AN INVESTIGATION INTO PONT'S INDEX

AND ARCHWIDTH CHANGES

Ken Marshall, B.D.S., M.D.Sc.

This paper submitted in partial fulfillment of the
requirements for a Certificate in Orthodontics
Oregon Health Sciences University.

June 1987

ACKNOWLEDGEMENTS

This research project is the result of guidance, inspiration and expertise provided by numerous individuals ... all of which has been provided with grace, generosity and candor. The following individuals have been paramount in the attainment of my U.S. orthodontic education and the materialization of this research project:

Douglas L. Buck D.D.S., M.S.D., Professor and Chairperson, Orthodontic Department;

Larry M. Doyle, D.D.S., Assistant Professor, Orthodontic Department;

Bhim S. Savara, D.M.D., M.S., Professor and Chairperson, Child Study Clinic;

Lauren Barratt, Administrative Asistant, Orthodontic Department;

Valerie Fishler, Computer Graphics, Audio-visual Department;

In addition, I owe words of gratitude to my fellow classmates Dave Birdwell, Jon Crew and Rod Nordberg whose talents, intellect and friendship have instilled in me enduring and amiable memories.

Finally, but not least, my warmest thoughts are for my family. To my wonderful wife and best friend, Robyn, whose energy, strength and indefatigable effervescence shine like a beacon in the darkness. To my two sons, Scott and Todd, who give meaning to my endeavours. The vacuum created by their temporary absence has made the price of my education far greater than anticipated.

TABLE OF CONTENTS

	Page
Introduction	4
Literature Review	6
Materials and Methods	23
Findings	31
Discussion	35
Summary and Conclusions	40
Bibliography	42
Figures	1-19
Tables	1-6
Appendices	A & B

AN INVESTIGATION INTO PONT'S INDEX

INTRODUCTION

Pont[1] introduced the concept of his tooth size/arch width indice in 1909, with the publication of his article in a German dental journal. Perhaps, this could be the only fact concerning Pont's Index about which there exists complete unanimity. From that time forth the validity, modification, misuse and abuse of this predictive index for arch width determination has been surrounded by controversy. This wrangling remains to this day, enhanced by the polarization between general dentists and orthodontists, (Editorial, 1984)[2], usually advocating non-extraction and extraction orientated treatment philosophies respectively.

To appreciate the present-day status of Pont's Index is to understand the complexities and subtleties of orthodontic history. Of particular importance is the Great Extraction Vs. Non-Extraction debate, the pendulum of which has swung to and fro since the turn of the century.

The rejection or integration of Pont's Index into orthodontic diagnosis is, to a large degree, dependent upon one's orthodontic educational heritage. The specialist orthodontic fraternity has shunned the concept as scientifically bogus:

> "Measurement of mesiodistal widths of incisors to predetermine maxillary interpremolar widths is of no value in the prediction of ultimate arch width in those regions" Joondeph, et. al. 1972.[3]

On the other hand, the generalist orthodontic community has embraced the alluring simplicity of Pont's Index with enthusiasm:

> "...this index offers a very simple method which may easily be applied in appraising arch form." White & Clark, 1976[4]

> "The size of the upper four incisors has a direct relationship to the inter-arch width of premolars and molars. Pont's valuable research and his Index are used as a guide in predetermining this arch width." Wiebrecht, 1975[5]

Still others view it's usefulness with cautious acceptance:

> "Arch predetermination ...is a useful aid in orthodontic diagnosis, provided one is willing to accept it as just that." Dewey, 1948[6]

The present reliance of the generalist orthodontic community on arch width determination indices to justify arch expansion to relieve dental crowding, may be gleaned from a recent "Casesolvers Award" (Rivard, 1986).[19] A general dentist presented diagnosis and treatment plans for three malocclusions. All three cases were deemed to be maxillary deficient in the transverse dimension by at least 5mm. A phase I treatment of "arch development" was recommended in two of the cases using an upper Schwartz appliance. No bilateral or unilateral posterior crossbites were present in any of the malocclusions presented. It was assumed by the reviewer that the lower arch was subsequently expanded during treatment to gain coordinated arches.

Other areas that have had an influence on the acceptance and credibility of Pont's Index are the following:

(1) The Crozat appliance and philosophy.
(2) The concept of Ideal Arch Form and the inviolate nature of the Mandibular Intercuspid Dimension.
(3) Studies specifically designed to prove, or disprove the validity of the predictive value of Pont's Index.

The literature in these areas will be discussed in an attempt to clarify the continued popularization of Pont's Index amongst generalist orthodontic groups and the rejection of the concept by specialist orthodontists in the U.S.

LITERATURE REVIEW

Hopefully, this literature review will elucidate the uncertain passage of Pont's Index through the turbulent seas of orthodontic history.

Orthodontic philosophies over the years have oscillated between a strict non-extraction approach (Angle ,1907[7]; Lamons ,1964[8]) and an approach that requires the extraction of teeth in a majority of cases (Tweed, 1944[9], 1963[10]; Begg & Kesling, 1977[11]). A major part of the treatment rendered in any orthodontic practice is concerned with lack of space - the transverse and sagittal crowding of teeth within the alveolus.

One school of thought considers that jaw size is assumed to be genetically predetermined and therefore immutable. Consequently, extraction of selected teeth is necessary in order to provide adequate space in the dental arch to align the remaining teeth (Hixon, 1971).[12]

The opposing school of thought, of which Angle (1907) [7]and Crozat (1920)[13] were staunch supporters, assumes that jaw size is not immutable and that malocclusion, especially dental crowding, results from a failure of the jaws to develop fully and to accomodate teeth. It was felt that since jaw size is to some extent environmentally determined and not under strict genetic control, early orthodontic intervention can be directed toward full development of the boney support of the dental arch and the accommodation of the entire dentition. Inherent in this viewpoint is the belief that dental arches can be "developed" or expanded to varying degrees with resultant post retention stability (Truitt, 1986).[20]

Bastion, (1983)[14] further expounds on this concept:

"...we must know where we are going according to the patient's genetic potential. A tool that is used to guide us in this direction is called Pont's Index...(this) index will give us a basic understanding of what proper arch width should be; that is, the patient's genetic potential for arch width." (my emphasis).

How do we define and measure the genetic potential for arch width dimensions?

It would appear reasonable to evaluate the "genetic potential for arch width" of a population group by examining untreated, ideal class I occlusions. The computation of a statistical mean for male and female arch widths from this sample group ∓ 2 standard deviations could be defined as the arch width genetic potential for that ethnic group. Garn(1958)[15] states that ∓2 standard deviations may be employed as the limits of clinical normality or in this case the genetic potential for arch width of a population group. However, Buck[16] highlights the dilemma of using the concept of "ideal" occlusion - only 5% of the population are ideal, 20% approximately normal, and 75% have malocclusion. Garn's (1958)[15] definition of clinical normality is the mean ∓2 standard deviations - i.e. 5% only are abnormal! In addition, variation amongst individuals is the biological norm (Lundstrom & Woodside, 1980)[21]; making it tenuous to predict future growth increments on an individual basis from population mean values.

1. CROZAT APPLIANCE & PHILOSOPHY

The evolution of Crozat Appliance Therapy and Philosophy was to prove to be, eventually, the entry point of Pont's Index into the U.S. orthodontic scene. For this reason, it is worthwhile to have a perspective on the origins and development of this technique.

Dr. George Crozat graduated from the Dewey School of Orthodontia in 1916 and then settled in New Orleans. Crozat developed his gold and platinum removable appliances as a result of influences of the Jackson's Crib Appliance (Jackson, 1904)[22] and the removable appliances developed by Dr. Walker of New Orleans (Lamons ,1964).[8]

Crozat addressed the American Association of Orthodontics on two occasions, once in the 1920's and again in 1960 in Washington D.C. (Hockel, 1983).[17] On both occasions the response was one of polite indifference. Furie (1959)[18] highlights the impact that these experiences had on Crozat:

> "A hero was born and crucified on the same day and this act apparently put out the fire of enthusiasm. There has been no further written word to this day by George Crozat."

Undoubtedly, the major reason for the disinterest towards Crozat's removable appliance technique was the preoccupation by the orthodontic profession with the evolution and clinical refinement of fixed appliances. Edward Angle's omnipresence in the orthodontic arena at that time was overwhelming.

Jackson (1953)[23] described the rejection of Crozat's ideas by the mainstream orthodontic specialty in the following terms:

> "These clinics were met with mixed opinions of approval due to the preponderant swing to fixed appliances which had been initiated so strongly by the forceful personality of Dr. Edward H. Angle."

Consequently, the only material that was published by Crozat was his 1920 article and, according to Hockel (1983)[17] a case report in 1924. This case report has not been locatable by this reviewer and was not referenced by Hockel. Therefore, Crozat personally published very little of his life's work. Clarification of the Crozat philosophy has been left to a small core of his avid followers.

The article by Lamons (1964)[8] was the first scholarly attempt to outline the dimensions and idiosyncrasies of Crozat philosophy and mechano-therapy. Since that time other articles have appeared sporadically within the mainstream specialist literature (Smythe, 1969[24]; Hitchcock, 1972[25]; Owen, 1985[26]; Parker, 1985[27]; Taylor, 1985[28]).

A greater number of Crozat articles were published within the generalist-orientated orthodontic literature (Devos, 1969;[29] Sheppe, 1971;[30] Dragan, 1976;[31] Baranko, 1984).[32] This is not surprising, as the use of the Crozat appliance has become almost totally restricted to general dentists; especially a small group of cultist, gnathological zealots epitomized by Hockel ,1983[17] and Boranko ,1984.[22] Dr. Crozat died in 1966, essentially spurned by the majority of the fixed appliance-orientated American orthodontic community. Many of his supporters believed that he had not received just recognition for this contributions to orthodontics (Wiztig & Spahl 1987).[33] Since that time, Dr. Albert T. Wiebrecht of Milwaukie, Wisconsin has established himself as the contemporary supreme Crozat illuminary. Dr. Wiebrecht had studied with Dr. Crozat every year at his office in New Orleans for a period of 40 years (Wiztig and Spahl, 1987).[33] Wiebrecht has taught the use of the appliance and advanced its design and clinical capabilities. More importantly, he introduced Pont's Index as a clinical rationalization for expanding non-extracted arches with the Crozat appliance (Wiebrecht, 1961).[34] It is important to note that Crozat was not an advocate of arch expansion with his appliance.

Hockel (1983),[17] in his review of the Wiebrecht/Crozat treatment philosophy, states the following:

> "Wiebrecht used the index to develop these ideal upper and lower arch widths in his patients as a first stage of treatment with Crozat's appliance. This was a bold step away from the way Crozat used his appliance and, to this day, is highly controversial among orthodontists."

In addition, Wiebrecht (1972),[35] strongly recommended interceptive or early treatment in contrast to Crozat who waited for the socalled "Golden Period" - 12 to 14 years - to treat his patients.

Due to these early case starts Wiebrecht's patients were in treatment for many years. Witzig and Spahl comment on this aspect of Wiebrecht's treatment approach:

> "The cardinal feature concerning the patient relative to being treated exclusively with Crozat Appliances is that of time. It is not uncommon for treatment in such cases to extend over 3 or 4 years."

However, this extended treatment duration appeared to be of little concern to Wiebrecht (1975):

> "One does not think of competing in time with other techniques."

Wiebrecht (1975) also stresses the orthopedic benefits of Crozat therapy, in much the same way Angle (1910) believed he stimulated bone growth with his mechano-therapy.

Wiebrecht states in his 1975[5] article:

> "This is not a philosophy of tooth movement. It is a philosphy of arch development... a development of the entire dentofacial complex - true facial orthopedics."

Wiebrecht, in my opinion, planted the seed of the Pont's Index controversy into American orthodontic soil. The harvest has been rich, as the fruit of arch width prediction indices have been eagerly devoured by pedodontists and generalist orthodontists alike (Truitt 1986,[20] Wiztig and Spahl 1987)[33] in their quest for justification of non-extraction therapy.

It now appears, that broad arches as predicted by Pont's Indices are interpreted as the proper and complete expression of that individuals genetic potential for arch width. In fact, this line of reasoning has been extended to the point where dental arch crowding, per se, is an expression of orthopedic underdevelopment. This concept is verbalized by Spahl (1987)[33] in a commentary on straight wire appliance mechano-therapy:

> "It is also common knowledge that arches with crowded teeth usually exhibit some form of orthopedic underdevelopment."

This review on the development of the Crozat Appliance would indicate that Crozat, himself, had unwittingly spawned the appliance that became the surrogate mother in the United States for Pont's Index. Whether Wiebrecht was the father or midwife, or both, is dependent on one's interpretation of the literature.

2. THE CONCEPT OF IDEAL ARCH FORM A ND THE INVIOLATE NATURE OF THE MANDIBULAR INTERCUSPID DIMENSION.

The long term stability of increase in arch width has been the subject of considerable discussion in the literature (Nance, 1947;[38] Riedel, 1975).[39] In contrast to the generalist's acceptance and utilization of Pont's Index, the specialist orthodontists have been strong advocates of extraction-orientated therapy and maintenance of the mandibular intercuspid dimension (Shapiro, 1974).[40] This viewpoint is founded in the historical debunking of Angle's non-extraction/expansion dogma (Grieve, 1932,[41] 1944;[42]Tweed 1944;[9] Strang, 1946)[46] and numerous studies that have highlighted the inevitable post-treatment relapse of mandibular intercuspid expansion (Steadman ,196l;[43] Walter, 1962;[44] Bishara et. al., 1973).[45] In 1969 McCauley[57] made the following statement:

> "Since these two mandibular dimensions, molar width and cuspid width, are of such an uncompromising nature, one might establish them as fixed quantities and build the arches around them."

Strang (1946)[46] says essentially the same thing:

> "I am firmly convinced that the axiom of the mandibular canine width may be stated as follows: The width as measured across from one canine to the other in the mandibular denture is an accurate index to the muscular balance inherent to the individual and dictates the limits of the denture expansion for this one area of treatment." (my emphasis)

Strang implies that his "arch development index" is dependent on the zone of equilibrium of muscular forces acting on the denture, as espoused later by Weinstein and Coworkers, 1963.[47] On this basis, it would appear clinically imprudent to expand dental arches on the basis of mesiodistal dimensions of upper incisors alone.

There were two critical factors that changed Strang's mind relative to extraction therapy. The first was that facial growth studies (Hellman, 1927;[48] Brodie ,1941)[49] had clearly demonstrated that the transverse dimension of the mandible stabilized by 5-7 years of age. The second factor was that osseous changes resulting from the application of orthodontic forces were limited to the alveolar processes - this is of course in direct contrast to Angle's concept of "Bone Growing", 1910.[36]

However, McInaney (1969,[50] 1980)[51] in a reevaluation of the literature on expansion and early treatment, questions the unassailability of Strang's axiom on mandibular canine width. He states (1969):[50]

> "A review of the writings of Tweed, Strang, Grieve and others, however, has not convinced me that the relapse of their cases was caused by the expansion of the dental arches, in which expansion treatment was utilized as the treatment procedure".

Instead, McInaney claims that relapse of the arch expansion was due to a lack of knowledge of gnathological concepts. The end of treatment occlusions of the four expansion cases presented by Strang (1946),[46] which relapsed out of treatment, showed evidences of midline shifts, premature centric occlusions, upper cuspids left high and out of centric occlusion. In addition, McInaney questions the validity of the entire end treatment occlusions on the basis that the cases were not mounted in proper hinge axis relationships. He laid the same criticisms at the door of Tweed's (1944)[9] and Grieve's (1944)[42] published works.

More importantly McInaney (1980)[51] stresses that arch expansion, especially in the mandible, is a viable treatment procedure if commenced in the primary or early mixed dentitions. He notes that most cases treated by these men were started no earlier than age 11 years.

