial base with early growth cessation. A superimposition on the plane of the sphenoid bone and the cribriform plate of the ethmoid bone, registered at the intersection of the midpoint of the curvature of the great wings with the sphenoid plane-cribriform plate contour, could be used for serial longitudinal studies of total facial change resulting from growth (1959).

Bolton-Brush Growth Study

In 1926, Broadbent created a roentgenographic cephalometer for the study of skulls of living individuals (Behrents and Broadbent Jr. 1984). Since that time, orthodontics has adopted cephalometrics as a

primary diagnostic tool for the evaluation of malocclusion. Originally developed for the study of growth and development of healthy children, the development of the cephalometer was followed rapidly by the Bolton Study of the Face of the Growing Child in 1928 and the Brush Inquiry in 1929 (Behrents and Broadbent Jr. 1984). Both of these studies were primarily aimed at evaluating and studying the growth and development of the craniofacial region from infancy to adulthood. Bolton Study participants were examined every three months from 0-1 years of age, every six months from 1-5 years of age, and adolescents were examined every year on or around their birthday. The Bolton Study records and examinations included dental impressions, lateral and frontal cephalometric radiographs, and hand-wrist radiographs.

The combined data of the Brush Inquiry and the Bolton Study of the Face and of the Growing Child are now located in the Bolton-Brush Growth Study Center at Case Western Reserve University in Cleveland, Ohio. Today, the Bolton-Brush Growth Study represents one of the largest collections of longitudinal cephalometric radiographs in the world. It houses cephalometric

radiographs of nearly six thousand subjects used in studies of growth and development throughout the world (Behrents and Broadbent Jr. 1984). It was from this database that longitudinal series of lateral cephalograms of untreated individuals were chosen for the present study.

Growth and Development

Evaluation of "patterns of growth" is critical to the field of orthodontics. Many malocclusions treated by orthodontists involve some skeletal component caused by variation in skeletal patterns. Deviating patterns of skeletal growth such as class II and class III growth patterns can present difficulties in achieving an ideal treatment result. One of the greatest allies in the successful management of malocclusion is the patience to allow growth to make its maximum contribution to the overall treatment (Brodie 1971). That being the case, we must have an understanding of growth process and growth patterns our patients are needed.

Enlow and Hans (1996) described the human head as having a natural tendency towards malocclusion. This stems from the evolutionary design of the head which allows for variations in head form. The sequential

nature of facial growth is such that regional imbalances are always occurring during the natural developmental processes. It is the natural adaptive ability of living organisms which responds to regional imbalances and is able to make corrective adjustments in an attempt to maintain balance.

Melvin Moss is one of the forefathers of modern growth theory. In 1960, Moss and Young published their original work on the functional matrix theory. The functional matrix theory described the source of bone's morphologic regulation. Stimuli, which start from the growth and action of all of the tissues (the functional matrix) within the growing head, function to switch the osteogenic and osteolytic tissues on or off. In 1969, Moss and Salentijin published a review defining the two basic types of functional matrix and discussed their differing, yet complementary, roles as the primary morphogenetic agencies in skeletal tissue growth. As described by Moss, the head is a region in which functions are carried out by a functional cranial component (1969). Each of these components is composed of two parts: 1) a functional matrix component which actually carries out the function and, 2) a skeletal unit

whose biomechanical role is to protect and support its specific functional matrix. The essence of the interplay between these two parts is that all skeletal units (including bone, cartilage or tendinous tissues) are always secondary to temporally primary changes in their specific functional matrices: bone apposition is dictated by the surrounding tissue. In his description of the functional matrix, Moss is clear that the term is not equivalent to only the soft tissues of the face (i.e., muscle, adipose, glands, nerves, vessels). For example, teeth are also a functional matrix. In orthodontics, as teeth erupt or are moved, they carry with them their related skeletal units (Moss and Salentijin 1969).

The reality of the craniofacial complex is that it is a complex interplay of interrelated and interdependent parts (Enlow and Hans 1996). The cranium is made up of two distinct regions with differing functions which must respond to each others functional needs; the neurocranium and the splanchnocranium. These regions have independent growth yet are irrevocably intertwined within the skull. Consequently, growth of the craniofacial complex does not occur proportionately such that relative sizes and proportions remain stable throughout life (Enlow and Hans

1996). Rather the complex nature of craniofacial growth leads many different parts to develop at different times, in different directions at different velocities to perform different and diverse functions. This causes proportions of the head to change through maturation into adulthood.

In addition to the craniofacial components which make up the structure of the head, functional cranial components can be organized into craniofacial capsules as well (Moss and Young 1960). The two craniofacial capsules are the neurocranial capsule and the orofacial capsule. Each capsule surrounds and protects a capsular functional matrix. In the case of the orofacial capsule, this capsule surrounds and protects the oronasopharyngeal functioning spaces. All functional components of the splanchnocranium arise, grow and are maintained within the orofacial capsule. The theory, then, is that the expansion and volumetric growth of this oronasopharyngeal functioning space (namely the airway and oral cavity) is the driving morphogenetic event in facial skeletal growth (Moss and Salentijin 1969).

Growth, as described above, is accomplished by both spatial and form changes during maturational development.

Consequently, mandibular growth is a combination of the morphologic effects of both the capsular and periosteal functional matrices (Moss and Salentijin 1969). Growth of the mandibular body is a product of remodeling of the surface of the mandible and the associated downward and forward displacement affect from the functional matrix (Enlow and Hans 1996).

Human craniofacial development, as described by Moyers (1979a), is an aggregate of both pattern and growth. Moyers description of pattern was the maintenance of the configuration of the face over time. Facial similarities in childhood are carried through the years through adolescence and adulthood. For Moyers, the term growth was described as the actual changes in size and shape. Moyers made these distinctions to clarify the use of these words, "pattern" and "growth" in the orthodontic literature. He felt that growth patterns did not exist as described by customary cephalometric description (1979). In orthodontics, pattern is often used as a description of a cross-sectional moment in time. For example, a patient may have a class II or class III "skeletal pattern." However, Moyers et al. (1979b) suggested that the growth of the various parts of

the craniofacial complex does not follow a pattern of growth in the traditional sense.

Observation of all of the bones of the facial skeleton would lead the observer to believe that the one with the greatest variation is the mandible. Mandibles may be large or small in the corpus, the ramus portions the condylar processes, or all of these (Holdaway 1983). From an anatomical standpoint, the ramus is the most important component of mandibular growth. Its importance lies in its responsibility for positioning the corpus and the mandibular dentition, the dentition's occlusion with the maxillary arch, and its ability for adaptation to changing craniofacial conditions (Enlow and Hans 1996). Any changes in the ramus-corpus junction are largely produced by ramus remodeling, and not the corpus, and are determined by the remodeling direction of the ramus with the condyle (Enlow and Hans 1996).

With regard to treatment, good mandibular growth can be thought of as translatory growth of the maxillary or mandibular basal bone (Johnston 1998). This concept rings especially true when discussing the mandibular growth of a retrognathic skeletal pattern. An improved relationship of the mandible to the maxilla in these

patients would be considered "good growth." Since growth of the mandible can be influenced by alterations in the functional environment, some believe that altered occlusal interdigitation, and other factors, may affect the size and shape of the mandible in the growing class II individual (McNamara 1981). Thus, the basis of mandibular correction of skeletal discrepancy through functional appliance therapy prevails in the orthodontic community.

In general, study of morphologic differences in the mandible within different Angle's classes of patients has shown variation in the morphology of the mandibular basal bone. For example, multiple studies have shown mandibular morphologic differences in class II patients when compared with class I patients (Buschang et al. 1986; Hunt 2001). Buschang et al. found that persons with class II malocclusion, including both division 1 and 2, have shorter mandibles and, consequently, greater anteroposterior discrepancy (1986). Size differences were established before 11 years of age. However, the majority were less than 0.5 standard deviation units with none of the differences greater than one standard deviation.

In 1998, Singh et al. studied the differences in mandibular morphology between class III and class I patients using finite-element morphometry. They found that anteroposterior elongation of the mandibular body incorporated within the class III configuration, was demonstrable using finite-element morphometry. Procrustes analysis indicated that the mean class I and class III mandibular configurations differed significantly for the sample studied. All but one of the seven age groups studied returned significant differences for normal and class III comparisons. They also showed that the combination of a longer mandibular corpus and shorter ramus, allied with the changes in mandibular and symphyseal angles, distinguish the class III morphology from the normal mandible. It was further observed that these morphologic differences were predominantly localized anteriorly and may have an effect on the prognathic mandibular profile associated with class III malocclusions. Consistency of differences indicates that skeletal variability noted early on, between the different Angle's classification patients, appears to continue throughout the growth of the facial skeleton.

Class II Malocclusion

The incidence of class II malocclusion in the general population was shown to be approximately 15% by NHANES III (National Health and Nutrition Estimates Survey III) and has been reported up to 30% by others (Proffit 1992; Wong and Chung 2002). Class II malocclusions were originally characterized by Edward Angle in 1899. Angle theorized that the maxillary first permanent molar was stable in its anteroposterior position relative to the skull. In his text, Angle (1907) wrote:

> "We believe that nature so very rarely errs in the location of the upper first molars—the very cornerstones, as it were, in the foundation of the structure of an organ so essential to the whole physical economy as the dental apparatus, as to make it a matter of little or no concern to us except, possibly, in research work"

Because of this belief in the consistency of the position of the maxillary permanent first molars, Angle based his classification system on the mandibular position defined by the relationship of the lower permanent first molar to its maxillary counterpart.

> "When from any cause the lower first molars lock distally to normal with the upper first molars on their eruption to the extent of more than one-half the width of one cusp on each side, it must necessarily follow that every

> succeeding permanent tooth to erupt must also occlude abnormally, all the lower teeth being forced into positions of distal occlusion, thereby causing more or less retrusion, or lack of development, or both, of the entire lower jaw."

Class II malocclusion is not a single entity. It can result from numerous combinations of skeletal and dental components. Since Angle's initial observations, many investigators have studied the causes of class II malocclusion. Although numerous studies have been performed, no consensus of the underlying skeletal causes for class II malocclusion can be agreed upon. In 2000, Rothstein and Yoon-Tarlie produced a study that did not support Angle's hypothesis that class II, division I malocclusion is characterized by an underdeveloped and/or posteriorly positioned mandible. They found that the mandible and dentition of class II, division I subjects were similar to the control subjects in size, form and position and that the maxillary permanent first molar in class II, division I patients is more mesially positioned and that the anterior segment of the maxilla is more protrusive.

Others have found conflicting results to those presented by Rothstein and Yoon-Tarlie (2000). Multiple

studies have shown that the relationship of the maxilla to the cranial base in class II division I and class I patients is not significantly different (Renfroe 1948; Ricketts 1960; McNamara 1981). In 1960, a study by Maj et al. found total mandibular length was similar in class II and class I patients in 96% of those studied at the same age. They concluded that positional relationships between the parts accounted for the anteroposterior differences noted.

In 1981, McNamara reviewed sixteen studies of class II division I patients and found that twelve of the studies indicated that the mandible is retrognathic in the class II division I malocclusion. The other four studies showed that the mandible did not differ significantly from the control. In general, many investigators have pointed out that a class II molar configuration can occur from a variety of skeletal and dental configurations. From his review of the literature, McNamara concluded that there was no agreement regarding the relative importance of the five different components of a class II malocclusion: maxillary position, mandibular position, maxillary dental

position, mandibular dental position, and vertical facial height.

In his study of nearly three hundred children 8-10 years of age, McNamara (1981) attempted to determine the relative frequency with which various identifiable components appear in the class II malocclusion. He found that in class II division I subjects, maxillary dental position in relation to the maxilla was normal. His results also showed that, in class II patients, all four measurements used in the analysis of mandibular position relative to upper facial structures indicated frequent mandibular retrusion. McNamara's results indicated that retrusion of the mandible was the most common recurring factor contributing to class II malocclusion. Only a small percentage of his class II sample exhibited maxillary skeletal protrusion relative to cranial and cranial base structures. On the average, the maxilla was in a neutral position, and when it was not in a neutral position, it was more often in a retruded than protruded position.

Class III Malocclusion

The incidence of class III malocclusion in American children is about 1% of the general population (Proffit

1992). This is very fortunate since class III malocclusion is regarded as one of the most difficult to treat.

In line with this concept of class II malocclusion, Edward Angle originally described class III malocclusion as a product of the mesial eruption of the mandibular first molar in relation to the "stable" maxillary first molar (Angle 1907). Angle's description of the class III malocclusion is bleak. He stated that:

> "In this class the marring of the facial lines is more noticeable and unpleasing than in either of the other classes, in advanced cases amounting to a striking deformity."

Originally, Angle described class III malocclusion and its association with mandibular prognathism without ever mentioning the role of the maxilla in this facial disharmony. He wrote:

> "Deformities under this class begin at about the age of the eruption of the first permanent molars, or even much earlier, and are always associated at this age with enlarged tonsils and the habit of protruding the mandible, the latter probably affording relief in breathing. When once the mesio-buccal cusp of the upper first molar begins to engage the distal incline of the disto-buccal cusp of the lower first molar, the effect is to mechanically force the mandible forward on each closure of the jaw. This in time forces the deciduous teeth, as well as each succeeding permanent tooth as it erupts, into malocclusion, thereby gradually

> causing all the other inclined planes to act out of harmony with Nature's intended plan, and accelerating the forward movement of the mandible."

In the past, as shown by Angle's description of class III malocclusion, mandibular prognathism and class III malocclusion were typically regarded as synonymous in the dental literature (Angle 1907; Guyer et al. 1986). The reality of this type of malocclusion is that a class III malocclusion may or may not present with mandibular prognathism, but those occlusal relationships comprise just one part of a much larger picture. Similarly, a patient with mandibular prognathism can show a class I occlusal relationship (Guyer et al. 1986).

Guyer et al. studied class III malocclusions in juveniles and adolescents. Their purpose was to compare the skeletal and dental characteristics of subjects with class III and class I malocclusion in four consecutive developmental age groups as well as to evaluate the skeletal variability among class III subjects in each of the age groups. They found that, on the basis of SNA value, the class III sample exhibited a maxilla that was significantly more retrusive than the class I sample in all except the 11-13 year age group. They also found

that the mean effective maxillary length of the class III sample was significantly shorter in all but the 5-7 year age group. Mandibular characteristics studied by this group also showed variability between the class III group and the control group. Most measures of horizontal mandibular skeletal position showed the class III sample had significantly more protrusive mandibles that the class I at all ages studied. The mean SN-MP angle of the class III sample was significantly higher than in the class I sample and mean mandibular length (Co-Gn) in the class III sample was significantly longer than in the class I sample. Differences in ramus height and corpus length were not found to be significantly different between the two samples. The mean class III gonial angle was larger than in the class I sample which may have accounted for the greater overall mandibular length without the corresponding increase in ramus height or corpus length.

Battagel (1993) studied the facial characteristics of a sample of children with a class III malocclusion and compared them with a normal cross-section of untreated class I in an attempt to create baseline material for subsequent studies of class III. In class III children,

Battagel found that articulare was further forward, the position of the mandible rather than its length was responsible for most of its prominence and the ascending ramus tended to be shorter and the gonial angle more obtuse, the maxilla tended to be more retruded and that this difference increased with age and an increase in lower anterior face height after age eleven. In the lower jaw, vertical change predominated but there was no more anterior-posterior change than in the control cases. Battagel also found that differences between males and females in the class III groups were generally related to linear differences in both the upper and lower face, indicating that male faces were larger than female faces.