This argument has begun to dominate the rationalization for early arch development. The critical factor appearing to be that collapse of intercuspid mandibular dimension occured if the expansion was begun after the bicuspids and permanent cuspids have erupted. (McInaney 1980).[51]

The era of functional appliance orthodontics in the United States is starting to provide valid data that expansion of dental arches is a stable proposition. Frankel's (1974,[52] 1980)[53] documentation of the stability of archwidth increase in both mandible and maxillary posttreatment has been impressive. Frankel appliance treatment in the mixed dentition period is notable for changes in arch form and the relative increase in arch width, particularly in the posterior region (McDougall, McNamara and Dierkes 1982;[54] Owen ,1983).[68]

McDougall et. al. (1982)[54] assessed the pre and post-treatment study cases of sixty CII Frankel appliance patients and compared the treatment results with a matched control group (N=47). The Frankel children wore their appliances for 18/20 hours each day for a period of two years. Average age of the patients at commencement of treatment was 9 years 5 months. The authors concluded:

> "The results of our study indicate that expansion of the maxillary and mandibular dental arches and their supporting structures occurs routinely when a functional regulator (FRI or FRII) is conscientiously worn by the patient." (my emphasis)

There appears to be an increasing trend towards non-extraction treatment or non-bicuspid extraction therapy within the orthodontic specialty. Cetlin and Ten Hoeve (1983)[56] have demonstrated marked arch dimensional increases with the use of lip bumpers and more recently Whitney and Sinclair (1987)[55] have demonstrated archwidth expansion in combination second molar extraction and appliance therapy. Invariably, the age at treatment commencement is ll years or less.

Specialist orthodontists will expand upper arches when there is a maxillary archwidth deficiency as clinically indicated by bilateral or unilateral posterior crossbites - these conditions have been shown not to be self correcting from the deciduous to mixed to permanent dentition (Kutin and Hawes 1969).[78] Clinicians frequently correct absolute or relative maxillary mandibular buccolingual discrepancies with rapid maxillary expansion (Bishara and Staley 1987).[58] This technique has been shown to produce stable expansion long-term, after allowing for over-expansion and adequate retention (Haas, 1980).[59] At the present time, the argument as to whether rapid or slow expansion regimes are more beneficial is still to be settled (Bell ,1982).[60]

The reality is that from clinical experience maxillary arch expansion in carefully selected cases is a viable treatment option (Timms, 1980).[61] The decision to expand, and the degree of expansion, is not dictated by the mesiodistal dimensions of the four upper incisors! Moreover, the primary goal of maxillary arch expansion is not usually a procedure to gain arch length.

In addition, the mandibular arch is invariably used as a template to which the maxilla is moulded. The mandibular intercanine dimension is carefully maintained. Contemporary orthodontic opinion is acutely aware of the hazards of mandibular expansion, as reflected in Proffit's (1986)[62] warning:

> "Expanding the mandibular intercanine distance with an anteriorly positioned screw in a removable appliance is not recommended, because excessive forces can easily be produced and because mandibular intercanine expansion is notoriously unstable." (my emphasis)

In contrast, Pont's Index is often the sole determinant for maxillary arch expansion or its euphemism "arch development" (Wiebrecht 1975).[5] The upper arch form developed to Ponts then becomes the template to which the mandible is expanded. This approach is diametrically opposed to the sanctity of the time-honored axiom - "that mandibular arch form should be maintained" (Riedel 1975).[39] Herein lies much of the controversy engendered by the use of Pont's Index. Those clinicians using Ponts as a clinical rationale for deciduous or mixed dentition arch development would argue strongly that:

> "early expansion affords an opportunity to exploit the potential for maximum growth and development." (McInaney et. al . ,1980)[51]

In addition, Melvin Moss' Functional Matrix Theory, (1969)[63] is offered as esoteric, conceptual support which allows adaptive changes to occur within the surrounding muscle/soft tissue matrix. Such a hypothesized "cause and effect" relationship is construed to imply treatment stability. To quote Hockel (1983):[17]

> "Bone can't tell the difference between a soft tissue matrix and an orthopedic appliance, therefore, changes in the form and position of the mandible and maxilla are achievable orthopedically and will be stable when function changes and stabilizes. The mechanisms for this action are not completely understood."

Perhaps, it is not inappropriate that Hixon comments on the relationship between arch expansion, dental crowding and relapse:

> "Arch expansion may also be used to reduce crowding, especially when the patient refuses to submit to extractions. Both the patient and the clinician accept

a higher risk of relapse when expansion is resorted to, but to some the choice is preferable to extractions." (Horowitz and Hixon ,1966)[64]

Longitudinal growth studies (Sillman, 1964;[65] Knott ,1972)[69] highlight the early immutability and establishment of the mandibular arch form. However, Pont's Index by its very nature ignores this documentation and instead, prefers to rationalize its validity in terms of expressing proper growth (arch development) potential.

In summary, the literature would suggest that expansion of the maxilla in younger age groups is a stable procedure (Haas 1980).[59] Expansion of the dental arches with functional regulators working through muscular forces appears to be stable (Frankel 1974).[70] However, considerable controversy exists in regard to buccal expansion of the mandibular arch, especially the intercanine dimension. Historically, the expansion of the mandibular arch was considered totally ill-fated (Nance, 1947;[38] Tweed,1944;[9] Strang, 1946).[46] More recent studies are more uncertain - some investigators emphasize relapse (Riedel ,1960;[71] Shapiro, 1974)[40] yet others indicate varying stability. Herberger (1981),[83] for instance, concludes that:

"...patients can be treated with cuspid expansion and a significant part of this expansion can be maintained in some cases."

Herberger[83] treated these patients with edgewise appliances commencing at II years of age.

The question as to whether early expansion of mandibular arch form is more effective and stable long term remains to be answered (Lutz and Poulton 1985).[66] But certainly, it could be safely concluded that expansion of the mandibular intercanine dimension, irrespective of age or treatment used, carries a realistic risk of relapse. The degree of risk would appear related to the degree of expansion (Schulhof et. al.,1978).[72] It appears that some individuals will tolerate expansion more readily than others (Gardner and Chaconas 1976).[73]

A clinician's willingness to expand dental arches, especially in borderline cases to avoid extraction, is largely a measure of that orthodontist's biological philosophy. At one end of the spectrum there are those who steadfastly believe that arch dimension is genetically predetermined and therefore immutable. Consequently, any expansion of intercuspid dimension is doomed to total relapse. Such a stance is reflected by Hixon's comment (Hixon and Klein, 1972)[67] on the need for retention appliances:

> "In general, the results are sufficiently stable that today retainers are placed only when some principle of treatment, such as arch expansion, has been accidentally violated."

At the other end of the spectrum others believe that jaw size is to some extent environmentally determined and not exclusively under genetic control. Thus, early orthodontic intervention can be directed toward full development of the bony support of the dental arch to accomodate the entire dentition (McInaney, 1980).[51] Those practitioners who use Pont's Index as a basis for arch expansion fall squarely into this category (Wiebrecht, 1975).[5]

As in most aspects of life, reality may lie somewhere between the two extremes.

3. STUDIES SPECIFICALLY DESIGNED TO PROVE OR DISPROVE THE VALIDITY OF THE PREDICTIVE VALUE OF PONT'S INDEX.

Somewhat surprisingly, the number of scientific studies evaluating Pont's Index are relatively few in the contemporary orthodontic literature. Historically, there appears to have been an interest in the German literature about the 1930's when such eminent individuals as Korkhaus (1929)[89] and Linder (1931),[92] Harth (1930)[91] and Greve (1933)[90] were evaluating the concept relative to German population samples. Even at this time, attitudes to the validity of Pont's Index were highly polarized. Greve (1933) was an antagonist, armed with low correlation coefficients (see Table 2) between Pont's predicted arch width and the sample arch width dimensions of perfect occlusions. Korkhaus and Linder-Harth had introduced modifications to Pont's Index in an attempt to satisfy the racial idiosyncrasies of German (rather than French) maxillary archforms (Muhlberg et al 1969).[76]

However, one fact is unequivocal - that Pont's Index stimulated interest across the international orthodontic spectrum. The nine studies available for review, after extensive search of the orthodontic literature (Table 1), attest to this fact.

Firstly, it is imperative that Pont's original intention is clearly understood. To achieve this aim it would be ideal to translate directly from his original article written in the German language (Pont 1909). This has not been possible, as a copy of the original article has been impossible to locate within the U.S. As an acceptable alternative the information gleaned from Joondeph et. al. (1970)[3] will be used as a true representation of the original.

On this basis, the following points are noteworthly:

1. Pont proposed a method for predeterming the ideal dental arch width from tooth size. He suggested that a constant relationship existed between the width of the four upper incisors and the width of the maxillary dental arch in the premolar and molar areas.

2. Pont concluded that in the ideal dental arch (maxilla only) the ratio of combined incisor width to transverse arch width was .80 in the premolar area and .64 in the molar area. These ratios have been translated into a table, often referred to as "Pont's Index".

3. These main values have since been used as a basis for predetermining the ideal dental arch width of patients for treatment purposes.

4. All of Pont's measurements and predictions were related to the maxillary dental arch only and did not include an assessment of the mandibular arch.

5. In orthodontic procedures Pont suggested that the maxillary dental arch should be expanded one or two millimeters more than that found in normal occlusions to allow for relapse and included this factor in his ratios.

6. Maxillary arch width was measured from the center of the first premolars and first molars.

With the above points in mind it becomes obvious when reviewing the literature that much of Pont's original intentions have been misinterpreted, modified, expanded, abused and misused. But the alluring simplicity and apparent clinical usefulness of Pont's ideas attracted many followers. A translation direct from Bernsman's (1982)[81] article reflects on this observation:

"To this day Pont's concept has found many followers, since at a cursory look it appears simple and clinically practical."

The fact that Pont so poorly defined his population sample still remains a mystery. This oversight has historically undermined any credibility which Pont may have sought and opened the door to other research efforts (Muhlberg, 1969).[76]

The studies to be reviewed individually are listed in Table 1. Those studies that used correlation coefficients to assess the predictive validity of Pont's Index are listed in Table 2, along with a description of the sample population group used.

Henry (1963)[74] used Pont's Index in an attempt to define, amongst other criteria, ideal occlusion in Australian 12 year olds. He deduces an Index of 81 (premolar) and 63 (molar) from measurements of upper incisor width in 30 children. On this basis he constructed a modified Pont's Index chart for Australian children. The statistical handling of the data was totally inadequate, only the mean values of incisor width for girls and boys were provided. No tests for statistical difference were applied...a subjective perusal of the difference between male and female mean values results in the following comment:

"It may be seen that boys possessed slightly larger teeth and broader arches than the girls."

The article indicates that Henry philosophically supports the validity of the predictive capability of Pont's Index. The data presented is totally inadequate for scientifically validating this viewpoint.

Cristoloveanu, et. al. (1969),[75] investigated Pont's Index for the estimation of arch width in the population of Tirgu mures ethnic group. The population sample group consisted of 200 individuals, 8-20 years old with normal occlusions. This group was selected after examining 3,000 rural and city individuals. The sample was approximately 50% male and female. Although not handled with vigorous statistical analysis, the results highlight dramatically the tremendous variation on an individual basis from Pont's predicted arch width values. For example, for the intermolar dimension only 10 out of 200 ideal occlusions matched with the predicted pont's value. It is of interest that this study also examined lower arch width dimension, despite the fact that Pont's Indices have no relationshiop to the mandibular arch form. This is the only study cited in Table 1, besides Bernsman (1982), that assesses lower arch width using the Pont's Index. Cristoloveanu's concluding remark is worth quoting:

> "It was found that individual variations are so important that, without the introduction of correction factors, the Pont Index is practically useless." (my emphasis)

Muhlberg, et. al. (1969),[76] examined Pont's Index with an intense and thorough statistical approach. In addition, the sample group of 417 normal occlusions was by far the most extensive listed in Table 1. The effort expended in gathering data for this study was mindboggling - some 4,897 German youth were examined to locate 417 ideal occlusions and 9,714 measurements were taken from the casts of these individuals for statistical interpretation. On this basis alone Muhlberg's article lays claim to "classic" status.

With the use of scatterplots and correlation coefficients (see Table 2) Muhlberg clearly demonstrated that Pont's Index has no useful, predictive clinical value. In addition, he showed that significant sex differences existed between the sum of the mesiodistal widths of the maxillary incisors.

Joondeph, et. al (1970,[3] 1972),[77] examined a group of 20 patients who had received non-extraction orthodontic treatment. These patients originally had a variety of malocclusions and were part of the University of Washington long term out-of-retention patient group. This study is unique in that it is the only investigation in Table I that uses orthodontically treated individuals to disprove Pont's concepts. Although the sample size was relatively small (N=20) this study clearly illustrated the inherent stability of using the lower arch form in the pre-existing malocclusion as a template to which the upper arch should be adjusted. Correlation coefficients (Table 2) of approximately 0.20 clearly indicate the futility of using tooth size to predict arch width. The concluding remark warrants quotation:

> "Measuring mesiodistal widths of incisors to predetermine maxillary interpremolar and intermolar widths is of no value in predicting ultimate arch width in those areas."

Worms, et. al. (1972),[79] assessed two distinct racial groups. The Navajo Indians (male and female) and male dental students presumed to be of Nordic heritage, from the Minnesota Dental

School. This article was published in JADA, and as such, was directed at the general dentist population rather than orthodontists. The clarity and conciseness of this article is possibly a result of this intended readership. In terms of lucidly outlining the concepts of Pont's Index and its fallibility as a diagnostic tool, this article has no peer in contemporary literature.

Like Cristoloveanu, this study graphically indicates the vast variability of tooth size/arch width relationships in patients with ideal occlusion. In addition, Worms and his colleagues stress the dangers of applying population means to individuals:

> "The range of the difference between the actual and the calculated arch form illustrates the great fallacy of arch width predetermination. Pont's Index is a mean measurement of a group and this index applies well to a discussion of the group. The average, however, does not apply to the individual."

This comment echos the stance that Hixon (Hixon and Klein, 1972)[67] has taken relative to predicting facial growth:

> "The best way available to estimate the adult size or form for a given patient is to measure his dimension (or angle) and to add the average change (growth) for the group. The error of prediction for the given patient under consideration is equal to the variation from the average growth change."

Worms and his co-workers calculated more correlations than any other study, varying from 0.06 to 0.28 - all totally useless in terms of prediction.

Gupta, et. al. (1979),[80] is one of only four articles published in contemporary U.S. orthodontic literature concerning Pont's Index. Unfortunately, this did not automatically bestow upon the authors scientific competence! This article is a classic in terms of misunderstanding statistical methods. Despite the fact that a correlation coefficient of approximately 0.50 (see Table 2) was determined between incisor width and arch size in their sample of 100 normal occlusions they drew the following conclusions:

> "Statistical evaluation revealed that Pont's Index was reliable to use but it had such a great range that it would be fallacious to assume that every case will be in the same order as predicted by the index."

Bernsman (1982)[81] was a fascinating study despite having the smallest sample size (N=13). The author was staunchly anti-Ponts in his review of the literature, and sets about proving his viewpoint.

"It is here, through simple argument, that the absurdity of the demand that arch width should be fixed upon the width of the incisors should be highlighted."

He selected 13 children with "anatomically correct" (one assumes "normal") occlusion. He measured the study casts of these children longitudinally, twice with a three year interval; noting the following dimensions:

1. Width upper incisors 2112
2. Arch width lower jaw (cusp tip to cusp tip of the first premolars)
3. Arch width upper jaw (cusp tip to cusp tip of the first premolars)

The first measurement in time was at 7-10 years of age. The second measurement at 10-13 years of age. This sample group was not defined in terms of sex.

Why the bicuspid width was measured instead of the molar dimension remains a mystery. In addition, the method of arch width measurement as described by Pont (1909) reaches from center of tooth to center of tooth. Bernsman (1982) uses buccal cusp tips; Henry uses distal pits; others use the middle fissure. How this affects the results is uncertain, but it must be assumed that Bernsman's arch width measurements were in excess of what Pont intended.