Similar to class II malocclusion, a class III malocclusion can exist with any number of combinations of skeletal and dental variations within the facial skeleton. In fact, it can be the result of any several combinations of aberrations in the craniofacial complex. Most characteristic aberrations associated with adult class III malocclusion are already present at an early age (Guyer et al. 1986). Few of the measurements that Guyer et al. found were significantly different from the

class I population in the oldest group that were not already present in the youngest age group.

Sanborn (1955) found that a similar number of his class III sample had actual mandibular protrusion, with the maxilla within the normal range of orthognathic position as presented with maxillary retrusion with normal mandibular position. Ten percent of Sanborn's subjects showed normal maxillary and mandibular position and ten percent showed maxillary retrusion with mandibular prognathism. Jacobsen et al. (1974), and Guyer et al. (1986) both found the highest frequency of class III presentation to be a combination of mandibular prognathism with normal maxillary position. In 1993, Battagel found that the mandible was both longer and more prominent in the class III groups. From Battagel's study, it was clear that the mandibular discrepancy was primarily responsible for the class III malocclusion and that there was remarkable vertical similarity between the class III and class I group regarding maxillary position although definite horizontal discrepancies were apparent (1993).

Dietrich (1970) found fewer subjects with mandibular protrusion only. However, in his study the frequency of

orthognathically positioned maxilla and mandible was 25%. Dietrich compared deciduous, mixed, and permanent dentition class III samples to class I subjects of corresponding maturational levels. The results showed that almost half of the deciduous dentition sample had neutral maxillary and mandibular positions. Only one-fourth of the mixed dentition and permanent dentition subjects presented with orthognathic relationships. This indicates that skeletal aberrations grew worse with time through the transition to the permanent dentition. Incidence of mandibular protrusion increased with age 50% from the primary to permanent dentition. Incidence of maxillary retrusion also increased about 50% from the primary to the permanent dentition in his study. Jacobsen et al. found similar increases in mandibular protrusion in his study in 1974. In their study of the craniofacial pattern of class III children in the deciduous dentition, Chang et al. (1992) found that all measures of relative maxillary and mandibular anteroposterior position showed highly significant differences between the normal and class III groups. The most significant differences were found in these anteroposterior intermaxillary skeletal relationships.

Others have noted that mandibular prognathism was partly the result of an increase in mandibular length (Williams and Andersen 1986, Guyer et al. 1986, HP Chang et al. 1992). Although Williams and Andersen did not show one morphologic trait that was indicative of potential class III, mandibular prognathism was a frequent observation. HP Chang et al. also noted that corpus length and ramus height showed similar mean values in the class I and class III groups indicating that no one morphologic trait is responsible although an increase in total mandibular length was noted (1992). True macrognathia, however, was uncommon (Williams and Andersen 1986). In the majority of cases, mandibular prognathism was the result of an increase in the ratio between mandibular length and dorsal position of the articulare (Williams and Andersen 1986).

Skeletal Convexity

In 1963, Bjork studied mandibular growth using serial superimpositions of tracings of children with metallic implants. Bjork found a reduction of the gonial angle over time with vertical condylar and ramal growth and an increase in the gonial angle with sagitally directed growth. Bjork also found that average growth at

the condyle was directed slightly forward in relation to a posterior tangent to the ramus.

What Bjork described were some of the anatomic changes in the mandible that led to a decrease in convexity of the bony profile over time. Bjork had previously published a study which showed that prognathism increased during growth. He also found that there was a slight increase in mandibular prognathism relative to maxillary prognathism leading to a straighter facial profile as the individual grew older.

In a retrospective study of serial lateral cephalograms, Lande (1952) found that the convexity of the facial profile nearly always decreased. In no case did the convexity increase result in a more convex profile during normal facial development, and in only two cases was there no change in convexity. The reason for this came from a differential forward magnitude of growth between the maxilla and mandible. It has been shown that there is a very distinct difference between the growth behavior of the maxilla and mandible in an anteroposterior direction (Lande 1952; Nanda and Ghosh 1995; Buschang et al. 1986; Chang et al. 1992; Johnston 1998). While the mandible tended to become more

prognathic, the maxilla showed very little change in Lande's study (1952). The mean tendency was for the increase in mandibular prognathism to take place after seven years of age and for the greatest change in profile to take place at gnathion (Lande 1952).

In 1998, Johnston conducted a retrospective study of 120 treated class II individuals to determine, what he termed, apical base change (ABCH). He found that in 90% of the population studied, a positive ABCH was noted. This meant that in those patients with positive ABCH, the mandibular position improved relative to maxillary position. In other words, class II patients tended to show favorable patterns of growth even in the absence of growth modification therapy.

Nanda and Ghosh (1995) studied the differential growth changes in the relationship of s A, B and pogonion in reference to the pterygoid vertical plane and their effect on the skeletal facial profile. In terms of percentage of growth increment in class I male and female subjects from 6-24 years of age, the anterior movement of B relative to A, and at pogonion relative to s B and A was approximately the same. The total growth increment for the same patients, however, showed that there was a

total growth increment of 6.07, 7.53 and 11.17 mm at s A, B, and pogonion, respectively, in the female sample and 9.49, 11.65, and 16.21 mm at s A, B, and pogonion in the male sample. This shows that there was a greater percentage increase at B relative to A and pogonion relative to A and B.

In 2002, Chung and Wong investigated the longitudinal craniofacial growth changes in untreated skeletal class II subjects with low, average and high MP-SN angles. In Chung and Wong's study sample, the high-angle group in their study was found to have higher ANB values than the low-angle group. From their study, Chung and Wong found that the amount of SNB increase was more than that of SNA in all groups (2002). That meant that the ANB angle of all groups decreased over time. In addition, it was found that B grew more forward than A in all age groups. Overall, the maxillomandibular relationships of the skeletal class II individuals that Chung and Wong studied tended to improve with growth from ages 9-18 in males and females of low, average, and high mandibular plane measurements.

Objective and Hypothesis

It is obvious from a review of the literature that there is little agreement on the anatomic presentation and cause of class II and class III malocclusions. Previous research regarding growth in different skeletal patterns begs the question of the differences between the extremes in orthodontics, class II and class III individuals. Does the facial skeleton grow differently in individuals with class III malocclusion than in those with class II malocclusion? Is the initial pattern of growth the determinant of the final facial pattern or does growth velocity change the facial pattern during adolescence? Does growth in these two classes follow a parallel path for velocity and amount, or do they exhibit diverging growth patterns?

Knowledge of whether or not the orthodontist can count on growth to aid in the correction of malocclusion in patients would be a priceless asset to the field of orthodontics. Knowledge of the expected magnitude of a patient's facial growth early in life could assist the clinician in identifying those who require some sort of growth modification treatment and ensure that the proper treatment was delivered while appropriate growth remains.

In addition, the ability to identify patients who would not benefit from interceptive growth modification treatment because their normal growth pattern would lead to more ideal facial balance without orthopedic correction would reduce unnecessary treatment.

This study will examine change in cephalometric points over time for class II subjects and class III subjects. Evaluation of serial cephalograms should elucidate the similarities (or differences) in growth between the class II and class III subjects. It is expected that the rate of change of cephalometric points for class II and class III subjects is approximately the same.

MATERIALS AND METHODS

Lateral cephalograms of untreated class III subjects were located from the Bolton-Brush Growth Study database. Twenty-nine individuals were identified as possible subjects for study. Of these, one subject was eliminated due to poor radiograph quality, one due to the detection of a functional shift, one due to no detectable growth and five due to missing hand-wrist radiographs. In total, twenty-one of the subjects (9 females, 12 males) met the following inclusion criteria:

> Untreated Caucasians of European Ancestry within the Bolton-Brush Growth
>
> Lateral cephalogram diagnosis of Class III malocclusion measured with Wits (-2 mm or less) or ANB angle (ANB $\leq$ 0°)
>
> Skeletal maturation within two years of chronologic age based on Greulich and Pyle's analysis (1959)
>
> Minimum of two radiographs in each series

The twenty-one class III subjects were then age-matched and sex-matched to an untreated class II sample which met the following inclusion criteria:

Untreated Caucasians of European Ancestry within the Bolton-Brush Growth Study

Lateral cephalogram diagnosis of class II Division I malocclusion measured by ANB angle (ANB ≥ 4°) or Wits (+3 mm or greater)

An overjet of 6 mm or greater as measured from the labial surface of the most anterior lower incisor to the labial surface of the most anterior upper incisor

A U1-NA measurement of 24° or higher

End-to-end or class II molar analysis as identified on the cephalogram

Skeletal maturation within two years of chronologic age based on Greulich and Pyle's analysis (1959)

The following cephalometric measurements were recorded and analyzed for each cephalogram:

Mandibular Measurements:

Mandibular length in mm (Ar-Gn)

Ramus height in mm (Ar-Go)

Corpus length in mm (Go-Po)

ΔX and ΔY of Point B

ΔX and ΔY of Pogonion

ΔX and ΔY Menton

SN-MP

Maxillary Measurements:

ΔX and ΔY of Point A

Maxillary/Mandibular:

WITS, ANB

All radiographs of the cephalometric series for each of the forty-two subjects were traced using a Staedtler Mars 780 lead drafting pencil with 2 mm 2H lead on 0.003" frosted acetate tracing paper. Each longitudinal series was traced in one sitting by a single researcher and all landmarks were identified by the same operator. Each linear measurement was made with a Mitutoyo *Digimatic* digital caliper (Mitutoyo Corp., Tokyo, Japan) to the nearest 0.01 mm. Each angular measurement was made using a 3M Unitek Cephalometric Protractor (Monrovia, CA) to the nearest 0.1°.

In order to evaluate the longitudinal changes within each cephalometric series, overall superimpositions, as described by Elmajian (1959) using the cranial base, were done. Cephalometric analysis of each series was done using a method similar to that described by Kim et al. (2002). On the first radiograph of each series, a horizontal reference plane was fabricated 7° from the sella-nasion plane through sella. From this horizontal reference plane a perpendicular vertical reference plane was created through sella. These reference planes were

then transferred through each cephalogram in the series from the first cephalogram via superimposition and represented the ordinate and abscissa for changes in the vertical and horizontal position of point A, point B, pogonion, and menton. For each age-matched, sex-matched series, comparisons were made by plotting the individual changes for measured points and completing a linear regression to identify the rate of change of each measurement within the individual's traced cephalogram.

Linear regression was calculated to identify a rate of change for each cephalometric point over time. In order to create a regression line, each value of a specific cephalometric point was plotted and a least-squares line was calculated. For a least-squares line, the sum of the squared vertical deviation of the observed data points from the least-squares line is smaller than the sum of the squared vertical deviations of the data points from any other line. This obtains a "best-fit" straight line for the data set.

The slope of this simple regression is the rate of change (mm/year) of the point studied. Once a regression representing the rate of change was created, then the

slope of the line (rate of change) was compared with other subjects' slopes to evaluate the differences.

The equation for the predicted regression line is:

$$\hat{y} = a + bx$$

where a equals the y-intercept and b equals the slope of the curve. A and b must be calculated in order to predict the values of $\hat{y}$ based on x. A and b can be obtained by the simultaneous solution of the following two "normal equations" for a data set:

$$\Sigma\ yi = na + b\ \Sigma\ xi$$

$$\Sigma\ xi\ yi = a\ \Sigma\ xi + b\ \Sigma\ x2i$$

The rates of change (slope of the regression) generated were then used to compare differences in magnitude of growth of the entire class II and class III samples. The resultant rates of change were statistically analyzed between the matched class II and class III subjects using a paired Student t-test analysis ($p < 0.05$).

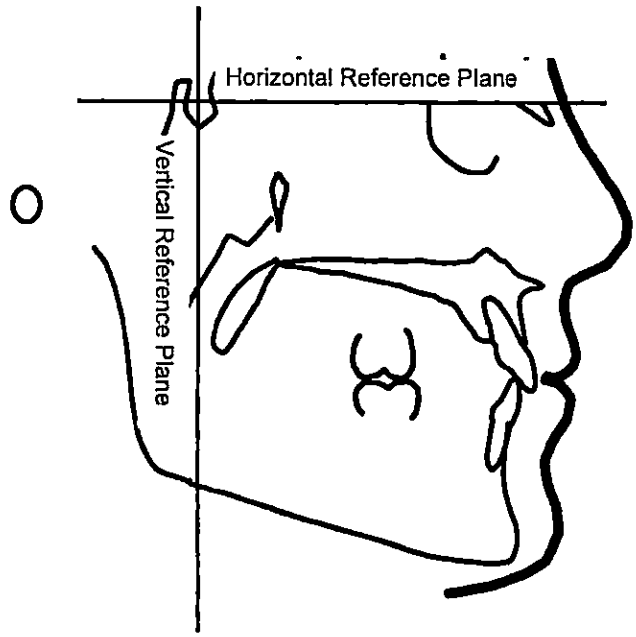


Figure 1. Horizontal and vertical reference planes

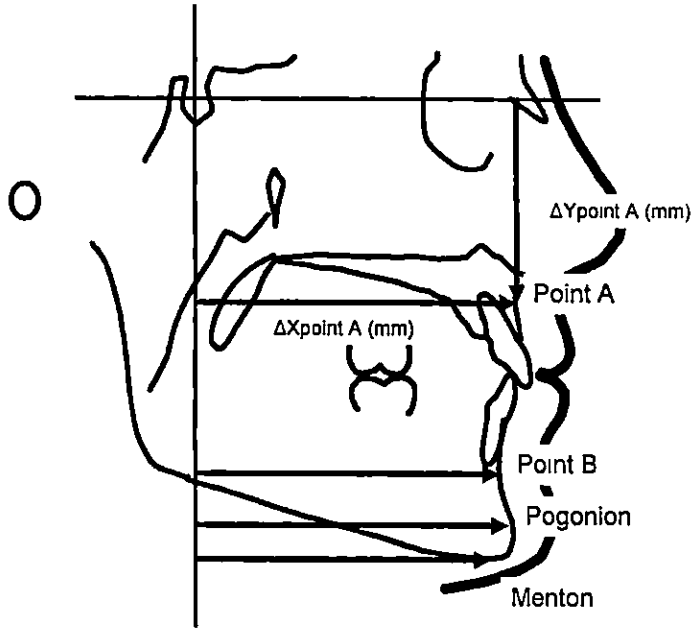


Figure 2. Cephalometric analysis of linear changes (mm) at point A, point B, pogonion and menton

One of the difficulties of any study involving measurement of specific points of successive cephalometric radiographs is the operator's ability to accurately identify landmarks consistently. There are many factors which can contribute to the envelope of error in landmark identification including radiographic noise, patient head position from cephalogram to cephalogram, landmark definition, etc. (Baumrind and Frantz 1971). The reliability of head film measurements has three significant concerns which needed to be addressed in the present study with regards to landmark identification. Even when replicating assessments of the same film landmark, identification errors are too large to be ignored, the magnitude of error greatly varies with different landmarks, and the distribution of these errors is not random, but rather systematic (Baumrind and Frantz 1971). In order to overcome the shortcomings of landmark identification of point A, point B, pogonion, menton, and gnathion, regional superimposition of the anterior surface of the maxilla and mandible were employed to carry landmarks through each individual tracing. At the completion of the tracing of a series, the aforementioned landmarks were found on the first cephalogram in which

the upper and lower central incisors were completely erupted then transferred via regional superimposition of the anterior surfaces of the mandible and maxilla to all other cephalograms in that series. This practice eliminated the envelope of error of landmark identification and ensured reliability of serial landmark identification and replication of landmark identification.

An error study (Table 1) was conducted to evaluate intraoperator reliability by selecting, at random, twenty radiographs in which all landmarks were re-measured. There were no significant differences between the error measurements and initial measurements.

TABLE 1.--Average Measurement and P-values of Error Study

Measurement	First measure (n=20)	Second Measure (n=20)	P-Value
Point A to Vertical	64.718	64.6885	0.15256
Point A to Horizontal	48.1705	48.1765	0.809482
Point B to Vertical	59.467	59.4325	0.141207
Point B to Horizontal	85.502	85.47	0.129271
Pog to Vertical	60.367	60.348	0.445301
Pog to Horizontal	98.2185	98.188	0.143353
Me to Vertical	54.3685	54.333	0.178948
Me to Horizontal	104.346	104.3405	0.807096
Ar-Gn (mm)	104.891	104.8655	0.348568
Ar-Go (mm)	43.698	43.7075	0.685869
Go-Gn (mm)	72.35	70.4405	0.314498
SN-MP	35.01	35.28	0.435045
Wits	-2.3225	-2.0165	0.296433
ANB	2.08	2.11	0.553937

Chronologic ages of each subject are shown in Tables 2, 3, 4 and 5.

TABLE 2.--Class III Male Sample and Age at which each Lateral Cephalogram was Traced.

Class III Males	Age												
	6	7	8	9	10	11	12	13	14	15	16	17	18
B0047									X	X			
B0062								X	X		X		
B0403											X	X	
B0522								X	X		X	X	
B0523									X	X			
B0625								X	X				
B0728								X	X				
B1380			X	X	X	X	X						
B1483	X		X	X		X	X						
B2419	X	X	X	X	X	X	X	X	X				
B3341							X	X	X	X	X	X	X
B3377					X	X	X	X	X	X	X		X

TABLE 3.--Class III Female Sample and Age at which each Lateral Cephalogram was Traced.

Class III Females	Age												
	6	7	8	9	10	11	12	13	14	15	16	17	18
B0116	X	X	X			X		X					
B0209							X	X					
B0271									X	X			
B0346									X	X			
B0428									X	X			
B0497								X	X				
B1306							X	X	X	X			
B3254							X	X		X	X		
B4304								X	X				

TABLE 4.--Class II Male Sample and Age at which each Lateral Cephalogram was Traced.

Class II Males	**Age**												
	6	7	8	9	10	11	12	13	14	15	16	17	18
B0113	X	X	X	X	X	X	X	X	X				
B0197									X	X			
B0216									X	X	X		
B0261			X	X	X	X	X						
B0279								X	X				
B0382									X	X			
B0398							X	X					
B1157							X	X	X	X	X	X	X
B1168											X	X	
B2274					X	X		X	X	X	X		X
B2551	X		X	X	X	X	X						
B2553								X	X		X	X	

TABLE 5.--Class II Female Sample and Age at which each Lateral Cephalogram was Traced.

Class II Females	**Age**												
	6	7	8	9	10	11	12	13	14	15	16	17	18
B0039									X	X			
B0119							X	X	X	X			
B1225							X	X		X	X		
B1269									X	X			
B1946									X	X			
B2146							X	X					
B2147									X	X			
B2235							X	X					
B2327	X	X	X			X		X					

RESULTS

The rate of change for the cephalometric landmarks measured to the vertical and horizontal reference planes represents the average of the rate of change in linear distance (mm) over time for the entire sample observed.

For angular measurements, the rate of change represents the change in angular measurement (degrees) over time. For example, the rate of change of point A to the vertical reference plane was the average of the rates of change for all twenty-one class II subjects for that linear measurement. This method of analysis allowed comparison of changes which occur in the different groups of subjects over time but does not quantify total change for each group.

Rate of change for all class II and class III subjects is presented in Table 6. There was no statistically significant difference in the rate of change of linear measurements between class II and class III subjects in the vertical direction. In the

horizontal direction, there was a statistically significant difference in the rate of change in Wits between class IIs and class IIIs in that Wits increased more over time in the class IIIs. ANB increased more significantly within all of the class IIIs than class IIs.

TABLE 6.--Comparison of Rate of Change for Class II and Class III Males and Females.

Measurement	**Class II M&F (rate of change)**	**Class III M&F (rate of change)**	**P-Values**
Point A to Vertical	0.764	0.617	0.366
Point B to Horizontal	0.911	0.966	0.659
Point A to Vertical	1.063	1.168	0.587
Point B to Horizontal	2.094	2.062	0.893
Pog to Vertical	1.312	1.437	0.621
Pog to Horizontal	2.046	2.086	0.872
Me to Vertical	1.438	1.646	0.419
Me to Horizontal	2.147	2.162	0.948
Ar-Gn (mm)	2.610	2.495	0.615
Ar-Go (mm)	1.806	1.296	0.206
Go-Gn (mm)	1.379	1.747	0.287
SN-MP	-0.424	-0.525	0.605
Wits	-0.444	-0.794	0.027*
ANB	-0.225	-0.413	0.050*

DISCUSSION

As previously stated, linear regression was calculated to identify a rate of change for each cephalometric point over time. The goal of linear regression was to minimize the difference between the observed and predicted values. It was necessary to use rate of change measurements because the untreated class III sample was limited. Analysis of rate change allowed evaluation of changes within the different skeletal samples over the large age range with which the sample presented.

Within each cephalometric series studied, a simple regression was calculated using the least-squares technique to give a value for the slope of the line representing the change of that cephalometric point over the period of time studied. A regression takes the change between all points into account giving a better representation of the average of the series than just the rate between the first and last measurement in a series. What this line represents is a change in mm/year for the

specific cephalometric point being analyzed. This rate of change was then compared to other rates of change of different cephalometric points to reveal differences or similarities in the amount each point changed during the time period studied.

The literature contains an abundance of studies which examined the morphometric presentation of class II and class III patients (Buschang et al. 1986; Battagel 1993, Guyer et al. 1986; Hunt et al. 2001; Maj et al. 1960; McNamara 1981; Ricketts 1960; Rothstein and Yoon-Tarlie 2000). These malocclusions have been shown to vary between individuals with regards to the morphologic cause of the discrepancy. The orthodontic literature tells us that the combination of the size of the mandible and maxilla, and the position of each jaw relative to the cranial base, are responsible for the discrepancy between the presentation of class II and class III malocclusions (Battagel 1993; Buschang et al. 1986; Chang et al. 1992; Guyer et al. 1986; Hunt 2001).

With regards to jaw position and jaw size in class II and class III patients, the current literature has an abundance of answers for the inquiring clinician. However, no previous studies can be found on the

differences in the rate of the morphometric changes of the maxilla and mandible in class II and class II patients over time. Class II and class III patients have the potential to differ in both size and position of the upper and lower jaws. But do they grow differently? The present study indicates that they do not. There was little difference in the rate of growth of class II and class III individuals in both the horizontal and vertical direction. In fact, variation between the linear measures of the mean rate of change for the two groups differed less than 0.3mm/year for almost all measurements studied (Table 6).

Although differences in rates of growth at individual points remained statistically insignificant, statistically significant differences in the rate of change of ANB and Wits were found between class II and class III subjects. It is possible that the differences in Wits appraisal of occlusal disharmony between the class II and class III subjects studied is the result of the additive effect of near differences that become statistically evident upon combination of the two groups (Table 6). A similar argument can be made for the

significant difference found in ANB when the two groups are combined.

Wits and ANB are two very different measures of antero-posterior alignment of the upper and lower jaws. Wits relies on the occlusal plane as a reference to describe the differences between the maxilla and mandible while ANB relies on the cranial base as its reference. If one of these two measures was not significant, then it could be assumed that any significant differences noted in one or the other could be due to chance. However, because both ANB and Wits showed statistically significant differences between the class II and class III subjects, and the inherent references for each are located in completely different regions of the head, the antero-posterior differences are difficult to ignore. It appears the additive effects of subtle differences in growth in the maxilla and mandible of class II and class III patients may validate the differences in facial growth that many orthodontists believe exist.

Brodie (1941) was a strong proponent of the idea of patterns of growth. He believed that the morphogenic pattern of the head was established by the third month of postnatal life and that once attained, it did not change.

Brodie was certain that, after an early age, the nasal floor, the occlusal plane, and the lower border of the mandible retained stable angular relationships during growth. While many would argue that patterns of growth do not exist, consistency of the differences noted between patients of the various Angle classes over time would indicate that skeletal variability, expressed at an early age, appears to continue throughout the growth of the facial skeleton (Moyers 1979a; Buschang 1986; Guyer et al. 1986; Hunt et al. 2001; Lande 1952; Singh et al. 1998).

The similarity in growth rates between class II and class III subjects, as shown in the present study, provides evidence that differences between class II and class III patients are, in fact, established early on. According to Hixon and Klein (1972), the most significant consistent finding of all longitudinal research has been the lack of meaningful relationship between any cephalometric measure and future growth. Even growth patterns, exhibited in past growth, have no usefulness in predicting future growth for a particular patient. This coincides with previous research that supports the idea that the same characteristics of a skeletal discrepancy

early in life will be carried throughout subsequent growth, from adolescence through adulthood (Buschang 1986; Guyer et al. 1986; Hixon and Klein 1972, Hunt 2001). Guyer et al. found that most characteristic aberrations associated with the adult class III malocclusion are already present at an early age. Few of the measurements were significantly different in a class I population in the oldest group that were not already present at the youngest age group (1986). Mitani et al. (1993) looked at the growth of untreated Japanese patients with mandibular prognathism during the three years after pubertal growth and found that morphologic characteristics of mandibular prognathism established before pubertal peak did not fundamentally change. In fact, their total growth increments were about the same as those with a normal mandible after the pubertal growth peak (Mitani et al. 1993). Others have reported similar findings for class II malocclusion; the mean growth between class I and class II patients shows similar changes, especially in post-pubertal development (Buschang 1986; Hunt 2001).

A patient's expression of growth during orthodontic treatment is a critical component of the final outcome.

Orthodontists are aware that no two patients are alike. Tools such as hand-wrist radiographs, VTO's, and standard growth curves are excellent aides in predicting average growth changes that will take place during treatment, but they are not true predictors of the growth that will occur during orthodontic care. One of the problems with assuming a particular pattern of growth is that individual patients can exhibit extreme variation. Studies which evaluate mean growth changes, such as the present study, only provide a group pattern. This is an excellent way to establish an average, but does not answer the questions we may have concerning our patients as individuals. It has been demonstrated that individual growth patterns do not necessarily follow the group pattern (Nanda and Ghosh 1995; Kim et al. 2002). In 2002, Kim et al. published a study that involved different skeletal patterns and horizontal expression of maxillary and mandibular growth using the same ordinate measuring technique used in the present study. Kim et al. noted that normal differential facial growth in which the mandible outpaced the maxilla was only found in 77% of forty patients. In the remaining 23%, the maxilla

actually outpaced the mandible in horizontal growth expression.

Similar to previous research, examination of the individual data collected within the present study revealed that excessive maxillary or excessive mandibular growth can occur regardless of the initial presentation of the malocclusion. For example, subject B3341 was a class III male whose radiographic series extended from age 12.0 to age 18.5. On the average, class III horizontal expression of growth at point A and B for class III males shows a rate of 0.665 and 1.234 mm/year respectively. Subject B3341 showed an average rate of 0.553 mm/year of horizontal change at point A and only 0.436 mm/year of horizontal change at point B. Total horizontal expression growth at point A and B was 3.36 mm and 2.62 mm. For this class III patient, the maxilla had a larger horizontal expression of growth than the mandible. Subject B3377 is a class III male whose radiographic series was similar to B3341 in that it extended from age 10.0 to age 17.0. However, subject B3377 showed a much more typical growth pattern during the time period studied. Total horizontal expression of growth was 8.05 mm at point A and 12.81 mm for point B.

The average rate of change for this patient was 1.410 and 1.995 mm/year at point A and B respectively, which resembled an expected outcome.

Although the data from the present study agrees with the findings of many previous studies, the sample size in the present study was small. In addition, individual variation in total growth, and the expression of that growth, was high. These two factors suggest the possible presence of a sample bias.

The present study helps to answer the question of whether there are similarities in the overall rate of growth between class II and class III individuals, but raises additional questions with relation to the presence of the timing of change in differently presenting malocclusions. Do class II and class III patients exhibit similar changes at similar intervals throughout growth? This study fails to address the question of timing of growth due to the lack of a sufficient number of untreated class III subjects needed to match the samples at specific ages. This current evaluation of the change in cephalometric measurements over time is unable to differentiate variations in rate for specific ages. Bjork (1963) indicated that there is a clear difference

between the mean growth rates for the juvenile and pubertal periods. In fact, examination of the human growth curve (and even good old-fashioned common sense) would tell us that, depending on both age and sex, a patient may grow significantly, modestly, or not at all during any given period. But while rates may vary over specific time periods, the overall rate of change in growing class II and class III patients, when measured in both the horizontal and vertical direction, does not appear to differ according to the data presented. What the data indicates is that variations in rate, which must occur in both groups, do not balance out over time.

In order to answer questions concerning differences in timing of growth between class II and class III subjects, additional radiographic series of untreated class III subjects would have to be found. If a sufficient number of subjects of the same ages could be procured, then analysis of the rate of change over time between specific time frames could be carried out. Additionally, with a larger sample, total growth could be evaluated between specific age groups for both the class II and class III subjects.