Spahl (Witzig and Spahl, 1987) makes an interesting comment about this problem:

"The premolar width is then calculated to be from central point to central point of the middle fissure across the first bicuspids by the following formula (American authors traditionally use the distal pit instead of the center of the middle fissure. This distance is so close that such discrepancies in all practicality are a moot point)."

Although Bernsman's (1982)[81] study had many shortcomings, it graphically highlighted the variability in change of maxillary arch dimension over the three year period. The individual variation was marked - 50% of lower arch widths did not alter in three years, others, especially maxillary arch, showed vast increases in arch width.

This study clearly demonstrated the vast individual variability in changes of arch width during mixed dentition over a three year period. These children had ideal occlusions with no orthodontic treatment.

Oliveira (1982)[82] assessed 111 individuals with normal occlusion which consisted of three racial groups: 50 Brazilians, 30 negroes, 31 mulatoes. Their ages ranged from 18-25 years; 72 were male, 39 were female. No statistical difference was found between racial groups which contradicts the concept of Pont's modification for different ethnic types (Korkhaus, 1929).[89] The males were shown to have statistically broader arch forms.

The studies reviewed show a wide degree of variability in their approach to investigating the validity of Pont's Index. Equally as evident is the distinct lack of intellectual integrity of some of the articles (Gupta, et. al., 1979).[80] However, those articles that statistically computed correlation coefficients (see Table 2) unequivocally and consistently demonstrate the total inability of Pont's Index to act as a diagnostic aid in predicting future ideal arch width from the widths of the upper incisors. Indeed, Joondeph et. al. (1972) decisively highlights the absurdity of this approach.

MATERIALS AND METHODS

The sample evaluated for this study comprised thirty six individuals from the longitudinal growth study, Child Study Clinic, Dental School, Oregon Health Sciences University. These subjects were Caucasian, of predominantly Northwestern European ancestry. Their parents resided in or near Portland, Oregon and were of middle socio-economic status. The child study clinic examined these children annually, within one month of each birthday, from three years to adulthood.

Dental casts of these thirty six individuals, seventeen males and nineteen females, were selected for measurement at two time intervals:

1. Mixed Dentition - Age 9 Years
2. Early Permanent Dentition - Age 14 Years

Appendices A and B identify the individuals from the child study clinic used in this investigation and their ages in years and months at the above two time intervals.

These individuals were considered to have either "acceptable" or "ideal" occlusions as judged from the permanent dentition study models. In addition, the subjects had received <u>no</u> orthodontic treatment whatsoever.

"Acceptable" occlusions in this study were defined according to the following criteria:

1. Class I molar relationship
2. Overbite < 4mm or 70%
3. Overjet < 3mm measured to central incisor with greatest overjet
4. Minimal crowding or spacing, both anterior and posterior
   - Upper arch <2mm spacing or crowding
   - Lower arch < 3mm spacing or crowding

5. No missing teeth
6. No supernumeraries
7. Full complement of teeth from first molar to first molar in both arches
8. No crossbites, anterior or posterior
9. No more than two teeth rotated in both arches > 60%

Seventeen individual measurements were recorded from each pair of study casts. These comprised four measurements of the mesiodistal width of each maxillary central and lateral incisor on the permanent dentition casts. The sum of these four incisor widths provided a total notated as S.I. The remaining thirteen measurements recorded the transverse dimensions of the archwidth using dental landmarks. These are defined below according to the numbered notations in Figures 1 and 2.

PERMANENT DENTITION STUDY MODELS (See Figure 1)

1 + 2 + 3 + 4 = S.I. The sum of the mesiodistal widths of the four maxillary incisors, measured at the contact points

5. Cusp tips of maxillary permanent cuspids

6. Lingual cusp tips of maxillary first bicuspids

7. Distal pits of maxillary first bicuspids

8. Central pits of maxillary first permanent molars

9. Middle buccal cusp tips of mandibular first permanent molars

10. Distal pits of mandibular first bicuspids

11. Cusp tips of mandibular permanent cuspids

MIXED DENTITION STUDY MODELS (See Figure 2)

12. Cusp tips of maxillary deciduous cuspids

13. Distal pits of maxillary first deciduous molars

14. Central pits of maxillary first permanent molars

15. Middle buccal cusps tips of mandibular first permanent molars

16. Distal pits of mandibular first deciduous molar

17. Cusp tips of mandibular deciduous cuspids

All measurements were made directly from the models after the above dental landmarks had been located and marked with a soft lead pencil. A precision-made venier caliper (John Bull, British Indicators Ltd., St. Albans, England) which incorporated sharp tungsten tips and a dial readout gauge was used for all toothsize and archwidth measurements.

ERROR ESTIMATION

The error analysis entailed replicate measurements made on the plaster study casts of twelve subjects randomly selected from the child study clinic sample group (N=36). Replicate measures were made of the mandibular intercuspid dimension using cusp tips as the designated landmark. This landmark was considered to be representative of the measurement error inherent in all archwidth measures used in this study (see Figures 1 and 2).

Landmark location and measurements of the mandibular intercuspid archwidth dimension were repeated with one week intervening between initial and replicate measures.

The following formula was used to calculate measurement error: S.E. Measure = $\sqrt{\frac{\Sigma(d)^2}{2N}}$

where d is the difference between the two measurements. As determined by the above procedure, the S.E. Measure for the data collected was 0.22 mm.

STATISTICAL ANALYSIS OF DATA

The statistical analysis of the data included the following:

I. Pearson's linear correlation co-efficients ( ) were derived for the following relationships:

(i) The ideal maxillary interpremolar width, calculated with the use of Pont's Index, was compared with the actual or observed interpremolar width on the permanent dentition casts for both males and females separately.

(ii) The ideal maxillary intermolar width, calculated with the use of Pont's Index, was compared with the actual or observed intermolar width on the permanent dentition casts for both males and females separately.

(iii) The ideal mandibular interpremolar width, calculated with the use of 'P' Index, was compared with the actual or observed interpremolar width on the permanent dentition casts for both males and females separately.

(iv) The ideal mandibular intermolar width calculated with the use of 'W' Index, was compared with the actual or observed intermolar width on the permanent dentition casts for both males and females separately.

II. The individual differences between observed and calculated (Ponts, 'P' and 'W' Indices) archwidth dimensions were computed for both males and females.

III. The mean and standard deviation for the intercanine, interpremolar and intermolar archwidth dimensions were computed for the entire permanent and mixed dentition sample.

IV. Student t tests were used to evaluate significant differences between the mean archwidth values of the mixed dentition (9 years) and permanent dentition (14 years) group at the 95% confidence level.

V. The differences between the mean archwidth values of the mixed dentiton (9 years) and permanent dentition (14 years) group were calculated.

ARCHWIDTH INDICES

This study used three separate archwidth indices that purported to predict optimum archwidth development. These were:

1. Ponts Index - Maxillary interpremolar and intermolar dimensions (Figure 3)
2. 'P' Index - Mandibular interpremolar dimension (Figure 4)
3. 'W' Index - Mandibular intermolar dimension (Figure 5)

Ponts original index was developed for the maxillary archwidth only. The 'P' and 'W' Indices were developed from Ponts Index in an attempt to provide a predictive index for the lower archwidth. The anatomical relationships of these indices are illustrated in Figures 3, 4 and 5. The following formula were used:

MAXILLARY ARCH 1. Ponts Molar Index = $\frac{SI \times 100}{64}$

2. Ponts Premolar Index = $\frac{SI \times 100}{80}$

These two formulate calculate the ideal Pont's molar width for the maxilla relative to the meassured value SII (sum of the mesiodistal width of the maxillary incisors)

MANDIBULAR ARCH 3. 'P' Index

The determination of the Pont's values for the lower archform is entirely dependent upon the values obtained from the upper model and its calculated ideal Pont's indices.

Understanding this calculation is dependent on the realization of an identical anatomical relationship. The dimension of the lingual cusp archwidth of the upper first premolars as calculated with Ponts Premolar Index is representative of an identical anatomical relationship in the mandible - the distance between distal pit lower first bicuspid to distal pit lower first bicuspid.

Lingual cusp 4I4 (calculated) = Pont's P = distal pits 4I4 (calculated).

4. 'W' Index

The ideal calculated distance from buccal middle cusp to buccal middle cusp lower first molars is referred to as Ponts 'W' and calculated by Ponts Molar Index - 1 = 'W' Index

The cusp/fossa relationship of the buccal middle cusp lower first molar and central pit upper first molar suggest identical archwidth dimensions. However, one millimeter is subtracted from the upper Ponts molar calculated value to ostensibly prevent the development of the lower arch too far laterally and the creation of a posterior crossbite.

FINDINGS

The findings of this study will focus on four distinct areas of interest:

1. Correlation coefficients derived for the relationships between the ideal archwidth, calculated using the Ponts, 'P' or 'W' index, and the actual or observed archwidth as measured from the permanent dentition study casts.

2. The variation on an individual basis from the calculated (ideal or Ponts) archwidth and observed archwidth dimensions.

3. A comparison between male and female, mandibular and maxillary archwidth values in the permanent and mixed dentition.

4. The changes that occurred in archwidth dimension over a period of five years - from mixed dentition (9 years) to the early permanent dentition (14 years). The contrast over this period of time between the upper and lower archwidth changes will be highlighted.

1. CORRELATION COEFFICIENTS

Correlation coefficients were calculated for eight distinct archwidth relationships between Pont's predicted ideal archwidth and the actual or measured archwidth. All of these 'r' values are presented in

Table 3. On perusal of this table it is evident that the correlation coefficients are of remarkably similar value at about r = 0.50. The noteworthy exception is the female mandibular interpremolar archwidth relationship which is distinctly lower at r = 0.23.

The male and female subjects were considered separately due to the previously documented sexual dimorphism of maxillary incisor width. (Muhlberg, 1969).

Scatter diagrams with calculated regression lines for the highest (r = 0.58) and the lowest (r = 0.23) 'r' values are shown in Figures 6 and 7. This highlights the greater degree of data scatter with the lower (r = 0.23) correlation coefficient value.

2. <u>INDIVIDUAL VARIATION FROM PONT'S PREDICTED ARCHWIDTH</u>.

The individual variations between the actual observed archwidth values and the predicted ideal Pont's archwidths are presented in Figures 8-15. These are the same cross-arch dimensions as assessed previously with correlation coefficients. The bar graph format helps to clearly visualize the variation on an individual basis from the Pont's predicted value, which is represented by zero on the horizontal or x axis. The differences have been presented in ascending order.

Identical measurements to those calculated with Pont's Index were found for only 2 out of a total of 144 archwidth predictions! Variation between the observed and calculated measurements was the norm. This variation in most cases was vast. For instance, the female mandibular interpremolar differences ranged from -9.1mm to +1.6mm. The negative differences are indicative of a measured archwidth <u>less</u>

than Pont's predicted ideal width. In the majority of cases the participants had a negative difference - that is, dental arches were narrower than indicated by Pont's values. Variation between observed and calculated measurements ranged from -9.1 +1.6 in the premolar region and from -8.1 +3.9 in the molar widths for both mandible and maxilla.

3. ARCHWIDTH DIMENSION IN THE EARLY PERMANENT DENTITION

The mean and standard deviation for the intercanine, interpremolar and intermolar archwidth dimensions were calculated for the entire permanent and mixed dentition sample. These mean archwidth values, male and female, of the permanent dentition are pictorially displayed in the form of three dimensional column graphs (Figures 16 and 17).

The differences between the mean archwidth values for the permanent and mixed dentitions were evaluated using Student t Tests at the 95% confidence level.

The results for the mandible were unequivocal, in that there exists no significant differences for any archwidth dimension between the 9 year and 14 year old individuals, either male or female. These results indicate that the mandibular archwidth which presents in a nine year old child represents that child's ultimate, adult lower dental archwidth. This statement holds true for all three cross-arch dimensions measured - intercanine, interpremolar and intermolar.

The results for the maxilla were almost diametrically opposed, statistically speaking, to the findings for the mandible. For all maxillary archwidth dimensions there was a statistically significant difference (p <

.05) between the 9 year and 14 year old individuals. The one exception to this statement is the female maxillary interpremolar dimension where no statistical difference existed between the two age groups. It is clear from Table 4 that an increase in maxillary archwidth occurs, to a varying degree, over the five year period from mixed to permanent dentition.

4. <u>CHANGES IN ARCHWIDTH FROM 9 YEARS TO 14 YEARS</u>

The individual mean differences between the three archwidth dimensions measured at 9 years and 14 years are listed in Tables 4 and 5. Although a statistical difference between archwidth at these two age groups may exist, the magnitude of these changes, may or may not be, clinically relevant. To clarify this point the mean archwidth differences were visually highlighted using three dimensional column graphs (Figures 18 and 19).

The mean archwidth changes in the mandible are, for all intents and purposes, clinically negligable. The changes fluctuated a half millimeter either side of zero (Figure 19). Much of this change may be accounted for by measurement error (S.E.M. 0.22).

The mean archwidth increase in the maxilla is more clinically meaningful, particularly in males where at least a millimeter in the premolar/molar archwidth can be expected over this five year period from mixed to permanent dentition. More importantly, a three millimeter increase in the male maxillary intercanine dimension occurred, almost twice that of the intercanine increase seen in the female group. The maxillary archwidth increase in males was virtually twice that of the females from 9 to 14 years of age.

DISCUSSION

The correlation coefficients derived from this study are all somehwat higher than previous studies for the relationship between Ponts and observed maxillary archwidth dimensions (see Table 2). Worms et al (1972)[79] indicated a maximum 'r' value of 0.28 for the relationship between Ponts ideal intermolar archwidth and that of a large group of dental students with ideal occlusions (N=606). Other studies such as Muhlberg (1969),[76] Joondeph (1972)[77] and Gupta (1979)[80] produced 'r' values of 0.22 to 0.49 for the relationship between tooth size (sum of the maxillary four incisors) and archwidth (maxillary interpremolar and intermolar archwidth).

The explanation for the difference in the r values between this study and others could be due to a number of factors. Firstly, the selection parameters used for the child study clinic (C.S.C) group to locate 'acceptable' occlusions were quite stringent. The occlusions used in this study ranged from 'acceptable' to 'ideal'. The lower limits of 'acceptability' were carefully defined prior to the selection process and outlined in Materials and Methods. It is likely that other studies with less stringent selection standards used individuals who were acceptable to their standards but 'unacceptable' as limited by this study's selection criteria. On this basis, it is possible that these sample groups have introduced a greater degree of variability in archform anda poorer correlation with the typically broad, rounded archforms predicated by Pont's Index. Although, it should be noted that in general, the selection criteria for the subjects of the studies cited in Table 1 and Table 2 were often vague and poorly defined.

Another consideration is the sexual dimorphism of tooth size. Mulhlberg (1969)[76] used t tests to show a statistical difference at the 99% confidence level between the mean values of female and male mesiodistal incisor widths (n=417). This difference clearly indicates the need to consider the two groups as a separate entity for investigation of tooth size/archwidth relationships. Gupta (1979)[80] did not separate males and females in his sample group of N=100, when evaluating the relationship between tooth size and archwidth.

Furthermore, the landmarks used in each study cited in Table I to determine archwidth are often poorly defined and lack consistency between one study and the next. This confusion is primarily in the interpremolar measure where a pilot study by this author indicated a mean difference of 1mm between distal pit and central groove determined archwidth. Some studies in Table 1 used central bicuspid groove, others distal pit. Others failed to define clearly the landmarks used (Bensman 1982).

A final consideration involves the archwidth differences between various racial groups. Worms (1972)[79] commented on this fact when he examined both a Navajo Indian and Caucasian group in the same study. Horth (1930)[91] and Linder (1931)[92] introduced modification factors to Ponts original index to allow for archform differences of German population groups. The C.S.C. subjects were Caucasian and of Northwestern European background. A racial group who could be considered highly homogeneous. It is not unlikely that as a group their mean archwidth values would differ from say, the Indian group of Gupta's (1979)[80] study. In summary, it is not surprising that when the various factors noted above are considered, that differences exist between correlation coefficient values of various studies.