APPENDIX

Subject B0039 Raw Data

B0039	Age			
	13.917	15.000	SUM	Change per year
A-pt to Vertical	62.130	64.030		1.754
A-pt to Horizontal	47.460	47.970		0.471
ΔX for A-pt	0.000	1.900	1.900	
ΔY for A-pt	0.000	0.510	0.510	
B-pt to Vertical	51.420	53.790		2.188
B-pt to Horizontal	93.300	95.270		1.819
ΔX for B-pt	0.000	2.370	2.370	
ΔY for B-pt	0.000	1.970	1.970	
Pog to Vertical	51.780	54.630		2.632
% Change Pog to Vertical	0.000	0.052	0.052	
Pog to Horizontal	108.200	110.040		1.699
ΔX for Pog	0.000	2.850	2.850	
ΔY for Pog	0.000	1.840	1.840	
Me to Vertical	46.210	49.330		2.881
% Change Me to Vertical	0.000	0.063	0.063	
Me to Horizontal	111.470	113.290		1.681
ΔX for Me	0.000	3.120	3.120	
ΔY for Me	0.000	1.820	1.820	
Ar-Gn (mm)	103.050	106.560		3.241
ΔAr-Gn (mm)	0.000	3.510	3.510	
Ar-Go (mm)	42.220	43.410		
ΔAr-Go (mm)	0.000	1.190	1.190	
Go-Gn (mm)	69.000	68.630		
ΔGo-Gn (mm)	0.000	-0.370	-0.370	
SN-MP	45.200	44.900		
Wits	3.800	2.710		
ANB	3.000	3.000		
			AVG	
Occlusal Plane	81.000	81.000	81.000	

Subject B0116 Raw Data

B116	Age						
	6.000	6.916	7.750	10.667	13.250	SUM	Change per year
A-pt to Vertical	54.570	55.210	60.060	60.650	62.920		1.096
A-pt to Horizontal	34.010	36.570	42.330	46.340	49.720		2.193
ΔX for A-pt	0.000	0.640	4.850	0.590	2.270	8.350	
ΔY for A-pt	0.000	2.560	5.760	6.010	1.380	15.710	
B-pt to Vertical	50.920	52.360	57.030	58.090	62.410		1.465
B-pt to Horizontal	70.210	71.300	75.110	83.740	86.860		2.462
ΔX for B-pt	0.000	1.440	4.670	1.060	4.320	11.490	
ΔY for B-pt	0.000	1.090	3.810	8.630	3.120	16.650	
Pog to Vertical	49.820	51.220	56.630	58.340	63.360		1.760
Pog to Horizontal	78.380	83.750	87.510	96.220	99.540		2.843
ΔX for Pog	0.000	1.400	5.410	1.710	5.020	13.540	
ΔY for Pog	0.000	5.370	3.760	8.710	3.320	21.160	
Me to Vertical	43.630	44.880	50.250	52.710	57.590		1.853
Me to Horizontal	88.260	89.420	93.300	102.450	105.820		2.597
ΔX for Me	0.000	1.250	5.370	2.460	4.880	13.960	
ΔY for Me	0.000	1.160	3.880	9.150	3.370	17.560	
Ar-Gn (mm)	85.470	90.380	94.970	104.380	110.210		3.343
ΔAr-Gn (mm)	0.000	4.910	4.590	9.410	5.830	24.740	
Ar-Go (mm)	29.720	33.880	36.680	40.250	43.980		1.786
ΔAr-Go (mm)	0.000	4.160	2.800	3.570	3.730	14.260	
Go-Gn (mm)	58.650	59.530	66.310	71.510	75.110		2.328
ΔGo-Gn (mm)	0.000	0.880	6.780	5.200	3.600	16.460	
SN-MP	37.900	38.100	38.200	38.200	37.900		-0.006
Wits	-4.900	-5.980	-5.980	-6.670	-8.520		-0.552
ANB	1.800	2.000	0.900	-1.200	-1.000		-0.469
						AVG	
Occlusal Plane	105.000	107.000	106.000	103.000	104.000	105.000	

Subject B0209 Raw Data

B209	Age 12.250	13.250	SUM	Change per year
A-pt to Vertical	65.490	65.800		0.310
A-pt to Horizonta	46.920	48.640		1.720
ΔX for A-pt	0.000	0.310	0.310	
ΔY for A-pt	0.000	1.720	1.720	
B-pt to Vertical	62.300	63.170		0.870
B-pt to Horizonta	84.990	87.780		2.790
ΔX for B-pt	0.000	0.870	0.870	
ΔY for B-pt	0.000	2.790	2.790	
Pog to Vertical	62.110	63.120		1.010
Pog to Horizontal	96.190	99.320		3.130
ΔX for Pog	0.000	1.010	1.010	
ΔY for Pog	0.000	3.130	3.130	
Me to Vertical	56.360	57.620		1.260
Me to Horizontal	103.050	106.010		2.960
ΔX for Me	0.000	1.260	1.260	
ΔY for Me	0.000	2.960	2.960	
Ar-Gn (mm)	103.980	106.990		3.010
ΔAr-Gn (mm)	0.000	3.010	3.010	
Ar-Go (mm)	43.560	45.080		1.520
ΔAr-Go (mm)	0.000	1.520	1.520	
Go-Gn (mm)	67.620	69.750		2.130
ΔGo-Gn (mm)	0.000	2.130	2.130	
SN-MP	35.800	34.500	35.150	-1.300
Wits	-3.310	-3.800		-0.490
ANB	-0.200	-0.700	-0.900	-0.500
			AVG	
Occlusal Plane	100.000	98.000	99.000	

Subject B0119 Raw Data

B119	Age					
	12.083	13.000	14.083	15.000	SUM	Change per year
A-pt to Vertical	65.510	65.820	66.280	66.500		0.350
A-pt to Horizontal	52.120	52.090	51.990	52.660		0.152
ΔX for A-pt	0.000	0.310	0.460	0.220	0.990	
ΔY for A-pt	0.000	-0.030	-0.100	0.670	0.540	
B-pt to Vertical	56.660	58.060	58.060	58.080		0.428
B-pt to Horizontal	83.050	83.830	84.610	84.850		0.630
ΔX for B-pt	0.000	1.400	0.000	0.020	1.420	
ΔY for B-pt	0.000	0.780	0.780	0.240	1.800	
Pog to Vertical	55.720	57.440	57.500	57.720		0.609
Pog to Horizontal	96.860	97.940	98.570	98.990		0.712
ΔX for Pog	0.000	1.720	0.060	0.220	2.000	
ΔY for Pog	0.000	1.080	0.630	0.420	2.130	
Me to Vertical	51.710	53.180	53.370	53.480		0.555
Me to Horizontal	100.780	101.950	102.820	103.190		0.823
ΔX for Me	0.000	1.470	0.190	0.110	1.770	
ΔY for Me	0.000	1.170	0.870	0.370	2.410	
Ar-Gn (mm)	102.000	103.960	104.750	105.880		1.257
ΔAr-Gn (mm)	0.000	1.960	0.790	1.130	3.880	
Ar-Go (mm)	43.510	44.290	44.080	45.820		0.672
ΔAr-Go (mm)	0.000	0.780	-0.210	1.740		
Go-Gn (mm)	72.050	74.230	77.730	77.160		1.931
ΔGo-Gn (mm)	0.000	2.180	3.500	-0.570		
SN-MP	32.900	32.900	32.500	32.500		-0.165
Wits	0.480	-0.500	-0.480	-0.500		-0.293
ANB	4.300	4.000	3.700	3.900		-0.154
Occlusal Plane	106.000	106.000	104.000	105.000		

Subject B1225 Raw Data

B1225	Age					
	12.000	13.000	15.000	16.000	SUM	Change per year
A-pt to Vertical	67.160	68.750	69.620	70.140		0.683
A-pt to Horizontal	45.480	48.080	48.940	48.940		0.778
ΔX for A-pt	0.000	1.590	0.870	0.520	2.980	
ΔY for A-pt	0.000	2.600	0.860	0.000	3.460	
B-pt to Vertical	62.000	64.680	65.740	67.520		1.210
B-pt to Horizontal	75.420	79.450	81.610	82.220		1.576
ΔX for B-pt	0.000	2.680	1.060	1.780	5.520	
ΔY for B-pt	0.000	4.030	2.160	0.610	6.800	
Pog to Vertical	61.220	64.730	67.500	69.430		1.919
Pog to Horizontal	92.510	96.610	98.830	99.200		1.560
ΔX for Pog	0.000	3.510	2.770	1.930	8.210	
ΔY for Pog	0.000	4.100	2.220	0.370	6.690	
Me to Vertical	56.080	59.910	62.550	64.470		1.942
Me to Horizontal	95.350	99.950	102.030	102.280		1.594
ΔX for Me	0.000	3.830	2.640	1.920	8.390	
ΔY for Me	0.000	4.600	2.080	0.250	6.930	
Ar-Gn (mm)	95.960	101.960	106.300	107.860		2.814
ΔAr-Gn (mm)	0.000	6.000	4.340	1.560	11.900	
Ar-Go (mm)	34.530	40.430	42.890	44.120		2.164
ΔAr-Go (mm)	0.000	5.900	2.460	1.230		
Go-Gn (mm)	72.060	74.120	78.050	78.020		1.585
ΔGo-Gn (mm)	0.000	2.060	3.930	-0.030		
SN-MP	31.100	30.000	28.100	27.100		-0.990
Wits	0.680	-0.460	-1.290	-2.140		-0.647
ANB	5.500	4.800	4.500	4.000		-0.330
Occlusal Plane	101.000	101.500	96.000	96.000		

Subject B1269 Raw Data

B1269	Age			
	13.917	15.000	SUM	Change per year
A-pt to Vertical	65.180	66.250		0.988
A-pt to Horizontal	48.200	48.700		0.462
ΔX for A-pt	0.000	1.070	1.070	
ΔY for A-pt	0.000	0.500	0.500	
B-pt to Vertical	55.600	57.580		1.828
B-pt to Horizontal	78.270	80.650		2.198
ΔX for B-pt	0.000	1.980	1.980	
ΔY for B-pt	0.000	2.380	2.380	
Pog to Vertical	59.350	61.810		2.271
Pog to Horizontal	93.060	95.160		1.939
ΔX for Pog	0.000	2.460	2.460	
ΔY for Pog	0.000	2.100	2.100	
Me to Vertical	54.520	56.990		2.281
Me to Horizontal	98.020	100.490		2.281
ΔX for Me	0.000	2.470	2.470	
ΔY for Me	0.000	2.470	2.470	
Ar-Gn (mm)	99.890	103.380		3.223
ΔAr-Gn (mm)	0.000	3.490	3.490	
Ar-Go (mm)	40.340	43.970		3.352
ΔAr-Go (mm)	0.000	3.630	3.630	
Go-Gn (mm)	71.770	73.060		
ΔGo-Gn (mm)	0.000	1.290	1.290	
SN-MP	30.300	29.600		
Wits	4.300	3.350		
ANB	4.800	4.500		
			AVG	
Occlusal Plane	81.000	79.000	80.000	

Subject B1946 Raw Data

B1946	Age			
	14.330	15.417	SUM	Change per year
A-pt to Vertical	69.180	69.520		0.313
A-pt to Horizontal	44.770	45.180		0.377
ΔX for A-pt	0.000	0.340	0.340	
ΔY for A-pt	0.000	0.410	0.410	
B-pt to Vertical	57.430	57.410		-0.018
B-pt to Horizontal	83.400	84.370		0.892
ΔX for B-pt	0.000	-0.020	-0.020	
ΔY for B-pt	0.000	0.970	0.970	
Pog to Vertical	57.790	57.790		0.000
Pog to Horizontal	94.340	95.070		0.672
ΔX for Pog	0.000	0.000	0.000	
ΔY for Pog	0.000	0.730	0.730	
Me to Vertical	50.540	50.540		0.000
Me to Horizontal	103.420	104.200		0.718
ΔX for Me	0.000	0.000	0.000	
ΔY for Me	0.000	0.780	0.780	
Ar-Gn (mm)	104.290	105.300		0.929
ΔAr-Gn (mm)	0.000	1.010	1.010	
Ar-Go (mm)	48.910	49.280		0.340
ΔAr-Go (mm)	0.000	0.370	0.370	
Go-Gn (mm)	69.820	70.790		
ΔGo-Gn (mm)	0.000	0.970	0.970	
SN-MP	35.100	35.200		
Wits	4.140	4.550		
ANB	7.300	7.300		
			AVG	
Occlusal Plane	101.000	102.000	101.500	

Subject B2146 Raw Data

B2146	Age			
	12.000	13.083	SUM	Change per year
A-pt to Vertical	63.770	64.560		0.729
A-pt to Horizontal	47.790	49.070		1.182
ΔX for A-pt	0.000	0.790	0.790	
ΔY for A-pt	0.000	1.280	1.280	
B-pt to Vertical	50.840	51.470		0.582
B-pt to Horizontal	83.690	85.520		1.690
ΔX for B-pt	0.000	0.630	0.630	
ΔY for B-pt	0.000	1.830	1.830	
Pog to Vertical	49.060	50.460		1.293
Pog to Horizontal	100.320	102.330		1.856
ΔX for Pog	0.000	1.400	1.400	
ΔY for Pog	0.000	2.010	2.010	
Me to Vertical	42.640	43.950		1.210
Me to Horizontal	104.210	106.310		1.939
ΔX for Me	0.000	1.310	1.310	
ΔY for Me	0.000	2.100	2.100	
Ar-Gn (mm)	96.130	98.540		2.225
ΔAr-Gn (mm)	0.000	2.410	2.410	
Ar-Go (mm)	42.160	42.700		0.499
ΔAr-Go (mm)	0.000	0.540	0.540	
Go-Gn (mm)	68.750	71.790		
ΔGo-Gn (mm)	0.000	3.040	3.040	
SN-MP	31.600	32.900		1.646
Wits	2.770	2.810		0.031
ANB	6.000	6.000		0.000
			AVG	
Occlusal Plane	106.000	106.000	106.000	

Subject B2147 Raw Data

B2147	Age			
	14.083	15.083	SUM	Change per year
A-pt to Vertical	74.730	74.810		0.080
A-pt to Horizontal	44.980	46.190		1.210
ΔX for A-pt	0.000	0.080	0.080	
ΔY for A-pt	0.000	1.210	1.210	
B-pt to Vertical	62.780	63.140		0.360
B-pt to Horizontal	82.670	85.140		2.470
ΔX for B-pt	0.000	0.360	0.360	
ΔY for B-pt	0.000	2.470	2.470	
Pog to Vertical	64.600	64.630		0.030
Pog to Horizontal	92.630	94.950		2.320
ΔX for Pog	0.000	0.030	0.030	
ΔY for Pog	0.000	2.320	2.320	
Me to Vertical	57.830	58.060		0.230
Me to Horizontal	98.880	101.290		2.410
ΔX for Me	0.000	0.230	0.230	
ΔY for Me	0.000	2.410	2.410	
Ar-Gn (mm)	105.140	106.700		1.560
ΔAr-Gn (mm)	0.000	1.560	1.560	
Ar-Go (mm)	46.890	47.040		0.150
ΔAr-Go (mm)	0.000	0.150	0.150	
Go-Gn (mm)	70.420	72.040		
ΔGo-Gn (mm)	0.000	1.620	1.620	
SN-MP	28.000	28.900		0.900
Wits	7.490	6.900		-0.590
ANB	6.200	6.100		-0.100
			AVG	
Occlusal Plane	97.000	97.000	97.000	

Subject B2235 Raw Data

B2235	Age			
	12.083	13.000	SUM	Change per year
A-pt to Vertical	66.340	66.350		0.011
A-pt to Horizontal	48.830	50.060		1.341
ΔX for A-pt	0.000	0.010	0.010	
ΔY for A-pt	0.000	1.230	1.230	
B-pt to Vertical	57.310	58.110		0.872
B-pt to Horizontal	80.170	82.360		2.388
ΔX for B-pt	0.000	0.800	0.800	
ΔY for B-pt	0.000	2.190	2.190	
Pog to Vertical	57.720	58.760		1.134
Pog to Horizontal	95.170	97.430		2.465
ΔX for Pog	0.000	1.040	1.040	
ΔY for Pog	0.000	2.260	2.260	
Me to Vertical	48.820	50.410		1.734
Me to Horizontal	102.100	104.550		2.672
ΔX for Me	0.000	1.590	1.590	
ΔY for Me	0.000	2.450	2.450	
Ar-Gn (mm)	99.880	102.420		2.770
ΔAr-Gn (mm)	0.000	2.540	2.540	
Ar-Go (mm)	42.580	45.920		3.642
ΔAr-Go (mm)	0.000	3.340	3.340	
Go-Gn (mm)	68.600	68.720		
ΔGo-Gn (mm)	0.000	0.120	0.120	
SN-MP	36.800	35.200		-1.745
Wits	3.340	2.630		-0.774
ANB	6.100	5.500		-0.654
			AVG	
Occlusal Plane	100.000	101.000	100.500	

Subject B2327 Raw Data

B2327	Age						
	6.000	7.000	8.000	11.000	13.167	SUM	Change per year
A-pt to Vertical	55.880	57.390	57.100	59.390	61.160		0.690
A-pt to Horizontal	42.340	42.870	44.620	48.150	49.920		1.112
ΔX for A-pt	0.000	1.510	-0.290	2.290	1.770	5.280	
ΔY for A-pt	0.000	0.530	1.750	3.530	1.770	7.580	
B-pt to Vertical	45.270	47.550	45.950	49.110	49.850		0.598
B-pt to Horizontal	78.330	78.420	81.640	87.710	94.300		2.287
ΔX for B-pt	0.000	2.280	-1.600	3.160	0.740	4.580	
ΔY for B-pt	0.000	0.090	3.220	6.070	6.590	15.970	
Pog to Vertical	43.950	47.270	47.610	50.980	52.170		1.054
Pog to Horizontal	90.650	91.220	94.340	100.410	106.940		2.307
ΔX for Pog	0.000	3.320	0.340	3.370	1.190	8.220	
ΔY for Pog	0.000	0.570	3.120	6.070	6.530	16.290	
Me to Vertical	36.910	40.810	41.750	44.530	46.150		1.138
Me to Horizontal	95.180	96.790	99.860	106.250	112.800		2.446
ΔX for Me	0.000	3.900	0.940	2.780	1.620	9.240	
ΔY for Me	0.000	1.610	3.070	6.390	6.550	17.620	
Ar-Gn (mm)	90.630	93.750	96.330	104.000	109.170		2.565
ΔAr-Gn (mm)	0.000	3.120	2.580	7.670	5.170	18.540	
Ar-Go (mm)	37.400	38.660	38.820	41.820	44.710		0.986
ΔAr-Go (mm)	0.000	1.260	0.160	3.000	2.89	7.310	
Go-Gn (mm)	61.950	64.100	67.160	71.240	76.06		1.890
ΔGo-Gn (mm)	0.000	2.150	3.060	4.080	4.82	14.110	
SN-MP	41.400	40.000	42.100	42.100	41.6		0.122
Wits	-3.970	-3.700	-3.360	-3.240	-2.47		0.183
ANB	4.400	4.800	4.800	4.000	4.3		-0.069
						AVG	
Occlusal Plane	112.000	112.000	112.000	110.000		111.500	

Subject B197 Raw Data

B197	Age 14.167	15.250	SUM	Change per year
A-pt to Vertical	73.810	73.950		0.129
A-pt to Horizonta	50.710	51.450		0.683
ΔX for A-pt	0.000	0.140	0.140	
ΔY for A-pt	0.000	0.740	0.140	
B-pt to Vertical	62.390	64.050		1.533
B-pt to Horizonta	83.120	86.280		2.918
ΔX for B-pt	0.000	1.660	1.660	
ΔY for B-pt	0.000	3.160	1.660	
Pog to Vertical	63.030	64.840		1.671
Pog to Horizontal	96.000	99.110		2.872
ΔX for Pog	0.000	1.810	1.810	
ΔY for Pog	0.000	3.110	1.810	
Me to Vertical	56.730	59.040		2.133
Me to Horizontal	100.510	103.550		2.807
ΔX for Me	0.000	2.310	2.310	
ΔY for Me	0.000	3.040	3.040	
Ar-Gn (mm)	103.550	107.260		3.426
ΔAr-Gn (mm)	0.000	3.710	3.710	
Ar-Go (mm)	45.810	50.270		4.118
ΔAr-Go (mm)	0.000	4.460	4.460	
Go-Gn (mm)	71.760	72.600		0.776
ΔGo-Gn (mm)	0.000	0.840	0.840	
SN-MP	28.100	27.100		-0.923
Wits	6.900	5.490		-1.302
ANB	6.500	5.000		-1.385
			AVG	
Occlusal Plane	98.500	97.500	98.000	

Subject B0216 Raw Data

B216	Age				
	14.000	15.000	16.000	SUM	Change per year
A-pt to Vertical	90.260	91.760	92.150		0.945
A-pt to Horizonta	50.930	52.010	52.740		0.905
ΔX for A-pt	0.000	1.500	0.390	1.890	
ΔY for A-pt	0.000	1.080	0.730	1.890	
B-pt to Vertical	82.750	85.090	85.610		1.430
B-pt to Horizonta	86.460	88.050	88.960		1.250
ΔX for B-pt	0.000	2.340	0.520	2.860	
ΔY for B-pt	0.000	1.590	0.910	2.860	
Pog to Vertical	87.320	89.450	90.230		1.455
Pog to Horizontal	98.300	99.540	100.090		0.895
ΔX for Pog	0.000	2.130	0.780	2.910	
ΔY for Pog	0.000	1.240	0.550	2.910	
Me to Vertical	82.520	85.260	86.480		1.980
Me to Horizontal	109.480	111.160	112.000		1.260
ΔX for Me	0.000	2.740	1.220	3.960	
ΔY for Me	0.000	1.680	0.840	2.520	
Ar-Gn (mm)	121.530	124.540	125.990		2.230
ΔAr-Gn (mm)	0.000	[illegible].010	1.450	4.460	
Ar-Go (mm)	50.160	[illegible]..560	53.860		1.850
ΔAr-Go (mm)	0.000	2.400	1.300	3.700	
Go-Gn (mm)	87.730	89.360	91.250		1.760
ΔGo-Gn (mm)	0.000	1.630	1.890	3.520	
SN-MP	24.000	22.900	20.500		-1.750
Wits	6.610	6.060	5.870		-0.370
ANB	5.400	5.100	5.300		-0.050
				AVG	
Occlusal Plane	92.000	92.000	92.000	92.000	

Subject B0261 Raw Data

B261	Age						
	8.000	9.000	10.000	11.000	12.000	SUM	Change per year
A-pt to Vertical	77.000	79.100	80.090	82.770	83.940		1.755
A-pt to Horizontal	44.830	45.240	45.250	45.430	46.970		0.447
ΔX for A-pt	0.000	2.100	0.990	2.680	1.170	6.940	
ΔY for A-pt	0.000	0.410	0.010	0.180	1.540	6.940	
B-pt to Vertical	66.600	69.320	71.120	75.610	74.780		2.265
B-pt to Horizontal	80.930	81.070	81.620	81.630	85.970		1.064
ΔX for B-pt	0.000	2.720	1.800	4.490	-0.830	8.180	
ΔY for B-pt	0.000	0.140	0.550	0.010	4.340	8.180	
Pog to Vertical	68.410	71.640	73.690	78.960	78.510		2.752
Pog to Horizontal	89.940	89.920	90.180	90.200	94.460		0.932
ΔX for Pog	0.000	3.230	2.050	5.270	-0.450	10.100	
ΔY for Pog	0.000	-0.020	0.260	0.020	4.260	10.100	
Me to Vertical	62.120	65.560	67.780	73.220	72.670		2.876
Me to Horizontal	96.830	97.000	97.680	97.970	102.720		1.275
ΔX for Me	0.000	3.440	2.220	5.440	-0.550	10.550	
ΔY for Me	0.000	0.170	0.680	0.290	4.750	5.890	
Ar-Gn (mm)	101.230	102.830	104.700	109.240	111.050		2.605
ΔAr-Gn (mm)	0.000	1.600	1.870	4.540	1.810	9.820	
Ar-Go (mm)	40.480	41.720	41.740	44.030	45.000		1.135
ΔAr-Go (mm)	0.000	1.240	0.020	2.290	0.970	4.520	
Go-Gn (mm)	72.510	74.070	77.120	79.460	81.180		2.273
ΔGo-Gn (mm)	0.000	1.560	3.050	2.340	1.720	8.670	
SN-MP	30.000	28.000	26.900	24.700	26.000		-1.130
Wits	6.540	5.360	5.120	3.450	4.410		-0.617
ANB	6.800	6.800	6.500	6.100	7.000		-0.030
						AVG	
Occlusal Plane	100.000	96.000	96.000	96.000	95.000	96.600	

Subject B0279 Raw Data

B279	Age 13.250	14.250	SUM	Change per year
A-pt to Vertical	61.650	61.970		0.320
A-pt to Horizonta	49.780	51.830		2.050
ΔX for A-pt	0.000	0.320	0.320	
ΔY for A-pt	0.000	2.050	0.320	
B-pt to Vertical	53.290	53.840		0.550
B-pt to Horizonta	78.730	82.430		3.700
ΔX for B-pt	0.000	0.550	0.550	
ΔY for B-pt	0.000	3.700	0.550	
Pog to Vertical	55.070	56.160		1.090
Pog to Horizontal	90.970	94.410		3.440
ΔX for Pog	0.000	1.090	1.090	
ΔY for Pog	0.000	3.440	1.090	
Me to Vertical	49.780	51.360		1.580
Me to Horizontal	97.970	101.560		3.590
ΔX for Me	0.000	1.580	1.580	
ΔY for Me	0.000	3.590	3.590	
Ar-Gn (mm)	96.290	100.660		4.370
ΔAr-Gn (mm)	0.000	4.370	4.370	
Ar-Go (mm)	40.520	42.980		2.460
ΔAr-Go (mm)	0.000	2.460	2.460	
Go-Gn (mm)	68.450	70.770		2.320
ΔGo-Gn (mm)	0.000	2.320	2.320	
SN-MP	32.100	32.200		0.100
Wits	7.510	7.410		-0.100
ANB	4.200	4.100		-0.100
			AVG	
Occlusal Plane	92.000	92.000	92.000	

Subject B0382 Raw Data

B382	Age 13.583	14.583	SUM	Change per year
A-pt to Vertical	64.580	65.510		0.930
A-pt to Horizonta	55.310	55.770		0.460
ΔX for A-pt	0.000	0.930	0.930	
ΔY for A-pt	0.000	0.460	0.930	
B-pt to Vertical	51.330	53.030		1.700
B-pt to Horizonta	93.840	97.140		3.300
ΔX for B-pt	0.000	1.700	1.700	
ΔY for B-pt	0.000	3.300	1.700	
Pog to Vertical	51.920	53.830		1.910
Pog to Horizontal	105.770	108.900		3.130
ΔX for Pog	0.000	1.910	1.910	
ΔY for Pog	0.000	3.130	1.910	
Me to Vertical	44.980	46.870		1.890
Me to Horizontal	114.630	118.060		3.430
ΔX for Me	0.000	1.890	1.890	
ΔY for Me	0.000	3.430	3.430	
Ar-Gn (mm)	104.980	108.580		3.600
ΔAr-Gn (mm)	0.000	3.600	3.600	
Ar-Go (mm)	48.240	50.170		1.930
ΔAr-Go (mm)	0.000	1.930	1.930	
Go-Gn (mm)	72.030	74.110		2.080
ΔGo-Gn (mm)	0.000	2.080	2.080	
SN-MP	36.400	36.100		-0.300
Wits	3.640	2.420		-1.220
ANB	6.000	5.500		-0.500
			AVG	
Occlusal Plane	104.000	104.000	104.000	

Subject B0398 Raw Data

B398	Age 12.500	13.417	SUM	Change per year
A-pt to Vertical	68.060	69.150		1.189
A-pt to Horizonta	55.040	56.260		1.330
ΔX for A-pt	0.000	1.090	1.090	
ΔY for A-pt	0.000	1.220	1.090	
B-pt to Vertical	55.590	56.360		0.840
B-pt to Horizonta	90.900	93.720		3.075
ΔX for B-pt	0.000	0.770	0.770	
ΔY for B-pt	0.000	2.820	0.770	
Pog to Vertical	55.210	55.930		0.785
Pog to Horizontal	99.900	102.690		3.043
ΔX for Pog	0.000	0.720	0.720	
ΔY for Pog	0.000	2.790	0.720	
Me to Vertical	47.410	47.670		0.284
Me to Horizontal	107.750	110.420		2.912
ΔX for Me	0.000	0.260	0.260	
ΔY for Me	0.000	2.670	2.670	
Ar-Gn (mm)	101.560	104.950		3.697
ΔAr-Gn (mm)	0.000	3.390	3.390	
Ar-Go (mm)	45.850	50.310		4.864
ΔAr-Go (mm)	0.000	4.460	4.460	
Go-Gn (mm)	68.020	67.580		-0.480
ΔGo-Gn (mm)	0.000	-0.440	-0.440	
SN-MP	37.100	35.900		-1.309
Wits	1.470	1.470		0.000
ANB	6.000	6.000		0.000
			AVG	
Occlusal Plane	107.000	107.000	107.000	

Subject B1157 Raw Data

B1157	Age								
	12.000	13.000	14.000	15.083	16.000	17.000	18.000	SUM	Change per year
A-pt to Vertical	64.590	65.780	66.810	67.650	69.650	70.770	71.340		1.185
A-pt to Horizont	53.790	55.280	57.080	59.070	60.970	62.210	62.520		1.799
ΔX for A-pt	0.000	1.190	1.030	0.840	2.000	1.120	0.570	6.750	
ΔY for A-pt	0.000	1.490	1.800	1.990	1.900	1.240	0.310	6.750	
B-pt to Vertical	50.200	51.620	52.010	53.110	55.470	57.410	58.550		1.188
B-pt to Horizont	90.600	92.440	96.370	101.980	105.940	107.490	109.880		3.991
ΔX for B-pt	0.000	1.420	0.390	1.100	2.360	1.940	1.140	8.350	
ΔY for B-pt	0.000	1.840	3.930	5.610	3.960	1.550	2.390	8.350	
Pog to Vertical	48.650	50.220	50.810	52.600	55.290	57.750	58.860		1.548
Pog to Horizonta	104.580	106.550	110.480	115.990	120.170	121.740	124.260		4.030
ΔX for Pog	0.000	1.570	0.590	1.790	2.690	2.460	1.110	10.210	
ΔY for Pog	0.000	1.970	3.930	5.510	4.180	1.570	2.520	10.210	
Me to Vertical	40.960	42.510	43.270	45.550	48.180	50.470	51.620		1.730
Me to Horizontal	110.880	112.910	117.090	123.010	127.430	128.860	131.390		4.286
ΔX for Me	0.000	1.550	0.760	2.280	2.630	2.290	1.150	10.660	
ΔY for Me	0.000	2.030	4.170	5.930	4.420	1.430	2.530	20.510	
Ar-Gn (mm)	105.660	107.630	110.900	116.720	121.600	124.020	126.600		4.062
ΔAr-Gn (mm)	0.000	1.970	3.270	5.820	4.880	2.420	2.580	20.940	
Ar-Go (mm)	42.350	44.120	44.200	47.200	50.380	51.910	54.710		1.894
ΔAr-Go (mm)	0.000	1.770	0.080	3.000	3.180	1.530	2.800	12.360	
Go-Gn (mm)	73.550	74.030	77.780	81.330	84.510	86.250	86.000		2.898
ΔGo-Gn (mm)	0.000	0.480	3.750	3.550	3.180	1.740	-0.250	12.450	
SN-MP	42.300	42.000	42.100	42.100	42.000	40.000	39.000		-0.049
Wits	3.920	3.630	3.640	2.150	1.700	0.800	-0.630		-0.589
ANB	5.900	5.900	5.700	5.000	4.800	5.000	4.500		-0.309
								AVG	
Occlusal Plane	110.000	108.000	107.000	107.000	105.000	104.000	104.000	106.429	