The present study is unique in that it considers the relationship between Ponts and observed archwidth values for the mandibular as well as the maxillary arch. the 'W' and 'P' indices, used to predict ideal mandibular archwidth, were introduced by Wiebrecht (Spahl, 1987).[37] This represented an attempt to clinically rationalize the need to expand the lower arch to match the 'developed' upper arch to Ponts ideal archwidth. It is not surprising that the r values for the lower arch are similar to the upper arch, as the 'P' and 'W' indices are simple anatomical transpositions of the Ponts ideal maxillary archwidth (see Figures 4 and 5).

The low female mandibular interpremolar 'r' value (0.23) is something of a mystery when viewed in relation to the other correlation coefficients of this study. Although, this value agrees closely to other studies of maxillary interpremolar dimension such as Worms (1972) with $r = 0.25$.

The coefficients of determination (r^2) for this present study range from 0.05 to 0.34. This indicates that less than 34% of the variation in actual archwidth values can be accounted for by Ponts calculated ideal archwidth values. For clinical purposes a correlation coefficient of less than 0.7 is generally not useful for prediction purposes. (Horowitz and Hixon, 1966).[64] On this basis, the use of Pont's Index would appear scientifically invalid and clinically unjustified as a guide to archwidth determination.

The individual differences between the actual and calculated archwidth values (Figures 8-15) illustrates the fallacy of Ponts archwidth determination. Pont's Index is a mean measurement of a group and this index applies well to a discussion of the group. The average, however, does not apply to the individual. Even if an error of ∓ 1mm were acceptable, only a small percentage of participants would be indicated within this tolerance margin for all measurements. The vast individual differences from Ponts predicted ideal archwidths highlight dramatically the great deal of error inherent in the use of these indices as it relates to these acceptable occlusions. Along with coefficient of determination (r^2) values of less than 0.34 these large individual variations emphasize the absurdity of demanding that archwidth should be fixed upon the width of the maxillary incisors.

Only two other studies analyzed the individual differences between predicted and observed archwidth values. This was in fact the main trust of Cristoloveanu's article where he tabulated numerically the individual differences from the ideal predicted archwidth for both mandibular and maxillary interpremolar and intermolar archwidths. At best he could only show 15/200 archwidth dimensions that fell within + .25mm of Ponts values. Worms et al, indicated by means of a line graph, a similar scenario.

This study showed that only 2/144 measured archwidths corresponded exactly with the socalled 'predictive' archwidth indices. In fact, there was not a single maxillary archwidth dimension that corresponded with Pont's ideal value. In both cases where the calculated and observed archwidth values coincided, it occurred in the mandible (see Table 6).

The changes which occurred in the archwidth dimension between 9 years and 15 years as documented in this study agree closely to previous longitudinal studies on archwidth development (Sillman ,1964;[65] Knott,1972)[69]. The clinical relevance of a mandible that has reached its virtual maximum archwidth dimension by the age of 9 years is critical to the pundits who talk about "expressing the full genetic potential of arch development". I would argue strongly that the full genetic potential for archwidth is expressed as an approximation to the mean for a similar racial group with acceptable to ideal occlusions. In this case (Northwestern European Caucasians), the female mandibular cuspid and molar widths are approximatley 25mm and 45 mm respectively while the same male archwidths are approximately one millimeter greater (Table 5). It is important to stress that at 9 years a child's mandibular archwidth development is complete, or to put this perspective in crisp, unequivocal terms - "what you see is what you get"! This fact apparently escapes those clinicians who commence treatment early in the mixed dentition with the expressed clinical desire to 'develop' or expand the lower archwidth,* invariably this strategy is designed to combat an impending or present archlength shortage as denoted by crowded incisors.

*According to a predetermined dimension predicted by the 'P' or 'W' index.

SUMMARY AND CONCLUSIONS

This study comprised thirty six individuals (seventeen male and nineteen female) selected from the longitudinal growth study, Child Study Clinic, Oregon Health Sciences University, Portland, Oregon. All of these subjects possessed occlusions that were considered to range from acceptable to ideal. The lower limits of 'acceptable' were carefully defined before the selection process and were considered to be quite stringent. Two sets of study models were selected for each individual - one in the mixed dentition (9 years) and the other in the early permanent dentition (14 years).

A total of seventeen archwidth measurements were made on both sets of plaster study models - eleven for the permanent dentition and six for the mixed dentition. The dental anatomic landmarks for each archwidth dimension were carefully defined. In addtion, the mesiodistal widths of the four maxillary incisors were measured at the contact points. The sum of these values was designated SI. A measurement error analysis was completed with the use of repeated measures.

The collected data was statistically analyzed to evaluate the validity of Pont's Index for the prediction of ideal maxillary archwidth, as well as the 'P' and 'W' Indices for the prediction of ideal mandibular archwidth. In addition, the indiviual differences between the calculated and actual archwidth measurements were evaluated.

The mean changes in archwidth from the mixed dentition (9 years) to the permanent dentition (14 years) were assessed for three archwidth dimensions - intercanine, interpremolar, and intermolar. All statistical procedures handled female and male groups as separate categories.

From the results of this study the following conclusions can be made:

(1) The correlation coefficients (r values) of 0.23 to 0.58 and coefficient of determination (r^2) values of 0.05 to 0.34, derived from this study for the relationships between Ponts, 'P', 'W' calculated ideal

archwidths and actual measured archwidths in the permanent dentition, clearly indicate that these Indices have no clinically reliable predictive value.

(2) Vast individual differences between Ponts, 'P' and 'W' predicted archwidth dimensions and the actual measured archwidth values are the norm. Only 2/144 actual archwidth measurements had values similar to the Index predicted archwidth dimension.

(3) The mandibular archwidth has attained its full adult size by the age of 9 years. No statistically significant change in lower archwidth was detected over the five year period from mixed dentition (9years) to early permanent dentition (14 years).

(4) The maxillary archwidth increases from the mixed dentition (9 years) to the early permanent dentition (14 years). The male increase is approximately twice that of the female and greatest for the intercuspid dimension.

(5) The results of this study highlight the fallacy and pitfalls of insisting that archwidth be determined by the sum of the mesiodistal width of the four maxillary incisors.

BIBLIOGRAPHY

1. Pont, A. Der Zahn-Index In Der Orthodontie Zahnarztuche Orthopedie, 3:306-321, 1909.

2. Editorial. Fragmentation Within the Profession: Time to Talk it Out. General Dentistry, May/June, 1984.

3. Joondeph, D. R., Riedel, R. A. and Moore, A. W. Pont's Index; A Clinical Evaluation. Angle Orthod., 40:112-118, 1970.

4. White, W. O. and Clark, J. T. The Crozat Removable Appliance. Int. J. Orthod., 14:6-13, 1976.

5. Wiebrecht, A. T. The Philosophy Underlying the Use of the Crozat Apliance. Int. J. Orthod., 13:14-15, 1975.

6. Dewey, M. Practical Orthodontics. 7th Edition. Revised by George Anderson. St. Louis. C. V. Mosby, 1948, p. 174.

7. Angle, E. H. Malocclusion of the Teeth. 7th Edition. S. S. White Dental Manufacturing Co., 1907.

8. Lamons, F. F. The Crozat Removable Appliance. Am. J. Orthod., 50:265-292, 1964.

9. Tweed, C. H. Indications for the Extraction of Teeth in Orthodontic Procedure. J. Orthod. Oral Surg., 30:40-409, 1944.

10. Tweed, C. H. Treatment Planning and Therapy in the Mixed Dentition. Am. J. Orthod., 49:881-887, 1963.

11. Begg, P. R. & Kesling, P. C. Begg Orthodontic Theory and Technique. 3rd Edition. W. B. Saunders Co., 1977.

12. Hixon, E. H. Growth of the Dentition and it's Supporting Structure. J.A.D.A., 82:782-788, 1971.

13. Crozat, B. G. Possibilities and Use of Removable Labio-Lingual Spring Appliances. Int. J. Orthod. Oral Surg., 6:1-7, 1920.

14. Bastian, C. B. Applied Functional Orthopedic and Orthodontic Therapy. A Synopsis, 1983.

15. Garn, S. M. Statistics: A Review. Angle Orthod. 28:148-165, 1958.

16. Buck, D. L. Personal Communication. 1986.

17. Hockel, J. L. The History and Theories of Crozat Orthopedics. Orthopedic Gnathology. Quintessence Publishing Co., 1983.

18. Furie, W. J. Removable Appliances. Am. J. Orthod., 45:456-471, 1959.

19. Rivard, R. Casesolvers Award. The Functional Orthodontist, 3:41-42, 1986.

20. Truitt, J. W. Course IV. Advanced Orthopedics, Orthodontics, Cephalometrics and Surgery. Sydney, Australia, Sept. 1986.

21. Lundstrum and Woodside, D. G. Individual Variation in Growth Directions Expressed at the Chin and the Midface. Europ. J. Orthod., 2:56-230, 1980.

22. Jackson, V. H. Orthodontia and Orthopedia of the Face. Philadelphia: J. B. Lippincott Company, 1904.

23. Jackson, A. F. The Nature and Place of Removable Appliances in Orthodontic Treatment. Am. J. Orthod., 39:818-835, 1953.

24. Smythe, R. B. The Crozat Removable Appliance. Am. J. Orthod., 55:739-747, 1969.

25. Hitchcock, H. P. Pitfalls of the Crozat Appliance. Am. J. Orthod., 62:461-468, 1972.

26. Owen, A. H. Cozat Treatment. J. Clin. Orthod., 19:109-127, 1985.

27. Parker, W. S. A Perspective fo the Crozat Appliance with Case Reports of it's Present Use. Am. J. Orthod., 88:1-21, 1985.

28. Taylor, W. H. Crozat Principles and Technique. J. Clin. Orthod., 19:429-441, 1985.

29. Devos, J. B. The Mechanics of Comparative Force Application for Crozat Appliance Therapy. J. Maxillofac. Orthop., 2:14-20, 1969.

30. Sheppe, J. H. The Construction and Use of a Crozat Appliance. Int. J. Orthod., 9:192-201, 1971.

31. Dragan, W. B. Combined Crozat-Bonded Labial Light Wire: A Technique. Int. J. Orthod., 4:5-11, 1976.

32. Baranko, J. G. Crozat Therapy for Orthopedic Gnathology. CDS Rev., 77:26-30, 1984.

33. Witzig, J. W. and Spahl, T. J. The Crozat Appliance. The Clinical Management of Basic Maxillofacial Orthopedic Appliances. P.S.G. Publishing Co., 1987, p. 327.

34. Wiebrecht, A. T. The Application of the Crozat Removable Appliance for the Development of Arches in Orthodontia. Fort. Rev. Chicago Dent. Soc., July, 1961, p. 131.

35. Wiebrecht, A. T. How to Avoid Problems in Interceptive Treatment. J. Maxillofacial Orthopedics. v(2):24-33, 1972.

36. Angle, E. H. Bone Growing. The Dental Cosmos. 52:262-267, 1910.

37. Spahl, T. H. The Straight Wire Appliance. The Clinical Management of Basic Maxillofacial Orthopedic Appliances. Witzig, J. W. and Spahl, T. W. P.S.G. Publishing. 1987, p. 502.

38. Nance, H. N. The Limitations of Orthodontic Treatment. Diagnosis and Treatment in the Permanent Dentition. Am. J. Orthod. Oral Surg., 33:253-300, 1947.

39. Riedel, R. A. Retention. Current Orthodontic Concepts and Techniques. Graber, T. M. and Swain, B. F. Eds. W. B. Saunders Co., 1975.

40. Shapiro, P. S. , Mandibular Dental Archform and Dimension; Treatment and Post-Retention Changes. Am. J. Orthod., 66:58-67, 1974.

41. Grieve, G. W. Some Theories Obstructing the Progress of the Science of Orthodontia. Int. J. Orthod. Oral Surg., 18:5-14, 1932.

42. Grieve, G. W. The Stability of a Treated Denture. Am. J. Orthod. Oral Surg., 30:171-195, 1944.

43. Steadman, S. R. Changes of Intermolar and Intercuspid Distances Following Orthodontic Treatment. Angle Orthod., 31:207-215, 1961.

44. Walter, D. C. Comparative Changes in Mandibular Canine and First Molar Widths. Angle Orthod., 32:233-241, 1962.

45. Bishara, S. E., Chadha, J. M. and Potter, R. B. Stability of Intercanine Width, Overbite and Overjet Correction. Am. J. Orthod., 63:588-595, 1973.

46. Strang, R. H. Factors of Influence in Producing a Stable Result in Treatment of Malocclusions. Am. J. Orthod., 32:313-332, 1946.

47. Weinstein, S., Haack, D. C., Morris, L. Y., Snyer, B. B. and Attaway, H. E. On an Equilibrium Theory of Tooth Position. Angle Orthod., 33:1-26, 1963.

48. Hellman, M. Changes in the Human Face Brought About by Development. Int. J. Orthodontia, 13:475, 1927.

49. Brodie, A. G. On the Growth Pattern of the Human Head From the Third Month to the Eighth Year of Life. Am. J. Anat., 68:209-262, 1941.

50. McInaney, J. B. An Examination and Re-Evaluation of the Dental Literature on the Subject of Expansion as an Orthodontic Treatment Procedure. The Journal of Maxillofacial Orthopedics, 2:27-31, 1969.

51. McInaney, J. G. Adams, R. M., and Freeman, M. , A Non-Extraction Approach to Crowded Dentitions in Young Children: Early Recognition and Treatment. J.A.D.A. 101:251-256, 1980.

52. Frankel, R. Decrowding During Eruption Under the Screening Influence of Vestibular Shields. Am. J. Orthod., 65:372-406, 1974.

53. Frankel, R. A Functional Approach to Orofacial Orthopedics. Br. J. Orthod., 7:41-51, 1980.

54. McDougall, P. D., McNamara, J. A., and Dierkes, J. M. Arch Width Development in Class II Patients Treated with the Frankel Appliance. Am. J. Orthod., 82:10-22, 1982.

55. Whitney, E. F., and Sinclair, P. M. An Evaluation of Combination Second Molar Extraction and Functional Appliance Therapy. Am. J. Orthod., 91:183-191, 1987.

56. Cetlin, N. M., and Ten Hoeve, A. Non-Extraction Treatment. J. Clin. Orthod., 17:396-413, 1983.

57. McCauley, D. R. The Cuspid and It's Function in Retention. Am. J. Orthod., 56:491-498, 1969.

58. Bishara, S. E. and Staley, R. N. Maxillary Expansion: Clinical Implications. Am. J. Orthod. Dentofac. Orthod. , 91:3-14, 1987.

59. Haas, A. J. Long Term Posttreatment Evaluation of Rapid Palatal Expansion. Angle Orthod. , 50:189-217, 1980.

60. Bell, R. A. A Review of Maxillary Expansion in Relation to Rate of Expansion and Patients Age. Am. J. Orthod. , 81:22-27, 1982.

61. Timms, D. J. A Study of Basal Movement with Rapid Maxillary Expansion. Am. J. Orthod. , 77:500-507, 1980.

62. Proffitt, W. R. Removable Appliances. Contemporary Orthodontics. C. V. Mosby Co. 1986, p. 276.

63. Moss, M. C. The Primary Role of Functional Matrices in Facial Growth. Am. J. Orthod. , 55:567-579, 1969.

64. Horowitz, I. and Hixon, E. An Approach to Diagnosis and Implications for Treatment. Horowitz, and Hixon, E., 1966, p. 369.

65. Sillman, J. H. Dimensional Changes of the Dental Arches: Longitudinal Study from Birth to 25 Years. Am. J. Orthod. , 50:824-842, 1964.

66. Lutz, H. D. and Poutlon, D. R. Stability of Dental Arch Expansion in the Deciduous Dentition. Angle Orthod., 55:299-3l5.