Subject B1168 Raw Data

B1168	Age			
	16.000	16.917	SUM	Change per year
A-pt to Vertical	74.370	75.120		0.818
A-pt to Horizonta	48.500	49.030		0.578
ΔX for A-pt	0.000	0.750	0.750	
ΔY for A-pt	0.000	0.530	0.750	
B-pt to Vertical	72.490	73.980		1.625
B-pt to Horizonta	87.110	88.400		1.407
ΔX for B-pt	0.000	1.490	1.490	
ΔY for B-pt	0.000	1.290	1.490	
Pog to Vertical	78.600	80.060		1.592
Pog to Horizontal	102.990	104.570		1.723
ΔX for Pog	0.000	1.460	1.460	
ΔY for Pog	0.000	1.580	1.460	
Me to Vertical	72.490	74.200		1.865
Me to Horizontal	111.430	112.730		1.418
ΔX for Me	0.000	1.710	1.710	
ΔY for Me	0.000	1.300	1.300	
Ar-Gn (mm)	118.150	120.140		2.170
ΔAr-Gn (mm)	0.000	1.990	1.990	
Ar-Go (mm)	49.260	51.500		2.443
ΔAr-Go (mm)	0.000	2.240	2.240	
Go-Gn (mm)	82.600	82.710		0.120
ΔGo-Gn (mm)	0.000	0.110	0.110	
SN-MP	25.700	25.100		-0.654
Wits	1.850	1.250		-0.654
ANB	4.000	3.600		-0.436
			AVG	
Occlusal Plane	90.500	90.000	90.250	

Subject B2274 Raw Data

B2274	Age								
	10.000	11.000	13.000	14.000	15.000	16.000	18.000	SUM	Change per year
A-pt to Vertical	68.760	70.970	71.530	72.190	73.820	74.030	74.890		0.844
A-pt to Horizont	52.510	53.910	56.200	56.990	58.190	58.280	59.130		1.113
ΔX for A-pt	0.000	2.210	0.560	0.660	1.630	0.210	0.860	6.130	
ΔY for A-pt	0.000	1.400	2.290	0.790	1.200	0.090	0.850	6.130	
B-pt to Vertical	57.000	58.120	60.080	60.160	59.970	61.550	61.590		0.639
B-pt to Horizont	88.320	91.770	97.590	99.540	102.990	105.860	109.380		2.855
ΔX for B-pt	0.000	1.120	1.960	0.080	-0.190	1.580	0.040	4.590	
ΔY for B-pt	0.000	3.450	5.820	1.950	3.450	2.870	3.520	4.590	
Pog to Vertical	57.440	58.830	60.640	60.960	60.530	62.220	62.230		0.663
Pog to Horizonta	98.790	102.250	108.010	110.050	113.580	116.650	119.960		2.873
ΔX for Pog	0.000	1.390	1.810	0.320	-0.430	1.690	0.010	4.790	
ΔY for Pog	0.000	3.460	5.760	2.040	3.530	3.070	3.310	4.790	
Me to Vertical	51.030	52.340	54.340	54.360	54.280	55.880	55.910		0.680
Me to Horizontal	105.780	109.140	115.080	116.990	120.660	123.530	127.010		2.892
ΔX for Me	0.000	1.310	2.000	0.020	-0.080	1.600	0.030	4.880	
ΔY for Me	0.000	3.360	5.940	1.910	3.670	2.870	3.480	21.230	
Ar-Gn (mm)	102.530	105.900	111.260	113.100	115.500	117.710	120.150		2.560
ΔAr-Gn (mm)	0.000	3.370	5.360	1.840	2.400	2.210	2.440	17.620	
Ar-Go (mm)	40.190	42.920	45.830	45.920	48.810	50.570	53.110		1.546
ΔAr-Go (mm)	0.000	2.730	2.910	0.090	2.890	1.760	2.540	12.920	
Go-Gn (mm)	73.200	74.640	78.230	80.320	81.230	82.260	83.370		1.683
ΔGo-Gn (mm)	0.000	1.440	3.590	2.090	0.910	1.030	1.110	10.170	
SN-MP	37.900	37.900	38.000	37.700	38.100	39.000	40.000		0.014
Wits	1.700	2.350	-0.370	0.280	0.830	-0.770	-0.930		-0.346
ANB	4.900	4.900	4.000	3.900	4.500	4.000	4.200		-0.158
								AVG	
Occlusal Plane	110.000	111.000	105.000	105.000	107.000	103.000	103.000	106.286	

Subject B2251 Raw Data

B2551	Age						
	6.083	8.167	9.000	10.000	12.167	SUM	Change per year
A-pt to Vertical	69.050	70.580	71.600	73.190	74.790		0.984
A-pt to Horizontal	40.920	42.410	42.460	42.850	45.270		0.678
ΔX for A-pt	0.000	1.530	1.020	1.590	1.600	5.740	
ΔY for A-pt	0.000	1.490	0.050	0.390	2.420	5.740	
B-pt to Vertical	60.720	61.790	61.800	63.640	64.140		0.602
B-pt to Horizontal	75.700	78.630	79.720	81.600	85.730		1.649
ΔX for B-pt	0.000	1.070	0.010	1.840	0.500	3.420	
ΔY for B-pt	0.000	2.930	1.090	1.880	4.130	3.420	
Pog to Vertical	59.500	61.990	62.360	64.170	64.750		0.869
Pog to Horizontal	87.510	90.450	91.700	93.700	97.730		1.690
ΔX for Pog	0.000	2.490	0.370	1.810	0.580	5.250	
ΔY for Pog	0.000	2.940	1.250	2.000	4.030	5.250	
Me to Vertical	53.660	56.270	56.530	58.290	58.880		0.877
Me to Horizontal	91.160	94.510	95.820	97.950	101.940		1.783
ΔX for Me	0.000	2.610	0.260	1.760	0.590	5.220	
ΔY for Me	0.000	3.350	1.310	2.130	3.990	10.780	
Ar-Gn (mm)	90.310	93.640	94.860	97.230	101.000		1.776
ΔAr-Gn (mm)	0.000	3.330	1.220	2.370	3.770	10.690	
Ar-Go (mm)	37.160	37.900	39.190	40.130	41.500		0.755
ΔAr-Go (mm)	0.000	0.740	1.290	0.940	1.370	4.340	
Go-Gn (mm)	64.160	67.290	67.330	68.830	71.710		1.209
ΔGo-Gn (mm)	0.000	3.130	0.040	1.500	2.880	7.550	
SN-MP	34.000	34.000	34.000	33.100	33.200		-0.163
Wits	1.220	1.400	2.380	1.650	1.710		0.091
ANB	7.000	6.500	7.000	7.500	8.200		0.229
						AVG	
Occlusal Plane	100.000	102.000	102.000	102.000	103.000	101.800	

Subject B2253 Raw Data

B2553	Age					
	13.000	14.000	16.000	17.000	SUM	Change per year
A-pt to Vertical	71.500	72.650	72.970	73.010		0.334
A-pt to Horizonta	52.400	53.190	55.480	55.580		0.865
ΔX for A-pt	0.000	1.150	0.320	0.040	1.510	
ΔY for A-pt	0.000	0.790	2.290	0.100	1.510	
B-pt to Vertical	60.850	61.840	62.720	62.710		0.460
B-pt to Horizonta	90.570	91.340	93.250	93.290		0.735
ΔX for B-pt	0.000	0.990	0.880	-0.010	1.860	
ΔY for B-pt	0.000	0.770	1.910	0.040	1.860	
Pog to Vertical	60.770	61.910	63.060	63.370		0.635
Pog to Horizontal	100.670	101.390	103.150	103.170		0.676
ΔX for Pog	0.000	1.140	1.150	0.310	2.600	
ΔY for Pog	0.000	0.720	1.760	0.020	2.600	
Me to Vertical	54.440	56.180	56.800	57.080		0.590
Me to Horizontal	110.170	111.430	112.780	112.750		0.651
ΔX for Me	0.000	1.740	0.620	0.280	2.640	
ΔY for Me	0.000	1.260	1.350	-0.030	2.580	
Ar-Gn (mm)	109.420	111.260	113.460	113.450		1.026
ΔAr-Gn (mm)	0.000	1.840	2.200	-0.010	4.030	
Ar-Go (mm)	46.000	47.530	49.300	49.740		0.925
ΔAr-Go (mm)	0.000	1.530	1.770	0.440	3.740	
Go-Gn (mm)	75.510	76.870	76.880	77.430		0.385
ΔGo-Gn (mm)	0.000	1.360	0.010	0.550	1.920	
SN-MP	33.900	32.000	32.100	31.100		-0.550
Wits	3.500	3.650	3.280	3.500		-0.037
ANB	4.000	4.000	3.500	3.200		-0.210
					AVG	
Occlusal Plane	104.000	101.000	101.000	99.000	101.250	

Subject B0428 Raw Data

B428	Age			
	14.330	15.330	SUM	Change per year
A-pt to Vertical	68.330	69.190		0.860
A-pt to Horizonta	50.340	50.480		0.140
ΔX for A-pt	0.000	0.860	0.860	
ΔY for A-pt	0.000	0.140	0.140	
B-pt to Vertical	69.760	70.290		0.530
B-pt to Horizonta	90.530	92.120		1.590
ΔX for B-pt	0.000	0.530	0.530	
ΔY for B-pt	0.000	1.590	1.590	
Pog to Vertical	68.580	69.010		0.430
Pog to Horizontal	104.740	106.290		1.550
ΔX for Pog	0.000	0.430	0.430	
ΔY for Pog	0.000	1.550	1.550	
Me to Vertical	60.840	61.630		0.790
Me to Horizontal	111.530	112.680		1.150
ΔX for Me	0.000	0.790	0.790	
ΔY for Me	0.000	1.150	1.150	
Ar-Gn (mm)	114.200	115.760		1.560
ΔAr-Gn (mm)	0.000	1.560	1.560	
Ar-Go (mm)	51.080	51.240		0.160
ΔAr-Go (mm)	0.000	0.160	0.160	
Go-Gn (mm)	73.460	74.760		1.300
ΔGo-Gn (mm)	0.000	0.000	0.000	
SN-MP	38.200	38.400	38.300	0.200
Wits	-8.820	-8.310	-8.565	0.510
ANB	-1.500	-1.500	-3.000	0.000
			AVG	
Occlusal Plane	100.500	100.500	100.500	

Subject B0271 Raw Data

B271	Age 13.833	14.833	SUM	Change per year
A-pt to Vertical	59.690	59.790		0.100
A-pt to Horizonta	49.250	50.270		1.020
ΔX for A-pt	0.000	0.100	0.100	
ΔY for A-pt	0.000	1.020	1.020	
B-pt to Vertical	54.950	55.590		0.640
B-pt to Horizonta	90.390	91.450		1.060
ΔX for B-pt	0.000	0.640	0.640	
ΔY for B-pt	0.000	1.060	1.060	
Pog to Vertical	54.130	54.740		0.610
Pog to Horizontal	103.610	104.810		1.200
ΔX for Pog	0.000	0.610	0.610	
ΔY for Pog	0.000	1.200	1.200	
Me to Vertical	47.150	47.950		0.800
Me to Horizontal	109.420	110.280		0.860
ΔX for Me	0.000	0.800	0.800	
ΔY for Me	0.000	0.860	0.860	
Ar-Gn (mm)	106.860	108.180		1.320
ΔAr-Gn (mm)	0.000	1.320	1.320	
Ar-Go (mm)	42.970	43.880		0.910
ΔAr-Go (mm)	0.000	0.910	0.910	
Go-Gn (mm)	71.450	75.120		3.670
ΔGo-Gn (mm)	0.000	0.000	0.000	
SN-MP	42.700	42.100	42.400	-0.600
Wits	-6.690	-7.050	-6.870	-0.360
ANB	0.000	-0.500	-0.500	-0.500
			AVG	
Occlusal Plane	105.000	107.000	106.000	

Subject B0346 Raw Data

B346	Age 13.500	14.500	SUM	Change per year
A-pt to Vertical	70.140	70.640		0.500
A-pt to Horizonta	45.140	45.330		0.190
ΔX for A-pt	0.000	0.500	0.500	
ΔY for A-pt	0.000	0.190	0.190	
B-pt to Vertical	76.420	78.100		1.680
B-pt to Horizonta	84.650	84.290		-0.360
ΔX for B-pt	0.000	1.680	1.680	
ΔY for B-pt	0.000	-0.360	-0.360	
Pog to Vertical	78.070	80.700		2.630
Pog to Horizontal	96.210	95.580		-0.630
ΔX for Pog	0.000	2.630	2.630	
ΔY for Pog	0.000	-0.630	-0.630	
Me to Vertical	73.950	76.940		2.990
Me to Horizontal	102.550	102.690		0.140
ΔX for Me	0.000	2.990	2.990	
ΔY for Me	0.000	0.140	0.140	
Ar-Gn (mm)	116.720	118.320		1.600
ΔAr-Gn (mm)	0.000	1.600	1.600	
Ar-Go (mm)	52.150	52.850		0.700
ΔAr-Go (mm)	0.000	0.700	0.700	
Go-Gn (mm)	76.460	78.100		1.640
ΔGo-Gn (mm)	0.000	0.000	0.000	
SN-MP	29.900	29.500	29.700	-0.400
Wits	-11.100	-12.240	-11.670	-1.140
ANB	-3.000	-3.500	-6.500	-0.500
			AVG	
Occlusal Plane	98.000	96.000	97.000	

Subject B0497 Raw Data

B497	Age 12.500	13.500	SUM	Change per year
A-pt to Vertical	66.640	67.160		0.520
A-pt to Horizonta	43.290	44.470		1.180
ΔX for A-pt	0.000	0.520	0.520	
ΔY for A-pt	0.000	1.180	1.180	
B-pt to Vertical	66.380	67.340		0.960
B-pt to Horizonta	82.460	85.320		2.860
ΔX for B-pt	0.000	0.960	0.960	
ΔY for B-pt	0.000	2.860	2.860	
Pog to Vertical	68.150	69.220		1.070
Pog to Horizontal	90.450	93.110		2.660
ΔX for Pog	0.000	1.070	1.070	
ΔY for Pog	0.000	2.660	2.660	
Me to Vertical	60.850	62.130		1.280
Me to Horizontal	99.460	102.280		2.820
ΔX for Me	0.000	1.280	1.280	
ΔY for Me	0.000	2.820	2.820	
Ar-Gn (mm)	106.670	109.080		2.410
ΔAr-Gn (mm)	0.000	2.410	2.410	
Ar-Go (mm)	41.570	42.180		0.610
ΔAr-Go (mm)	0.000	0.610	0.610	
Go-Gn (mm)	76.210	79.250		3.040
ΔGo-Gn (mm)	0.000	0.000	0.000	
SN-MP	32.100	32.000	32.050	-0.100
Wits	-5.970	-6.670	-6.320	-0.700
ANB	0.600	0.000	0.600	-0.600
			AVG	
Occlusal Plane	100.000	98.000	99.000	

Subject B1306 Raw Data

B1306	Age					
	12.083	13.667	14.250	15.250	SUM	Change per year
A-pt to Vertical	58.200	59.200	59.640	59.410		0.422
A-pt to Horizonta	50.620	52.150	52.160	52.130		0.497
ΔX for A-pt	0.000	1.000	0.440	-0.230	1.210	
ΔY for A-pt	0.000	1.530	0.010	-0.030	1.510	
B-pt to Vertical	49.530	50.690	51.220	51.710		0.703
B-pt to Horizonta	89.070	92.820	94.530	94.990		1.964
ΔX for B-pt	0.000	1.160	0.530	0.490	2.180	
ΔY for B-pt	0.000	3.750	1.710	0.460	5.920	
Pog to Vertical	48.400	49.590	50.410	50.820		0.794
Pog to Horizontal	99.390	103.150	104.550	105.000		1.855
ΔX for Pog	0.000	1.190	0.820	0.410	2.420	
ΔY for Pog	0.000	3.760	1.400	0.450	5.610	
Me to Vertical	42.470	43.950	44.600	45.030		0.834
Me to Horizontal	103.360	106.950	108.600	108.940		1.858
ΔX for Me	0.000	1.480	0.650	0.430	2.560	
ΔY for Me	0.000	3.590	1.650	0.340	5.580	
Ar-Gn (mm)	101.240	105.680	107.200	108.280		2.292
ΔAr-Gn (mm)	0.000	4.440	1.520	1.080	7.040	
Ar-Go (mm)	38.960	41.220	42.770	43.630		1.528
ΔAr-Go (mm)	0.000	2.260	1.550	0.860	4.670	
Go-Gn (mm)	68.590	71.410	72.000	71.990		1.133
ΔGo-Gn (mm)	0.000	2.820	0.590	-0.010	3.400	
SN-MP	48.000	47.900	47.900	47.100		-0.251
Wits	-5.280	-6.170	-6.640	-7.260		-0.628
ANB	0.300	0.000	-0.100	-0.800		-0.325
					AVG	
Occlusal Plane	109.000	110.000	111.000	110.000	110.000	

Subject B3254 Raw Data

B3254	Age					
	12.083	12.917	15.083	16.250	SUM	Change per year
A-pt to Vertical	59.010	60.700	61.540	61.750		0.588
A-pt to Horizonta	48.600	50.630	50.720	51.490		0.544
ΔX for A-pt	0.000	1.690	0.840	0.210	2.740	
ΔY for A-pt	0.000	2.030	0.090	0.770	2.890	
B-pt to Vertical	56.920	58.800	61.540	63.350		1.480
B-pt to Horizonta	86.450	88.890	91.040	91.730		1.193
ΔX for B-pt	0.000	1.880	2.740	1.810	6.430	
ΔY for B-pt	0.000	2.440	2.150	0.690	5.280	
Pog to Vertical	58.200	60.670	64.210	66.740		1.957
Pog to Horizontal	104.250	106.790	109.170	109.620		1.229
ΔX for Pog	0.000	2.470	3.540	2.530	8.540	
ΔY for Pog	0.000	2.540	2.380	0.450	5.370	
Me to Vertical	52.930	55.600	59.260	62.240		2.115
Me to Horizontal	107.870	110.420	112.830	113.890		1.359
ΔX for Me	0.000	2.670	3.660	2.980	9.310	
ΔY for Me	0.000	2.550	2.410	1.060	6.020	
Ar-Gn (mm)	103.460	106.920	111.300	113.870		2.384
ΔAr-Gn (mm)	0.000	3.460	4.380	2.570	10.410	
Ar-Go (mm)	39.660	42.030	44.880	46.630		1.588
ΔAr-Go (mm)	0.000	2.370	2.850	1.750	6.970	
Go-Gn (mm)	75.060	78.020	80.450	80.940		1.328
ΔGo-Gn (mm)	0.000	2.960	2.430	0.490	5.880	
SN-MP	38.000	37.000	34.600	33.100		-1.162
Wits	-5.770	-6.120	-8.220	-9.570		-0.929
ANB	-1.900	-1.400	-2.800	-3.400		-0.428
					AVG	
Occlusal Plane	104.000	104.000	100.000	99.000	101.750	

Subject B4304 Raw Data

B4304	Age			
	12.583	13.833	SUM	Change per year
A-pt to Vertical	68.680	69.400		0.576
A-pt to Horizonta	52.970	53.570		0.480
ΔX for A-pt	0.000	0.720	0.720	
ΔY for A-pt	0.000	0.600	0.600	
B-pt to Vertical	69.230	70.960		1.384
B-pt to Horizonta	94.450	95.900		1.160
ΔX for B-pt	0.000	1.730	1.730	
ΔY for B-pt	0.000	1.450	1.450	
Pog to Vertical	72.280	74.050		1.416
Pog to Horizontal	104.970	106.350		1.104
ΔX for Pog	0.000	1.770	1.770	
ΔY for Pog	0.000	1.380	1.380	
Me to Vertical	67.460	69.510		1.640
Me to Horizontal	112.720	114.350		1.304
ΔX for Me	0.000	2.050	2.050	
ΔY for Me	0.000	1.630	1.630	
Ar-Gn (mm)	111.240	113.300		1.648
ΔAr-Gn (mm)	0.000	2.060	2.060	
Ar-Go (mm)	41.970	42.560		0.472
ΔAr-Go (mm)	0.000	0.590	0.590	
Go-Gn (mm)	80.930	82.880		1.560
ΔGo-Gn (mm)	0.000	1.950	1.950	
SN-MP	32.900	32.000		-0.720
Wits	-5.930	-7.730		-1.440
ANB	0.000	-0.300		-0.240
			AVG	
Occlusal Plane	97.500	97.800	97.650	

Subject B0047 Raw Data

B0047	Age 13.417	14.500	SUM	Change per year
A-pt to Vertical	62.310	63.460		1.062
A-pt to Horizontal	53.970	55.790		1.681
ΔX for A-pt	0.000	1.150	1.150	
ΔY for A-pt	0.000	1.820	1.150	
B-pt to Vertical	59.460	61.390		1.782
B-pt to Horizontal	94.800	100.190		4.977
ΔX for B-pt	0.000	1.930	1.930	
ΔY for B-pt	0.000	5.390	1.930	
Pog to Vertical	58.430	60.720		2.114
Pog to Horizontal	111.910	117.560		5.217
ΔX for Pog	0.000	2.290	2.290	
ΔY for Pog	0.000	5.650	2.290	
Me to Vertical	49.900	52.670		2.558
Me to Horizontal	118.320	124.400		5.614
ΔX for Me	0.000	2.770	2.770	
ΔY for Me	0.000	6.080	6.080	
Ar-Gn (mm)	115.370	120.570		4.801
ΔAr-Gn (mm)	0.000	5.200	5.200	
Ar-Go (mm)	43.720	50.540		6.297
ΔAr-Go (mm)	0.000	6.820	6.820	
Go-Gn (mm)	81.230	80.350		-0.813
ΔGo-Gn (mm)	0.000	-0.880	-0.880	
SN-MP	42.800	42.800		0.000
Wits	-7.340	-9.290		-1.801
ANB	-0.300	-1.000		-0.646
			AVG	
Occlusal Plane	105.000	103.000	104.000	

Subject B0062 Raw Data

B0062	Age 14.833	15.917	SUM	Change per year
A-pt to Vertical	68.440	69.590		1.061
A-pt to Horizontal	53.450	53.480		0.028
ΔX for A-pt	0.000	1.150	1.150	
ΔY for A-pt	0.000	0.030	1.150	
B-pt to Vertical	63.680	65.160		1.365
B-pt to Horizontal	91.600	91.850		0.231
ΔX for B-pt	0.000	1.480	1.480	
ΔY for B-pt	0.000	0.250	1.480	
Pog to Vertical	64.470	66.500		1.873
Pog to Horizontal	108.770	108.910		0.129
ΔX for Pog	0.000	2.030	2.030	
ΔY for Pog	0.000	0.140	2.030	
Me to Vertical	57.280	59.750		2.279
Me to Horizontal	114.910	115.190		0.258
ΔX for Me	0.000	2.470	2.470	
ΔY for Me	0.000	0.280	0.280	
Ar-Gn (mm)	113.300	115.190		1.744
ΔAr-Gn (mm)	0.000	1.890	1.890	
Ar-Go (mm)	48.270	48.480		0.194
ΔAr-Go (mm)	0.000	0.210	0.210	
Go-Gn (mm)	81.790	83.520		1.596
ΔGo-Gn (mm)	0.000	1.730	1.730	
SN-MP	33.600	32.100		-1.384
Wits	4.160	4.120		-0.037
ANB	1.300	1.000		-0.277
			AVG	
Occlusal Plane	102.000	102.000	102.000	

Subject B0403 Raw Data

B403	Age 16.167	17.083	SUM	Change per year
A-pt to Vertical	65.900	66.340		0.480
A-pt to Horizontal	50.980	51.120		0.153
ΔX for A-pt	0.000	0.440	0.440	
ΔY for A-pt	0.000	0.140	0.440	
B-pt to Vertical	66.900	69.170		2.478
B-pt to Horizontal	90.580	90.670		0.098
ΔX for B-pt	0.000	2.270	2.270	
ΔY for B-pt	0.000	0.090	2.270	
Pog to Vertical	69.440	71.650		2.413
Pog to Horizontal	102.930	103.000		0.076
ΔX for Pog	0.000	2.210	2.210	
ΔY for Pog	0.000	0.070	2.210	
Me to Vertical	64.760	67.380		2.860
Me to Horizontal	112.110	112.230		0.131
ΔX for Me	0.000	2.620	2.620	
ΔY for Me	0.000	0.120	0.120	
Ar-Gn (mm)	114.660	115.000		0.371
ΔAr-Gn (mm)	0.000	0.340	0.340	
Ar-Go (mm)	47.780	48.340		0.611
ΔAr-Go (mm)	0.000	0.560	0.560	
Go-Gn (mm)	82.740	82.800		0.066
ΔGo-Gn (mm)	0.000	0.060	0.060	
SN-MP	28.800	27.100		-1.856
Wits	-5.410	-7.090		-1.834
ANB	-1.200	-2.000		-0.873
			AVG	
Occlusal Plane	96.000	96.000	96.000	

Subject B0522 Raw Data

B522	Age 13.167	14.167	16.167	17.167	SUM	Change per year
A-pt to Vertical	61.550	61.990	63.440	63.660		0.567
A-pt to Horizontal	48.340	48.730	50.010	50.440		0.548
ΔX for A-pt	0.000	0.440	1.450	0.220	2.110	
ΔY for A-pt	0.000	0.390	1.280	0.430	2.110	
B-pt to Vertical	57.070	59.060	61.320	61.730		1.158
B-pt to Horizontal	81.040	81.840	87.340	88.530		2.048
ΔX for B-pt	0.000	1.990	2.260	0.410	4.660	
ΔY for B-pt	0.000	0.800	5.500	1.190	4.660	
Pog to Vertical	57.090	58.990	62.010	63.230		1.530
Pog to Horizontal	95.310	96.370	101.610	102.800		2.022
ΔX for Pog	0.000	1.900	3.020	1.220	6.140	
ΔY for Pog	0.000	1.060	5.240	1.190	6.140	
Me to Vertical	50.330	52.580	55.730	57.120		1.673
Me to Horizontal	100.890	102.200	107.800	109.100		2.202
ΔX for Me	0.000	2.250	3.150	1.390	6.790	
ΔY for Me	0.000	1.310	5.600	1.300	8.210	
Ar-Gn (mm)	107.480	109.680	116.170	117.860		2.725
ΔAr-Gn (mm)	0.000	2.200	6.490	1.690	10.380	
Ar-Go (mm)	43.440	45.500	49.320	50.700		1.834
ΔAr-Go (mm)	0.000	2.060	3.820	1.380	7.260	
Go-Gn (mm)	74.820	75.730	79.910	80.340		1.522
ΔGo-Gn (mm)	0.000	0.910	4.180	0.430	5.520	
SN-MP	36.200	34.900	33.800	33.200		-0.710
Wits	-3.450	-4.620	-6.420	-6.550		-0.800
ANB	-0.100	-0.500	-1.200	-1.500		-0.350
					AVG	
Occlusal Plane	106.000	104.000	101.000	101.000	103.000	

Subject B0523 Raw Data

B523	Age 13.917	14.917	SUM	Change per year
A-pt to Vertical	66.210	67.310		1.100
A-pt to Horizontal	50.290	50.900		0.610
ΔX for A-pt	0.000	1.100	1.100	
ΔY for A-pt	0.000	0.610	1.100	
B-pt to Vertical	65.560	67.610		2.050
B-pt to Horizontal	88.990	90.710		1.720
ΔX for B-pt	0.000	2.050	2.050	
ΔY for B-pt	0.000	1.720	2.050	
Pog to Vertical	69.040	71.770		2.730
Pog to Horizontal	108.430	110.260		1.830
ΔX for Pog	0.000	2.730	2.730	
ΔY for Pog	0.000	1.830	2.730	
Me to Vertical	59.670	62.490		2.820
Me to Horizontal	115.950	117.880		1.930
ΔX for Me	0.000	2.820	2.820	
ΔY for Me	0.000	1.930	1.930	
Ar-Gn (mm)	112.430	115.800		3.370
ΔAr-Gn (mm)	0.000	3.370	3.370	
Ar-Go (mm)	49.340	50.430		1.090
ΔAr-Go (mm)	0.000	1.090	1.090	
Go-Gn (mm)	75.210	77.690		2.480
ΔGo-Gn (mm)	0.000	2.480	2.480	
SN-MP	38.100	37.200		-0.900
Wits	-6.510	-8.000		-1.490
ANB	-0.800	-1.800		-1.000
			AVG	
Occlusal Plane	101.000	101.000	101.000	

Subject B0625 Raw Data

B625	Age 12.750	13.750	SUM	Change per year
A-pt to Vertical	70.440	70.480		0.040
A-pt to Horizontal	47.980	48.800		0.820
ΔX for A-pt	0.000	0.040	0.040	
ΔY for A-pt	0.000	0.820	0.040	
B-pt to Vertical	68.540	68.750		0.210
B-pt to Horizontal	86.400	88.900		2.500
ΔX for B-pt	0.000	0.210	0.210	
ΔY for B-pt	0.000	2.500	0.210	
Pog to Vertical	68.540	68.700		0.160
Pog to Horizontal	102.830	105.210		2.380
ΔX for Pog	0.000	0.160	0.160	
ΔY for Pog	0.000	2.380	0.160	
Me to Vertical	62.050	62.490		0.440
Me to Horizontal	108.940	111.230		2.290
ΔX for Me	0.000	0.440	0.440	
ΔY for Me	0.000	2.290	2.290	
Ar-Gn (mm)	110.540	112.520		1.980
ΔAr-Gn (mm)	0.000	1.980	1.980	
Ar-Go (mm)	44.200	44.250		0.050
ΔAr-Go (mm)	0.000	0.050	0.050	
Go-Gn (mm)	77.510	78.900		1.390
ΔGo-Gn (mm)	0.000	1.390	1.390	
SN-MP	34.300	33.400		-0.900
Wits	-6.770	-7.920		-1.150
ANB	0.000	-0.300		-0.300
			AVG	
Occlusal Plane	103.000	103.000	103.000	