67. Hixon, E., and Klein, P. Simplified Mechanics: A Means of Treatment Based on Available Scientific Information. Am. J. Orthod., 62:113-141, 1972.

68. Owen, A. H. Morpologic Changes in the Transverse Dimension Using the Frankel Appliance. Am. J. Orthod., 83:200-217, 1983.

69. Knott, V. B. Longitudinal Study of Dental Arch Widths as Four Stages of Dentition. Angle Orthod., 42:387-394, 1972.

70. Frankel, R. Decrowding During Eruption Under the Screening Influences of Vestibular Shields. Am. J. Orthod., 65:372-406, 1974.

71. Riedel, R. A. A Review of the Retention Problem. Angle Orthod., 30:179-199, 1960.

72. Schulhof, R. J. , Lestrel, P. E., Walters, R., and Schuler, R. The Mandibular Dental Archform and Buccal Expansion.

73. Gardner, S. D., and Chaconas, S. J. Posttreatment and Post Retention Changes Following Orthodontic Therapy. Angle Orthod., 46:151-161, 1976.

74. Henry, R. G. A Study of Australian Children with Excellent Occlusion. Aust. Dent. J., 8:123-126, 1963.

75. Cristoloveanu, R., Demeter, M., and Voloc, H. Indicele Pont La Poputatia Din Tiirgu Mures. Stomat., 16:255--264, 1969.

76. Muhlberg, G., Brauninger, H., and Weiskopf, J. "Criticism of the Pont Index with Special Regard to Sex-linked Influence. Statistical Analysis of 417 Eugnathic Dentitions." Dtsch. Stomat.,19:689-700, 1969.

77. Joondeph, D. R., Moore, A. W., and Riedel, R. A. Use of Pont's Index in Orthodontic Diagnosis., J.A.D.A., 85:341-345, 1972.

78. Kutin, G., and Hawes, R. R., Posterior Cross-bites in the Deciduous and Mixed Dentitions. Am. J. Orthod., 56:491-504, 1969.

79. Worms, F. W., Speidel, T. M., Isaacson, R. J., and Meskin, L. H. Pont's Index and Dental Arch Form., J.A.D.A., 85:876-881, 1972

80. Gupta, D. S., Sharma, B. P. , and Aggarwal, S. P. Pont's Index as Applied to Indians. Angle Orthod., 49:269-271, 1979.

81. Bernsman, J. F. Anatomisch Korrekte Okklusion Und Ponscher Index. Zahnarztlishe Praxis (Berlin), 33:201-204, 1982.

82. Oliveira, O.L., Negra, E. S., and Aguiar, A. C. "Pont's Index in Brazilian Adults, Individuals, Whites, Negroes and Mulatoes." Arq. Cent. Est. Cur. Odont., 19:205-213, 1982.

83. Herberger, R. J., Stability of Mandibular Intercuspid Width After Long Periods of Retention, Angle Orthod., 51:78-83, 1981.

84. Haupl, K. Orthodontic Diagnosis. Textbook in Functional Jaw Orthopedics. Haupl, K., Grossman, W. J. and Clarkson, C. V. Mosby Co., 1951, p. 103.

85. Greve, K. Uber Die Gultigkeit Des Pontschen Index. Fortschr. Orthodontik, 3:163-186, 1933. Cited by Moorries, C. The Dentition of the Growing Child. Harvard Univ. Press, 1959.

86. Stifter, J. A Study of Pont's, Howe's, Rees', Niff's, and Bretton's Analysis of Clan I Adult Dentitions. Angle Orthod., 28:215-225, 1958.

87. Smyth, C., and Young, M. Facial growth in Children with Special Reference to Dentition - Medical Research Council, Special Report Series No. 171, London 1932, Cited by Horowitz and Hixon: The Native of Orthodontia Diagnosis. C. V. Mosby Co., 1966.

88. Korkhaus, G. Biomechanische Gebiss Und Kieferorthopadia. Handbuch der Zahaheilk. J. F. Bergman, Munich., Vol. IV, 1939. Cited by: Hotz, R: Orthodontia in Everyday Practice. J. B. Lippincott & Co., 1961.

89. Korkhaus, G. Fortschr. Zahnitk, 5:810, 1929.

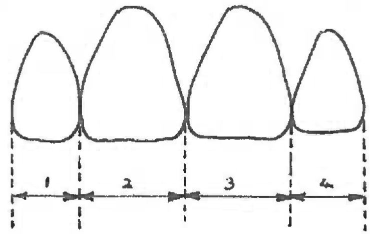
90. Greve, K. Fortschr. Orthodontik, 3:163, 1933.

91. Harth, G. Dtsch. Mscher. Zahnhk. 48:2537, 1930.

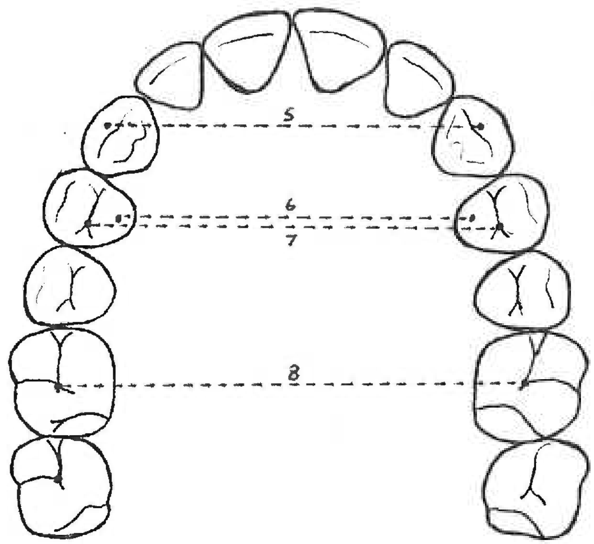
92. Linder, H. Fortschr. Orthodontik, 22:211, 1931.

Figure 1

PERMANENT DENTITION - ARCHWIDTH/TOOTH SIZE MEASUREMENTS



SI = 1 + 2 + 3 + 4



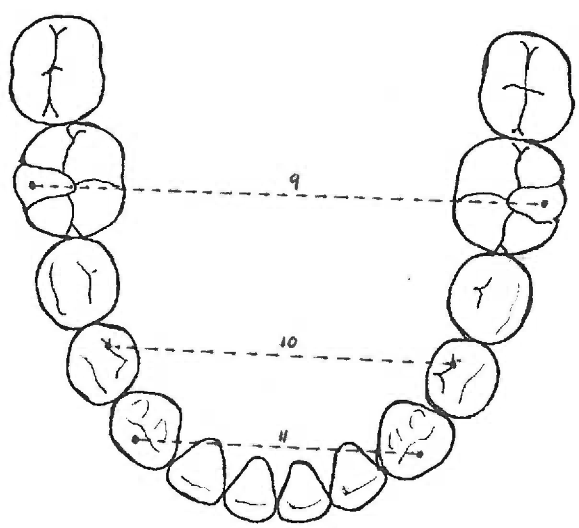


Figure 2

Mixed Dentition - Archwidth Measurements

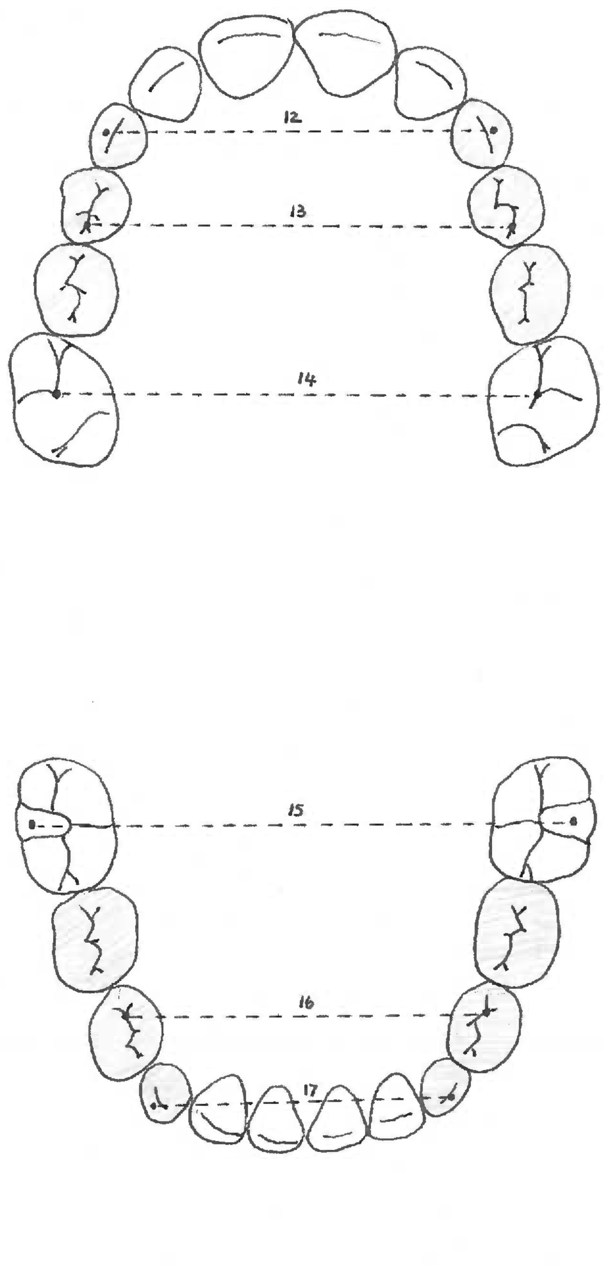


Figure 3

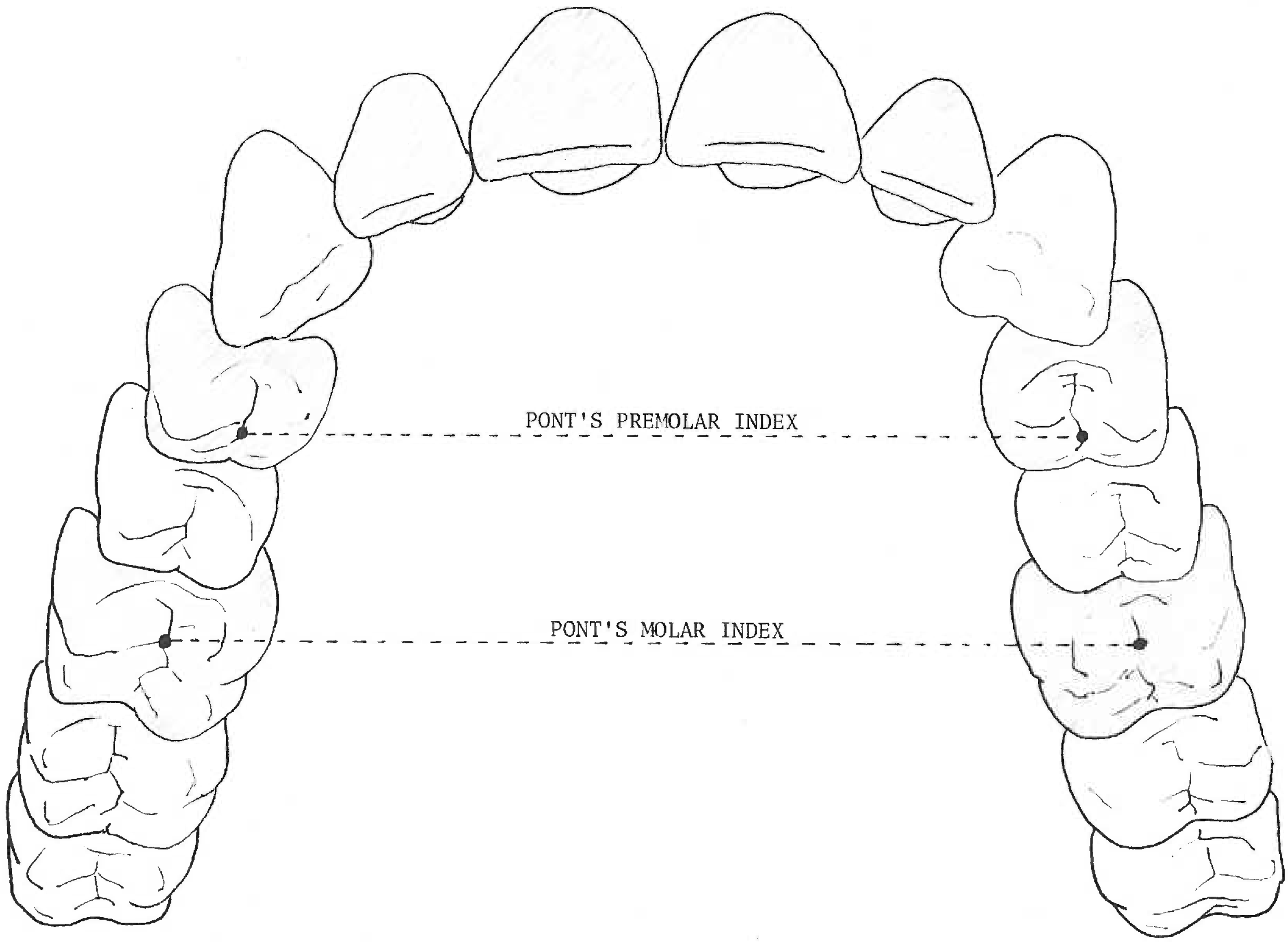


Figure 4

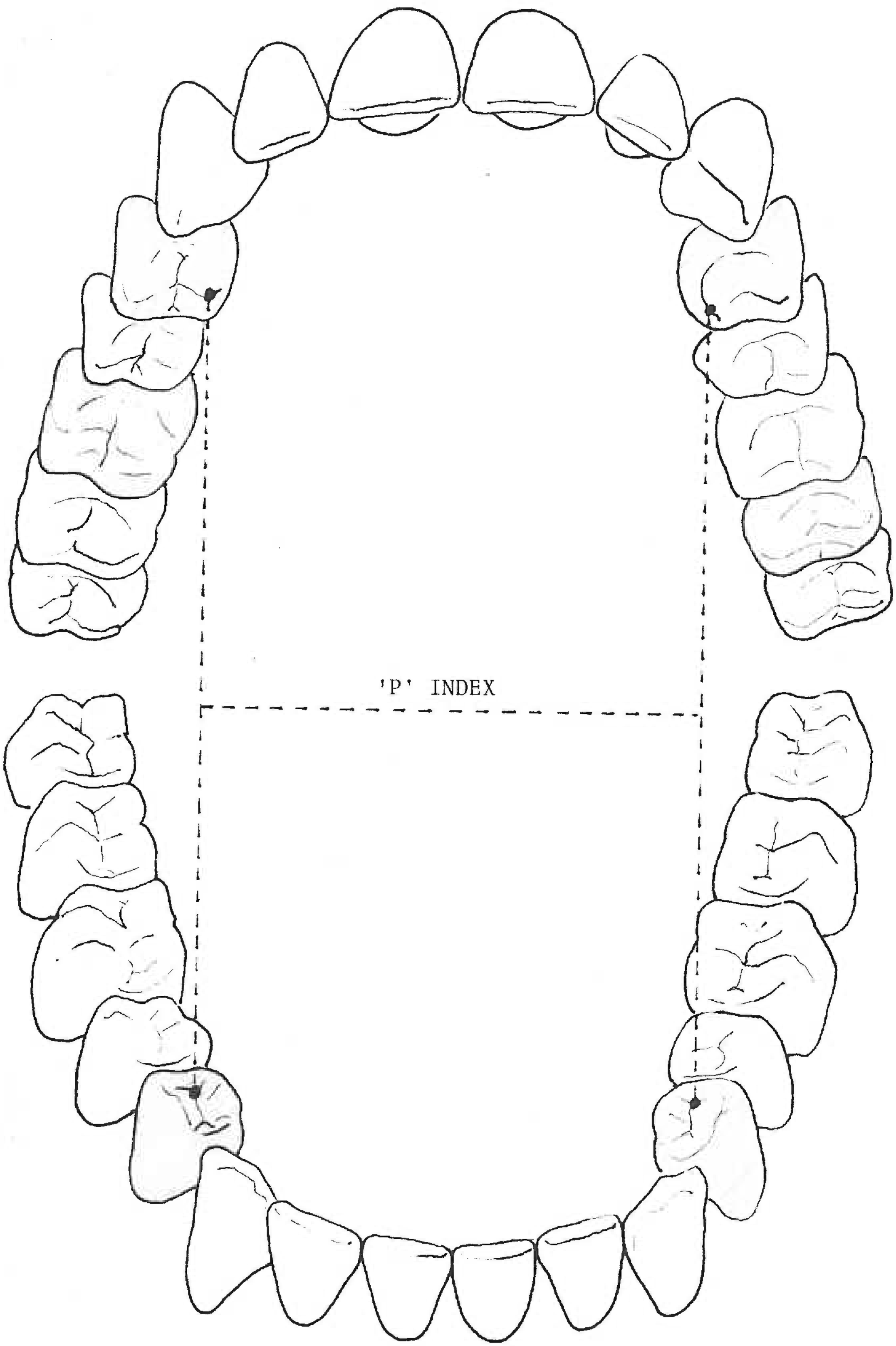
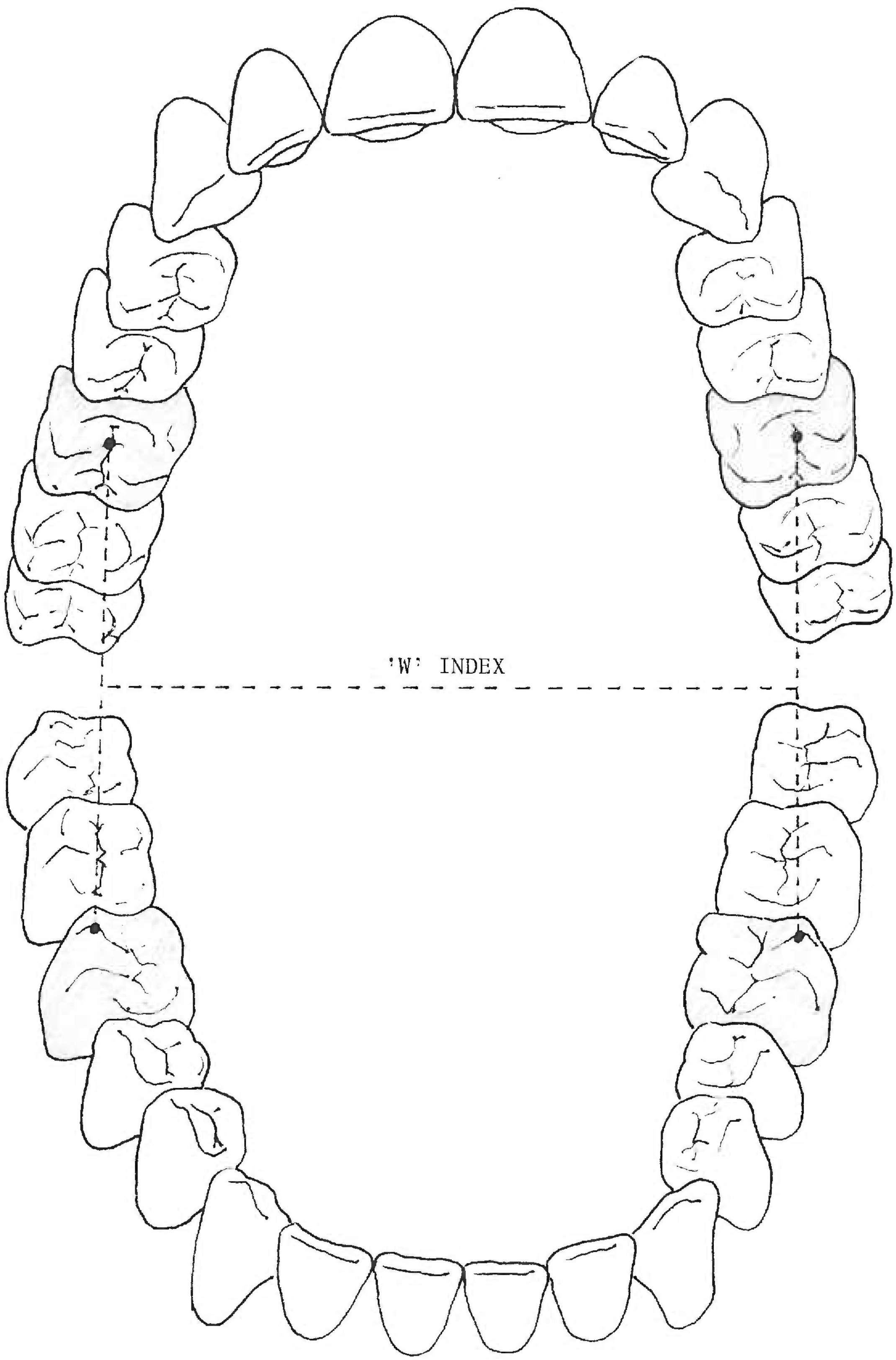


Figure 5



Scatter Plot and Regression Line Female Mandible 'P' 4-4 vs. Observed 4-4

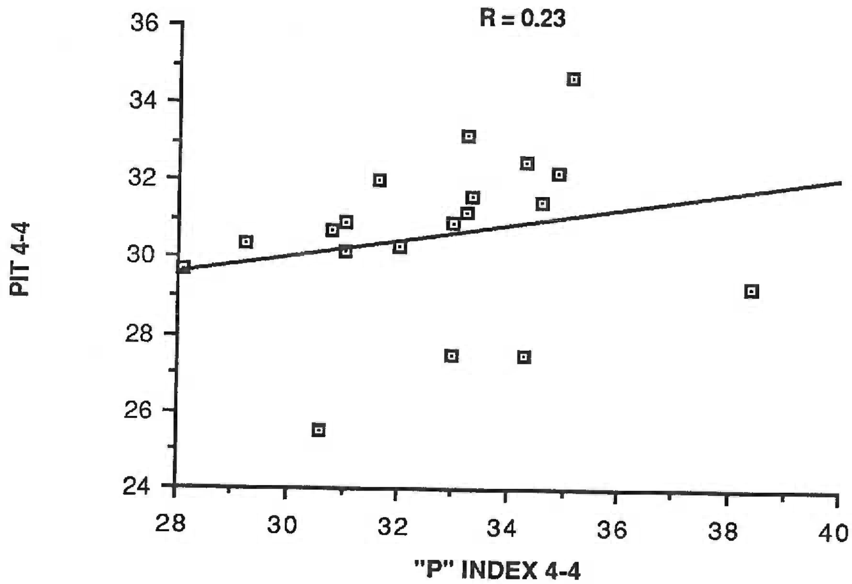


Figure 6

Scatter Plot and Regression Line Female Maxilla Ponts 4-4 vs. Observed 4-4

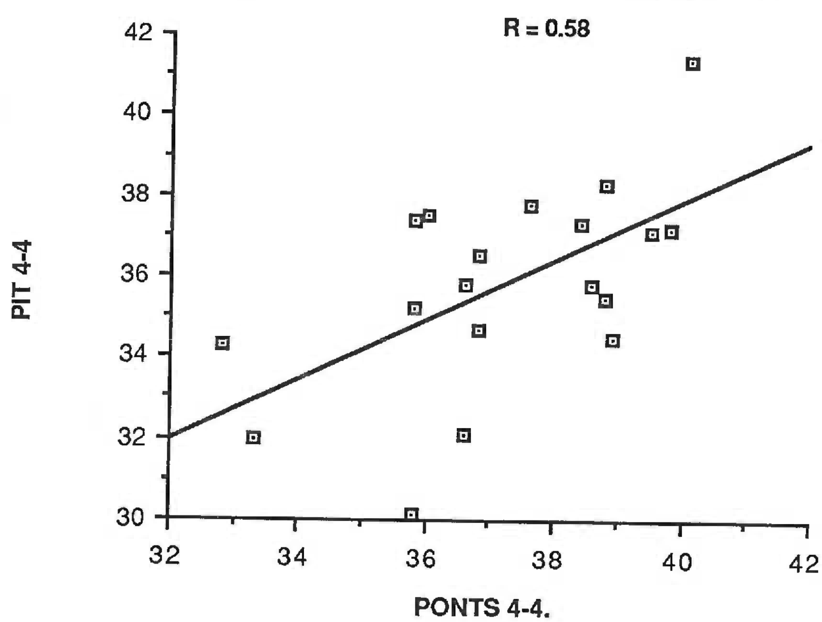


Figure 7

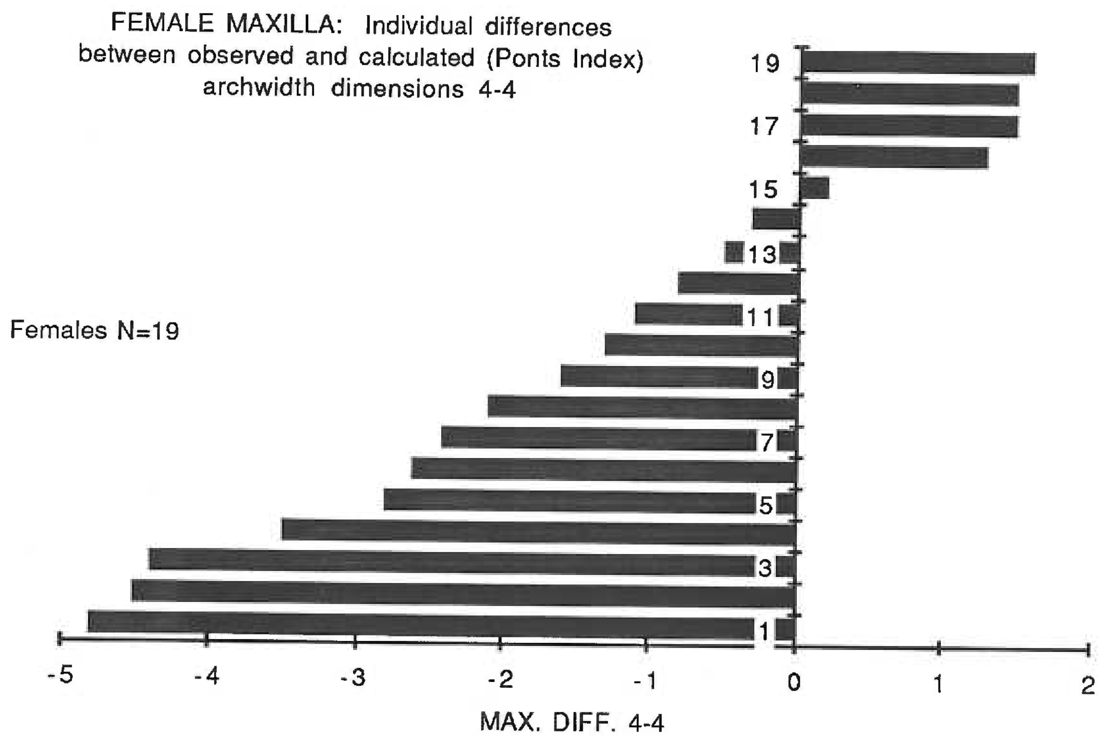

FEMALE MAXILLA: Individual differences
between observed and calculated (Ponts Index)
archwidth dimensions 4-4
Females N=19
19
17
15
13
11
9
7
5
3
1
-5
-4
-3
-2
-1
0
1
2
MAX. DIFF. 4-4

Figure 8

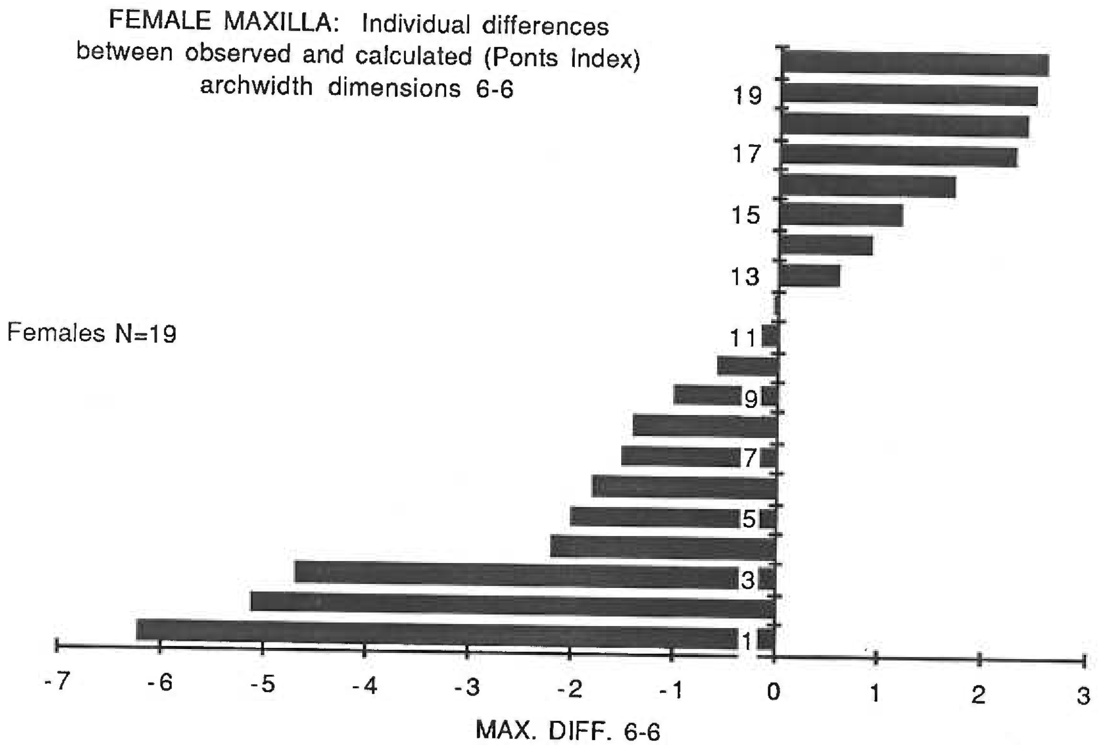

FEMALE MAXILLA: Individual differences between observed and calculated (Ponts Index) archwidth dimensions 6-6
Females N=19
19
17
15
13
11
9
7
5
3
1
-7
-6
-5
-4
-3
-2
-1
0
1
2
3
MAX. DIFF. 6-6