Subject B0728 Raw Data

B728	Age			
	12.750	13.667	SUM	Change per year
A-pt to Vertical	65.330	66.010		0.742
A-pt to Horizontal	51.950	53.980		2.214
ΔX for A-pt	0.000	0.680	0.680	
ΔY for A-pt	0.000	2.030	0.680	
B-pt to Vertical	62.620	63.070		0.491
B-pt to Horizontal	92.890	96.110		3.511
ΔX for B-pt	0.000	0.450	0.450	
ΔY for B-pt	0.000	3.220	0.450	
Pog to Vertical	62.010	62.430		0.458
Pog to Horizontal	103.710	106.830		3.402
ΔX for Pog	0.000	0.420	0.420	
ΔY for Pog	0.000	3.120	0.420	
Me to Vertical	54.820	55.400		0.632
Me to Horizontal	109.510	112.530		3.293
ΔX for Me	0.000	0.580	0.580	
ΔY for Me	0.000	3.020	3.020	
Ar-Gn (mm)	109.260	111.710		2.672
ΔAr-Gn (mm)	0.000	2.450	2.450	
Ar-Go (mm)	40.860	41.880		1.112
ΔAr-Go (mm)	0.000	1.020	1.020	
Go-Gn (mm)	77.360	79.280		2.094
ΔGo-Gn (mm)	0.000	1.920	1.920	
SN-MP	39.000	38.900		-0.109
Wits	-6.140	-6.340		-0.218
ANB	-0.800	-1.000		-0.218
			AVG	
Occlusal Plane	102.000	102.500	102.250	

Subject B1380 Raw Data

B1380	Age						
	7.917	8.917	10.000	11.000	12.000	SUM	Change per year
A-pt to Vertical	62.900	62.950	64.430	65.380	66.300		0.902
A-pt to Horizontal	46.480	47.350	49.010	49.000	51.260		1.094
ΔX for A-pt	0.000	0.050	1.480	0.950	0.920	3.400	
ΔY for A-pt	0.000	0.870	1.660	-0.010	2.260	3.400	
B-pt to Vertical	60.950	63.160	63.620	63.010	65.280		0.828
B-pt to Horizontal	80.830	81.760	85.950	87.190	88.630		2.058
ΔX for B-pt	0.000	2.210	0.460	-0.610	2.270	4.330	
ΔY for B-pt	0.000	0.930	4.190	1.240	1.440	4.330	
Pog to Vertical	58.630	61.220	61.320	61.000	63.360		0.898
Pog to Horizontal	92.880	93.870	98.350	99.570	101.180		2.183
ΔX for Pog	0.000	2.590	0.100	-0.320	2.360	4.730	
ΔY for Pog	0.000	0.990	4.480	1.220	1.610	4.730	
Me to Vertical	51.410	54.520	54.530	54.640	56.540		1.010
Me to Horizontal	96.520	97.790	102.150	103.610	105.190		2.266
ΔX for Me	0.000	3.110	0.010	0.110	1.900	5.130	
ΔY for Me	0.000	1.270	4.360	1.460	1.580	8.670	
Ar-Gn (mm)	97.200	100.130	103.430	104.310	106.730		2.270
ΔAr-Gn (mm)	0.000	2.930	3.300	0.880	2.420	9.530	
Ar-Go (mm)	39.770	41.780	42.500	43.070	45.190		1.181
ΔAr-Go (mm)	0.000	2.010	0.720	0.570	2.120	5.420	
Go-Gn (mm)	65.440	66.720	69.240	69.720	70.600		1.304
ΔGo-Gn (mm)	0.000	1.280	2.520	0.480	0.880	5.160	
SN-MP	34.500	33.500	35.000	34.900	33.500		-0.053
Wits	-6.140	-8.210	-6.810	-7.460	-7.360		-0.161
ANB	2.200	1.000	2.000	2.900	2.500		0.246
						AVG	
Occlusal Plane	105.000	101.000	103.000	105.000	102.000	103.200	

Subject B1483 Raw Data

B1483	Age						
	6.333	8.000	9.000	11.000	12.000	SUM	Change per year
A-pt to Vertical	60.630	61.690	63.220	64.300	65.060		0.792
A-pt to Horizontal	42.240	45.560	46.630	49.000	50.830		1.437
ΔX for A-pt	0.000	1.060	1.530	1.080	0.760	4.430	
ΔY for A-pt	0.000	3.320	1.070	2.370	1.830	4.430	
B-pt to Vertical	54.700	54.200	57.260	57.340	58.230		0.683
B-pt to Horizontal	80.050	82.010	83.510	88.090	90.270		1.853
ΔX for B-pt	0.000	-0.500	3.060	0.080	0.890	3.530	
ΔY for B-pt	0.000	1.960	1.500	4.580	2.180	3.530	
Pog to Vertical	49.940	51.690	55.490	55.710	56.490		1.166
Pog to Horizontal	96.490	99.230	100.860	105.320	107.710		1.992
ΔX for Pog	0.000	1.750	3.800	0.220	0.780	6.550	
ΔY for Pog	0.000	2.740	1.630	4.460	2.390	6.550	
Me to Vertical	43.280	44.080	47.880	48.210	48.840		1.036
Me to Horizontal	99.750	102.640	105.280	110.090	112.690		2.320
ΔX for Me	0.000	0.800	3.800	0.330	0.630	5.560	
ΔY for Me	0.000	2.890	2.640	4.810	2.600	12.940	
Ar-Gn (mm)	93.350	96.560	101.320	105.030	107.640		2.559
ΔAr-Gn (mm)	0.000	3.210	4.760	3.710	2.610	14.290	
Ar-Go (mm)	36.460	36.820	37.860	39.220	40.630		0.740
ΔAr-Go (mm)	0.000	0.360	1.040	1.360	1.410	4.170	
Go-Gn (mm)	64.030	68.550	72.060	75.740	76.350		2.221
ΔGo-Gn (mm)	0.000	4.520	3.510	3.680	0.610	12.320	
SN-MP	44.100	43.100	42.800	43.000	43.900		-0.040
Wits	-6.480	-4.970	-6.570	-5.930	-6.530		-0.052
ANB	1.200	2.800	2.400	2.700	2.400		0.170
						AVG	
Occlusal Plane	109.000	109.000	112.000	109.000	108.000	109.400	

Subject B2419 Raw Data

B2419	Age 5.917	6.917	7.917	8.917	9.917	11.000	12.000	13.000	14.000	SUM	Change per year
A-pt to Vertical	54.480	54.610	52.230	52.030	52.270	52.800	52.810	52.830	53.070		-0.700
A-pt to Horizontal	45.510	45.530	46.990	46.940	47.880	49.790	49.860	50.460	51.450		0.615
AX for A-pt	0.000	0.130	-2.380	-0.200	0.240	0.530	0.010	0.020	0.260	-1.390	
AY for A-pt	0.000	0.020	1.460	-0.050	0.940	1.910	0.070	0.600	1.590	-1.390	
B-pt to Vertical	48.070	49.060	49.650	51.690	53.440	53.320	55.720	56.820	60.270		1.337
B-pt to Horizontal	79.910	82.310	85.860	87.440	89.710	93.450	95.040	99.690	102.790		2.453
AX for B-pt	0.000	0.990	0.590	2.040	1.750	-0.120	2.400	1.100	4.550	13.300	
AY for B-pt	0.000	2.600	3.350	1.580	2.270	3.740	1.590	4.650	7.750	13.300	
Peg to Vertical	45.990	48.120	50.280	52.540	54.700	56.850	57.470	59.710	63.690		2.184
Peg to Horizontal	90.480	93.300	96.480	98.210	100.540	104.370	106.260	110.530	113.680		2.503
AX for Peg	0.000	2.130	2.160	2.260	2.160	0.150	2.620	2.240	6.220	19.940	
AY for Peg	0.000	2.820	3.180	1.730	2.330	3.830	1.890	4.270	7.420	19.940	
Me to Vertical	41.730	43.080	45.910	48.180	50.140	50.500	53.180	55.700	60.130		2.192
Me to Horizontal	94.480	97.180	100.860	102.830	104.940	108.950	110.810	115.620	118.660		2.657
AX for Me	0.000	1.350	2.830	2.270	1.960	0.360	2.680	2.520	6.950	20.920	
AY for Me	0.000	2.700	3.680	1.970	2.110	4.010	1.860	4.810	7.850	28.990	
Ar-Gn (mm)	90.780	94.000	97.650	100.320	104.110	106.800	110.060	115.490	119.120		3.298
ΔAr-Gn (mm)	0.000	3.220	3.650	2.670	3.790	2.690	3.260	5.430	9.060	33.770	
Ar-Go (mm)	33.970	34.830	36.490	38.210	40.500	41.140	43.190	46.360	48 480		1.644
ΔAr-Go (mm)	0.000	0.860	1.660	1.720	2.290	0.640	2.050	3.170	5.290	17.680	
Go-Gn (mm)	65.040	68.200	69.680	71.320	72.180	74.710	76.710	78.740	81.260		1.740
ΔGo-Gn (mm)	0.000	3.160	1.480	1.640	0.860	2.530	2.000	2.030	4.550	18.250	
SN-MP	43.000	43.500	42.900	41.900	42.100	43.900	41.900	42.100	40.900		-0.340
Wits	-4.180	-5.650	-8.490	-11.880	-13.640	-13.630	-16.110	-17.640	-21.900		-2.515
ANB	-0.800	-1.500	-4.100	-6.100	-7.000	-6.800	-8.000	-8.900	-11.900		-1.700
Occlusal Plane	110.000	110.000	106.000	109.000	106.000	105.000	105.000	105.000	106.000	AVG 106.889	

Subject B3341 Raw Data

B3341	Age								
	12.000	12.917	14.000	15.000	16.000	17.083	18.500	SUM	Change per year
A-pt to Vertical	74.560	75.770	76.770	76.280	76.950	77.820	77.820		0.522
A-pt to Horizontal	49.820	51.080	54.720	56.900	57.100	57.430	57.480		2.027
ΔX for A-pt	0.000	1.210	1.000	-0.490	0.670	0.870	0.000	3.260	
ΔY for A-pt	0.000	1.260	3.640	2.180	0.200	0.330	0.050	3.260	
B-pt to Vertical	72.970	73.170	73.090	74.110	74.700	75.460	75.590		0.436
B-pt to Horizontal	89.330	91.230	97.090	102.060	103.300	105.160	106.040		3.855
ΔX for B-pt	0.000	0.200	-0.080	1.020	0.590	0.760	0.130	2.620	
ΔY for B-pt	0.000	1.900	5.860	4.970	1.240	1.860	0.880	2.620	
Pog to Vertical	72.270	72.320	72.160	73.560	75.370	76.220	76.520		0.738
Pog to Horizontal	110.400	112.270	118.180	123.170	124.210	126.070	126.790		3.831
ΔX for Pog	0.000	0.050	-0.160	1.400	1.810	0.850	0.300	4.250	
ΔY for Pog	0.000	1.870	5.910	4.990	1.040	1.860	0.720	4.250	
Me to Vertical	66.400	66.720	67.130	68.550	70.120	70.700	71.140		0.920
Me to Horizontal	114.150	115.980	122.310	127.370	128.690	130.480	131.550		4.025
ΔX for Me	0.000	0.320	0.410	1.420	1.570	0.580	0.440	4.740	
ΔY for Me	0.000	1.830	6.330	5.060	1.320	1.790	1.070	17.400	
Ar-Gn (mm)	114.160	115.930	120.770	125.890	127.650	129.230	129.540		3.672
ΔAr-Gn (mm)	0.000	1.770	4.840	5.120	1.760	1.580	0.310	15.380	
Ar-Go (mm)	44.820	46.100	46.890	50.410	51.100	51.980	52.920		1.673
ΔAr-Go (mm)	0.000	1.280	0.790	3.520	0.690	0.880	0.940	8.100	
Go-Gn (mm)	81.890	82.640	87.020	89.840	90.930	92.420	92.320		2.517
ΔGo-Gn (mm)	0.000	0.750	4.380	2.820	1.090	1.490	-0.100	10.430	
SN-MP	35.700	35.000	36.000	36.100	36.100	36.000	35.900		0.193
Wits	-4.260	-3.480	-2.430	-4.580	-4.020	-4.230	-4.060		-0.063
ANB	2.500	3.500	4.000	3.000	3.000	3.000	3.000		0.047
								AVG	
Occlusal Plane	100.000	99.000	98.000	99.000	98.000	98.000	98.000	98.571	

Subject B3377 Raw Data

B3377	Age									
	10.000	11.000	12.000	13.000	14.000	15.000	16.000	17.000	SUM	Change per year
A-pt to Vertical	65.290	67.510	68.040	69.430	71.380	71.880	72.930	73.340		1.410
A-pt to Horizontal	51 630	51.760	52.280	54.260	55.850	58.770	58.660	58.670		1.094
ΔX for A-pt	0.000	2.220	0.530	1.390	1.950	0.500	1.050	0.410	8.050	
ΔY for A-pt	0.000	0.130	0 520	1.980	1.590	2.920	-0.110	0.010	8.050	
B-pt to Vertical	61.210	64.870	65.470	66.780	70.230	70.980	72.930	74.020		1 995
B-pt to Horizontal	95.010	96.440	98.790	103.070	108.080	112.380	113.510	114.590		3.277
ΔX for B-pt	0.000	3.660	0.600	1.310	3.450	0.750	1.950	1.090	12.810	
ΔY for B-pt	0.000	1.430	2.350	4.280	5.010	4.300	1.130	1.080	12.810	
Pog to Vertical	63.000	67.530	68.050	69.420	73.220	73.830	76.170	78.090		2.233
Pog to Horizontal	108.700	109.940	112.360	116.760	121.800	126.100	127.330	128.120		3.302
ΔX for Pog	0.000	4.530	0 520	1.370	3.800	0 610	2.340	1.920	15.090	
ΔY for Pog	0 000	1.240	2.420	4.400	5.040	4.300	1.230	0.790	15.090	
Me to Vertical	55 260	60.020	60.960	62 980	66.680	67.530	69 580	71.850		2.580
Me to Horizontal	115.650	117.240	119.510	123.760	129.210	133.810	135 050	136.010		3 364
ΔX for Me	0.000	4.760	0.940	2.020	3.700	0.850	2.050	2.270	16.590	
ΔY for Me	0.000	1.590	2.270	4.250	5.450	4.600	1.240	0.960	20.360	
Ar-Gn (mm)	114.740	117.090	118.900	122 280	129.000	132.740	135.570	137.830		3.371
ΔAr-Gn (mm)	0.000	2.350	1.810	3.380	6.720	3 740	2.830	2.260	23.090	
Ar-Go (mm)	46.300	46.330	47.750	48.680	52 730	53.870	54.860	55.870		1.521
ΔAr-Go (mm)	0.000	0.030	1.420	0 930	4.050	1.140	0.990	1.010	9.570	
Go-Gn (mm)	78.210	80.840	81.960	84.500	88.630	91.550	93.480	94.800		2.450
AGo-Gn (mm)	0.000	2.630	1.120	2.540	4.130	2.920	1.930	1.320	16.590	
SN-MP	40.000	38.500	38.800	38.800	37.100	37.100	36.000	36.000		-0.590
Wits	-4.170	-4.800	-6.580	-6.980	-7.230	-7.380	-9.100	-11.000		-0.830
ANB	0.000	-0.100	-0.100	-0 400	-0.900	-1.000	-1 100	-1.500		-0.210
									AVG	
Occlusal Plane	101.000	100 000	101.000	101.000	99.000	99.000	99.000	98.000	99.750	

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