Figure 9

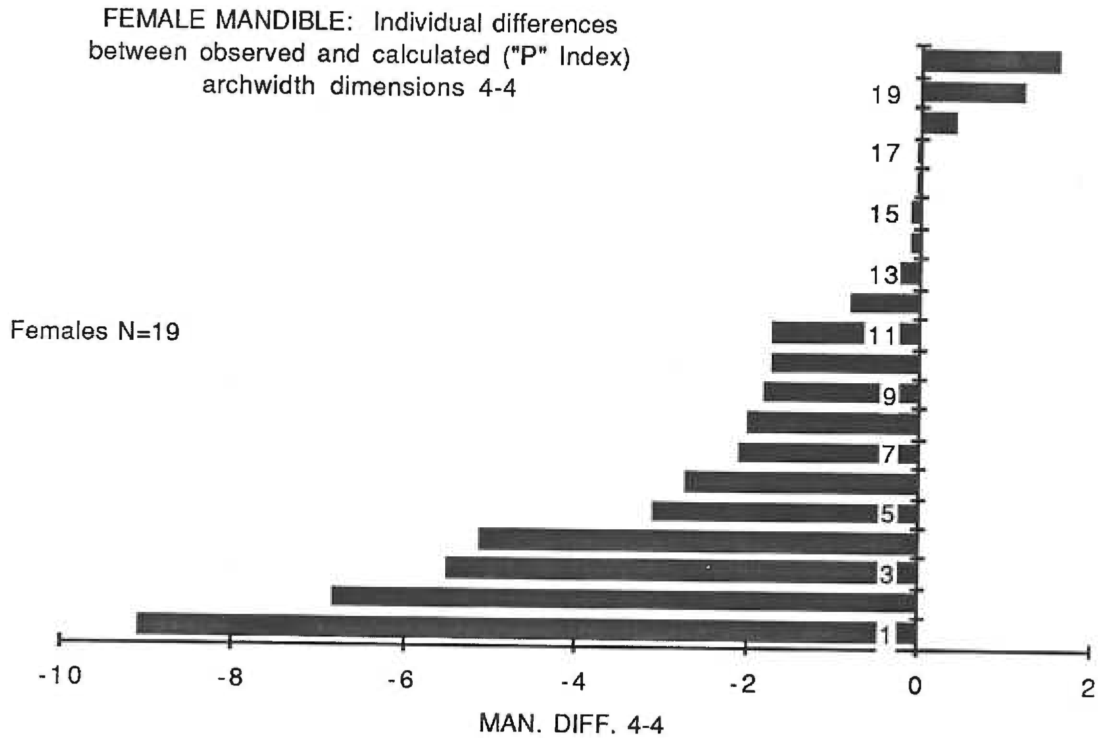

FEMALE MANDIBLE: Individual differences between observed and calculated ("P" Index) archwidth dimensions 4-4
Females N=19
19
17
15
13
11
9
7
5
3
1
-10
-8
-6
-4
-2
0
2
MAN. DIFF. 4-4

Figure 10

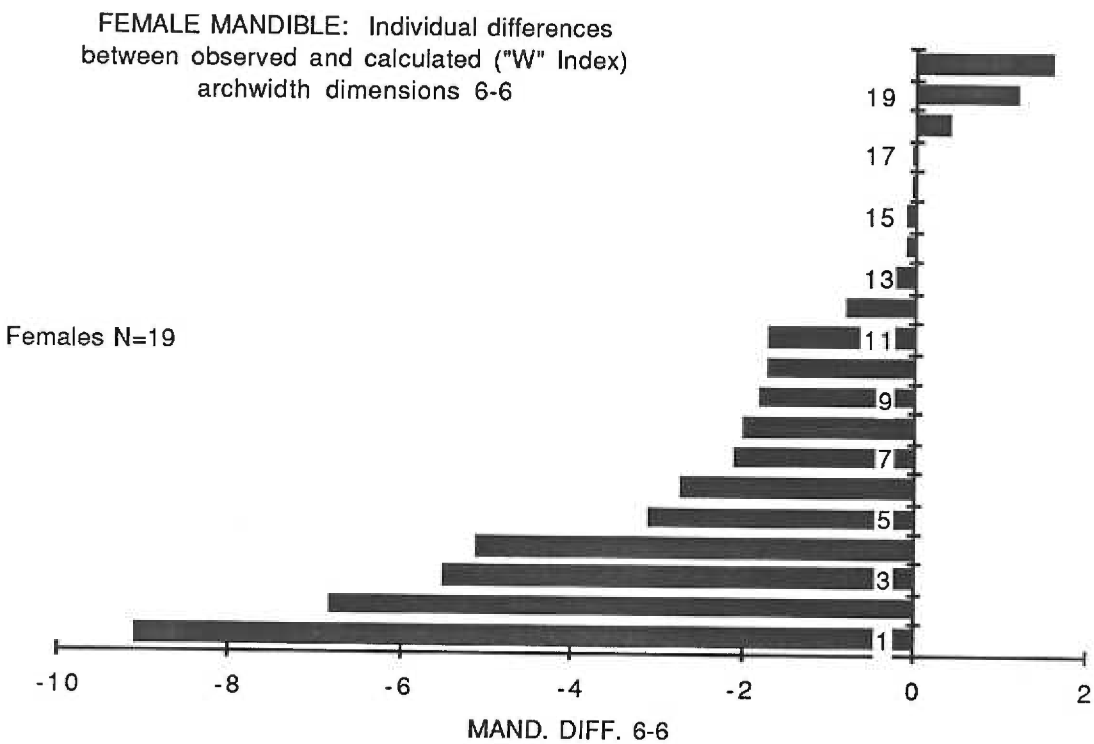

FEMALE MANDIBLE: Individual differences
between observed and calculated ("W" Index)
archwidth dimensions 6-6
Females N=19
19
17
15
13
11
9
7
5
3
1
-10
-8
-6
-4
-2
0
2
MAND. DIFF. 6-6

Figure 11

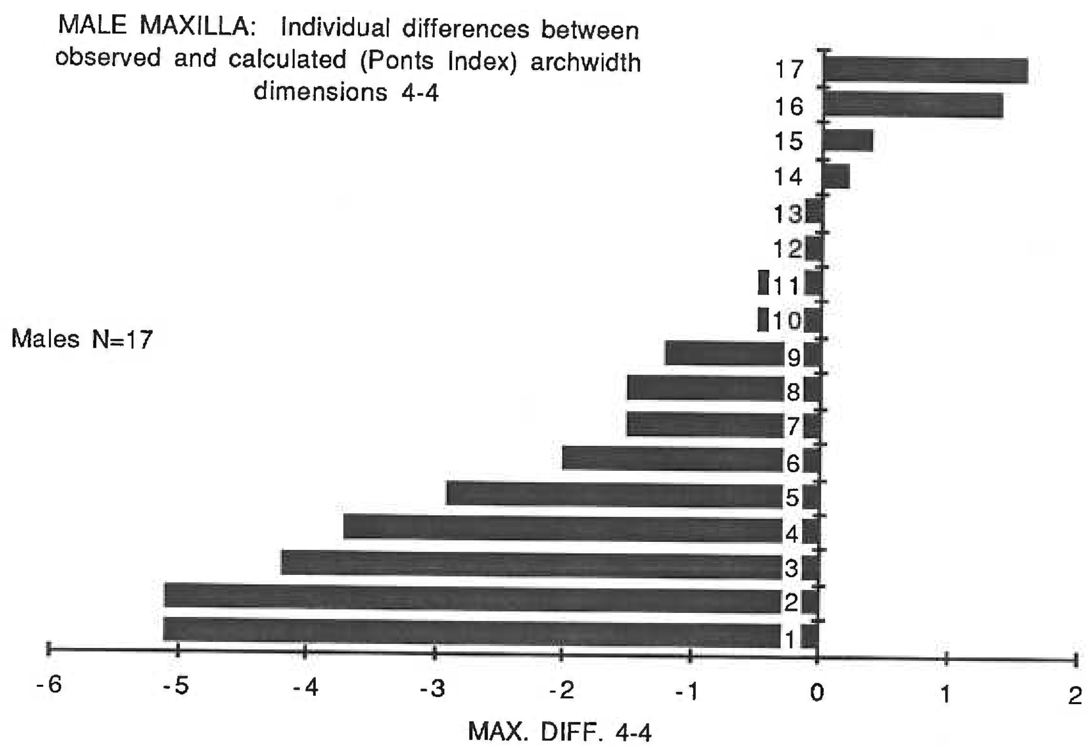

MALE MAXILLA: Individual differences between observed and calculated (Ponts Index) archwidth dimensions 4-4
Males N=17
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
-6
-5
-4
-3
-2
-1
0
1
2
MAX. DIFF. 4-4

Figure 12

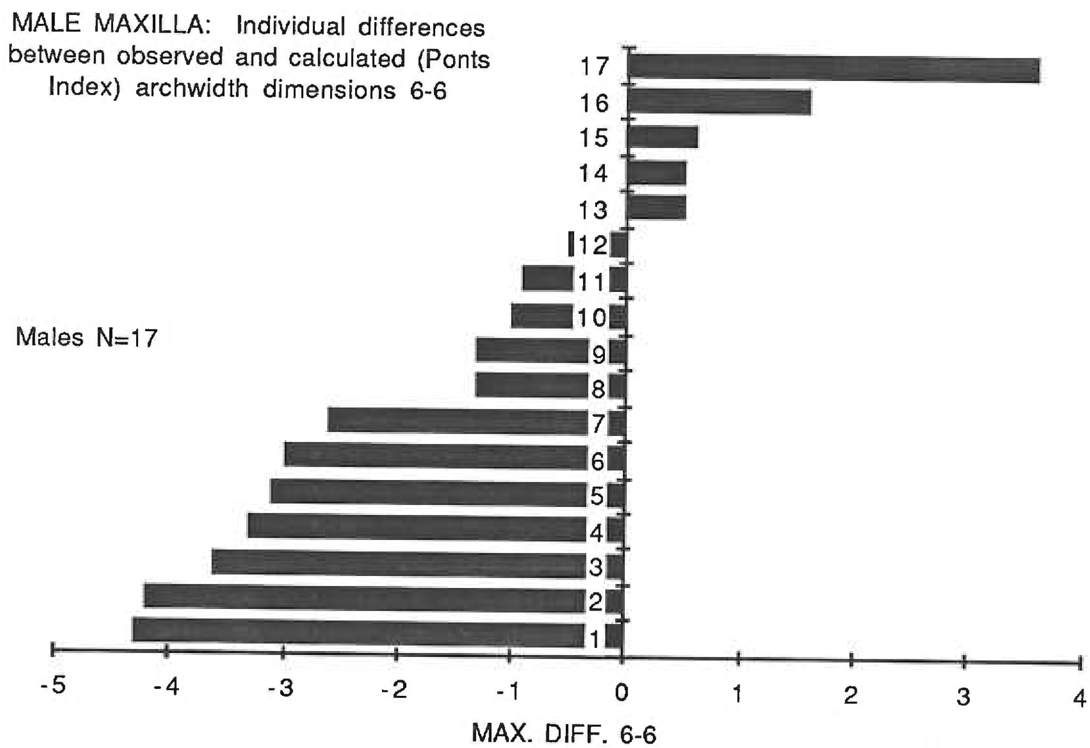

MALE MAXILLA: Individual differences between observed and calculated (Ponts Index) archwidth dimensions 6-6
Males N=17
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
-5
-4
-3
-2
-1
0
1
2
3
4
MAX. DIFF. 6-6

Figure 13

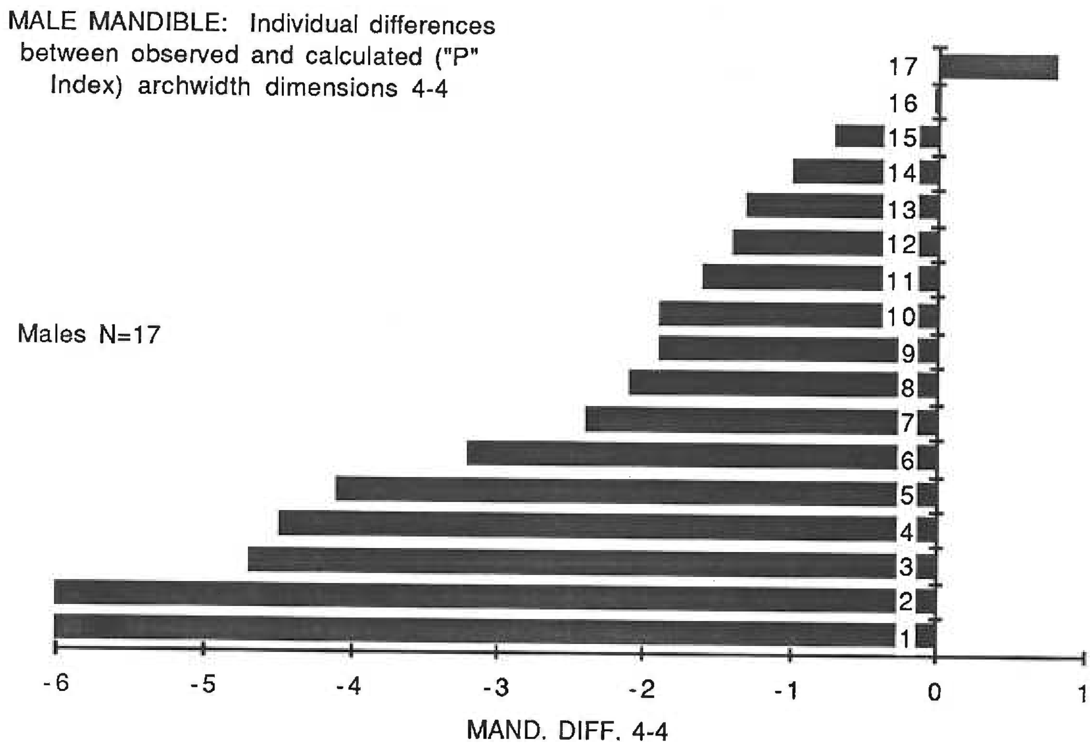

MALE MANDIBLE: Individual differences between observed and calculated ("P" Index) archwidth dimensions 4-4
Males N=17
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
-6
-5
-4
-3
-2
-1
0
1
MAND. DIFF. 4-4

Figure 14

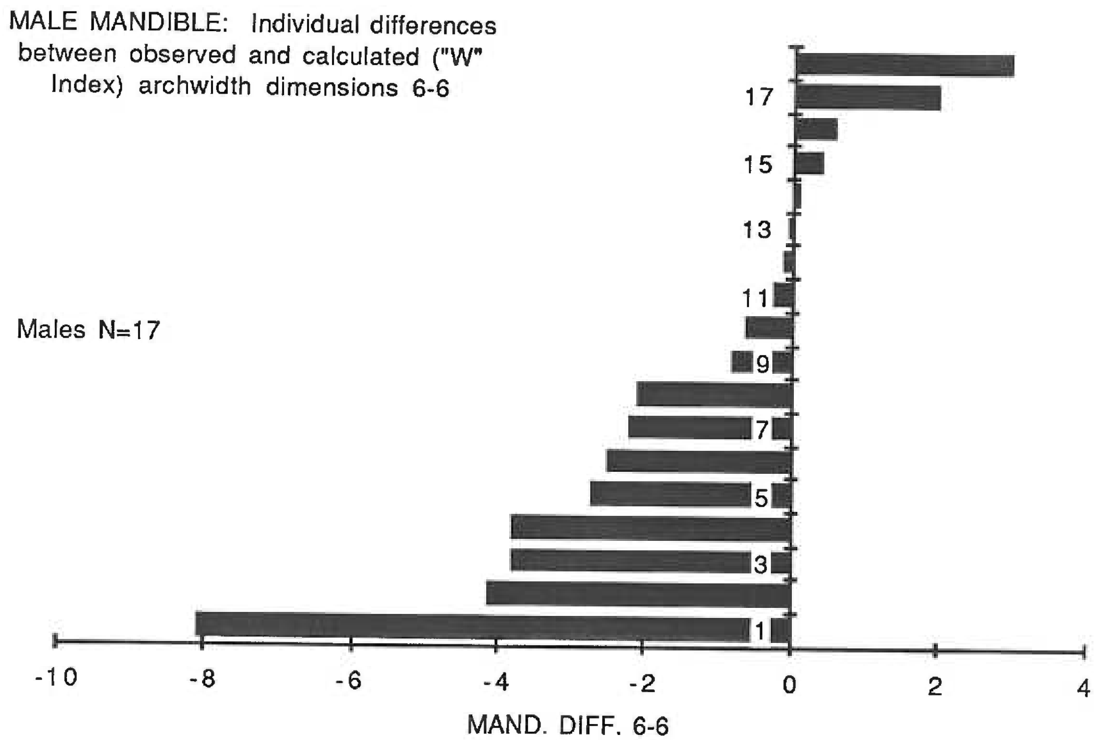

MALE MANDIBLE: Individual differences between observed and calculated ("W" Index) archwidth dimensions 6-6
Males N=17
17
15
13
11
9
7
5
3
1
-10
-8
-6
-4
-2
0
2
4
MAND. DIFF. 6-6

Figure 15

Mandibular Mean Archwidth. Permanent Dent. Male and Female.

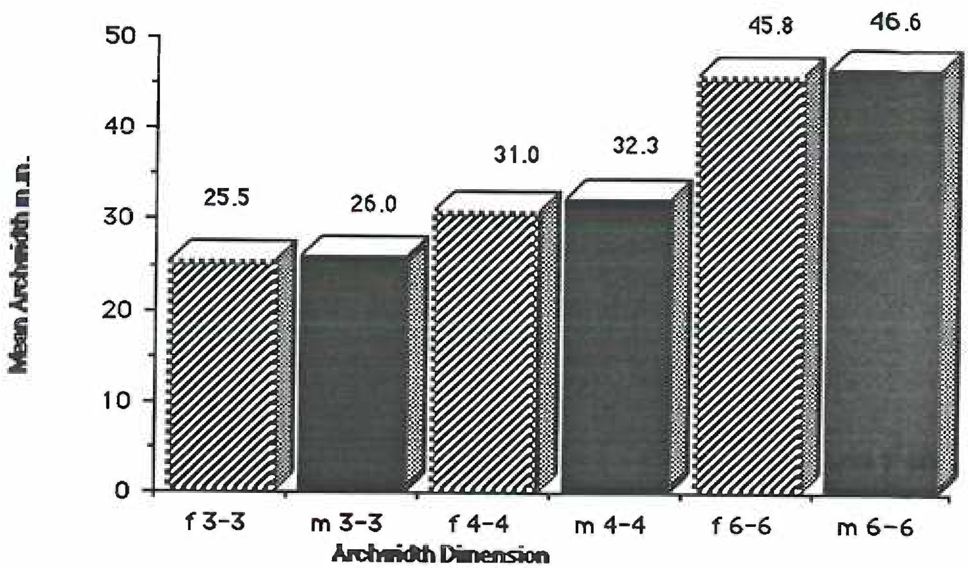


Figure 16

Maxillary Mean Archwidth. Permanent Dent. Male and Female.

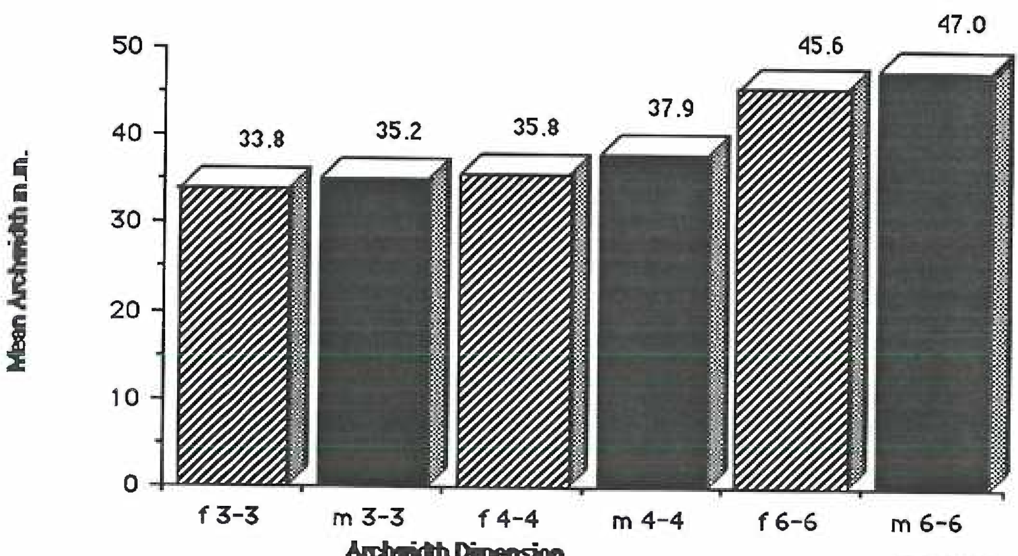


Figure 17

Maxillary Mean Archwidth Differences between 9 years and 14 years. Male and female

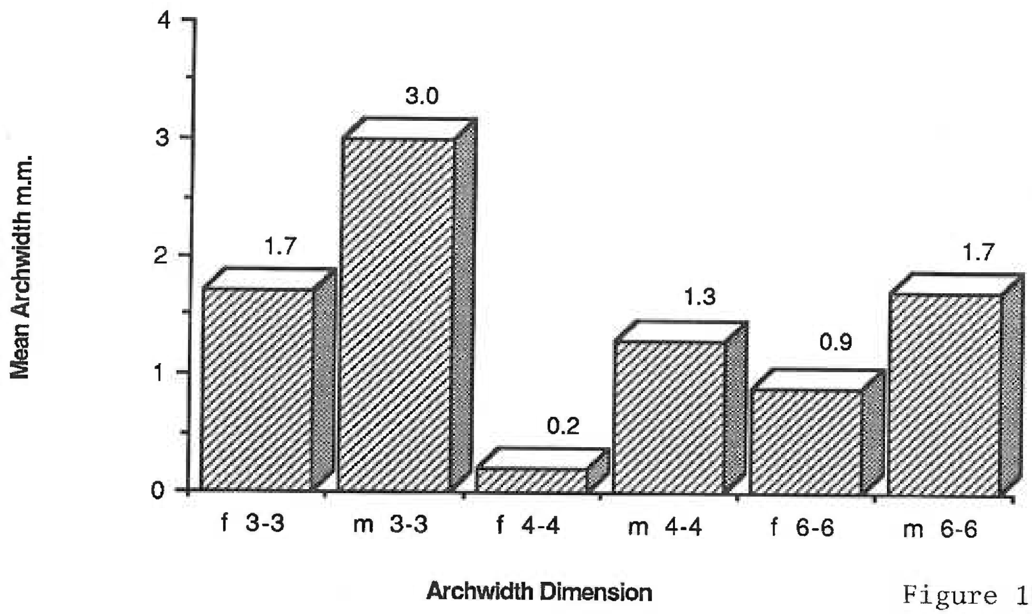


Figure 18

Mandibular Mean Archwidth Differences Between 9 years and 14 years. Male and female.

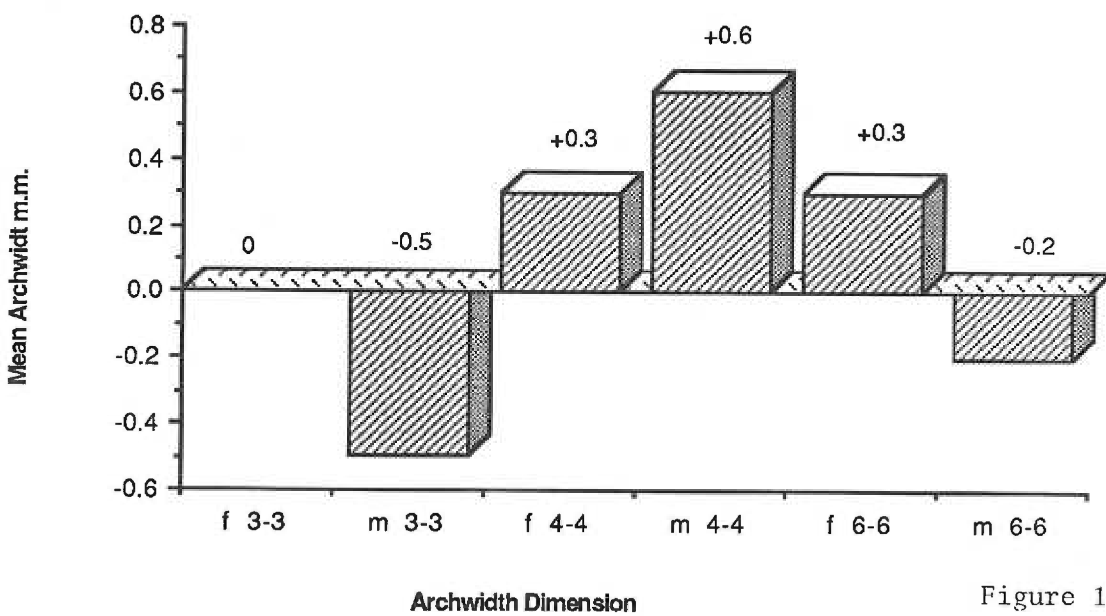


Figure 19

TABLE 1: PONT'S INDEX STUDIES

STUDY	SAMPLE	RESULTS & CONCLUSIONS
(1) PONT 1909[1]	FRENCH N = ?	Determined a constant ratio between (1) The width of the four maxillary incisors and; (2) the width of the maxillary arch.
(2) HENRY 1963[74]	AUSTRALIAN N = 60	Philosophically agrees with validity of Pont's Index. Modified Ponts Premolar Index 81 and Molar Index 63 for Australian 12 year old children.
(3) CRISTOLOVEANU[75]	CZECH? N = 200	Individual variation so great that Pont's Index is useless. Assesses both upper and lower archwidth.
(4) MULHBERG 1969[76]	E. GERMAN N = 417	Low correlation coefficients - Ponts of no predictive value. Sex linked differences tooth size. A "classic" study in terms of sample size and statistical integrity.
(5) JOONDEPH[3,77] ET AL 1970/1972	U.S. N = 20	Original mandibular archwidth should form template for upper archwidth to ensure maximim stability of treatment results. Pont's Index of no value in predication of maxillary arch width.
(6) WORMS ET AL[79] 1972	U.S. N = 204	The use of Pont's Index scientifically invalidated.
(7) GUPTA 1979[80]	INDIAN N = 100	Misinterpretation of low correlation coefficients, i. e., Pont's Index a reliable clinical tool.
(8) BERNSMAN 1982[81]	W. GERMAN N = 13	Vast individual variability of archwidth changes during mixed dentition over 3 year period. Pont's Index useless as a clinical tool.
(9) OLIVEIRA 1982[82]	BRAZILIAN N = 111	

TABLE 2

CORRELATION COEFFICIENTS DERIVED FROM PONT'S INDEX STUDIES

STUDY		CORRELATION	'r' VALUE	SAMPLE DESCRIPTION
1. MULHBERG [76]	1969	Σ2112* to 4-4**	♂ 0.43 ♀ 0.36	EAST GERMAN/US ADOLESCENTS N=204 N=213 Normal (eugnathic) occlusions
		Σ2112 to 6-6***	♂ 0.35 ♀ 0.33	
2. JOONDEPH et al 1970/1972 [3,77]		Σ2112 to 4-4 10 years retent	0.29	AMERICAN WHITES-Age not specified N=20 Malocclusions treated non-extraction
		Σ2112 to 6-6 10 years retent	0.22	
		Pont's Ideal 4-4 to 4-4 10 yrs retent	0.23	
		Pont's Ideal 6-6 to 6-6 10 yrs retent	0.20	
3. WORMS et al [79]	1972	Pont's 4-4 to 4-4 Navajo	♂ 0.24	AMERICAN INDIAN 11-21 years N=51
		Pont's 6-6 to 6-6 Navajo	♂ 0.06	
		Pont's 4-4 to 4-4 Navajo	♀ 0.13	AMERICAN INDIAN 11-21 years N=40
		Pont's 6-6 to 6-6 Navajo	♀ 0.17	
		Pont's 4-4 to 4-4 Dental Students	♂ 0.25	WHITE AMERICAN DENTAL STUDENTS N=113 All ideal occlusions
		Pont's 6-6 to 606 Dental Students	♂ 0.28	
4. GUPTA et al [80]	1979	Σ2112 to 4-4	0.46	INDIAN-Age & sex not considered N=100 Normal occlusions A complete permanent dentition except for third molars
		Σ2112 to 6-6	0.49	
CITED STUDIES				
5. SMYTHE & YOUNG [87]		Σ2112 to 4-4	0.40	ENGLISH-Age & sex? N=? Cited Horowitz & Hixon 1966
		Σ2112 to 6-6	0.40	
6. GREVE [85,90]	1933	Σ2112 to 4-4	-0.34	GERMAN-Age & sex? N=102 Perfect occlusions Cited Joondeph et al 1970
		Σ2112 to 6-6	0.24	

*Σ2112 the sum of the mesiodistal widths of the four maxillary incisors
** Maxillary first interpremolar archwidth
*** Maxillary first intermolar archwidth

Table 3

Correlation Co-Efficients (r) between the Calculated (Pont's, 'P' and 'W' Indices) and Observed InterarchWidths

Sample Group	Arch	Interarch Width	r	Index
Males N = 17	Maxilla	Interpremolar	0.46	Ponts
		Intermolar	0.54	Ponts
	Mandible	Interpremolar	0.49	'P'
		Intermolar	0.45	'W''
Females N=19	Maxilla	Intermolar	0.58	Ponts
		Interpremolar	0.52	Ponts
	Mandible	Interpremolar	0.23	'P'
		Intermolar	0.54	'W'

Table 4

Maxilla
Archwidth Comparisons between Mixed (9 years) and Permanent (14 years) Dentitions

MALE

Archwidth Comparison	Mixed Dent. Archwidth m.m.	Permanent Dent. Archwidth m.m.	Mean Diff.	t Test
C-C vs 3-3	32.2 ±1.4	35.2 ±1.7	3.0	p<.001*** n=17
D-D vs 4-4	36.6 ±1.7	37.9 ±2.2	1.3	p<.05* n=17
6-6 vs 6-6	46.1 ±1.6	47.8 ±2.0	1.7	p<.05* n=17

FEMALE

Archwidth Comparison	Mixed Dent. Archwidth m.m.	Permanent Dent. Archwidth m.m.	Mean Diff.	t Test
C-C vs 3-3	32.1 ±1.9	33.8 ±2.2	1.7	p<.001*** n=15
D-D vs 4-4	35.6 ±2.4	35.8 ±2.7	0.2	NS n=14
6-6 vs 6-6	44.7 ±2.1	45.6 ±3.0	0.9	p<.01** n=19

Table 5

Mandible
Archwidth Comparisons between Mixed (9 years) and Permanent (14 years) Dentitions

MALE

Archwidth Comparison	Mixed Dent. Archwidth m.m.	Permanent Dent. Archwidth m.m.	Mean Diff.	t Test
C-C vs 3-3	26.5 ± 1.6	26.0 ± 1.5	-0.5	NS n=16
D-D vs 4-4	31.7 ±1.9	32.3 ±1.6	0.6	NS n=15
6-6 vs 6-6	46.4 ±1.9	46.6 ±2.5	-0.2	NS n=17

FEMALE

Archwidth Comparison	Mixed Dent. Archwidth m.m.	Permanent Dent. Archwidth m.m.	Mean Diff.	t Test
C-C vs 3-3	25.5 ±2.2	25.5 ±2.0	0	NS n=10
D-D vs 4-4	30.7 ±1.9	31.0 ±1.9	0.3	NS n=15
6-6 vs 6-6	45.5 ±2.3	45.8 ±2.9	0.3	NS n=19

Table 6
Differences between Calculated and Observed Archwidth values m.m.

Ponts Index Maxilla Male n=17		Ponts Index Maxilla Female n=19		'P' Index Mandilble Male n=17		'W' Index Mandible Female n=19	
4-4	6-6	4-4	6-6	4-4	6-6	4-4	6-6
-5.1	-4.3	-4.8	-6.2	-6.0	-8.1	-9.1	-4.8
-5.1	-4.2	-4.5	-5.1	-6.0	-4.1	-6.8	-4.1
-4.2	-3.6	-4.4	-4.7	-4.7	-3.8	-5.5	-3.1
-3.7	-3.3	-3.5	-2.2	-4.5	-3.8	-5.1	-1.6
-2.9	-3.1	-2.8	-2.0	-4.1	-2.7	-3.1	-1.1
-2.0	-3.0	-2.6	-1.8	-3.2	-2.5	-2.7	-0.9
-1.5	-2.6	-2.4	-1.5	-2.4	-2.2	-2.1	-0.5
-1.5	-1.3	-2.1	-1.4	-2.1	-2.1	-2.0	-0.5
-1.2	-1.3	-1.6	-1.0	-1.9	-0.8	-1.8	-0.4
-0.5	-1.0	-1.3	-0.6	-1.9	-0.6	-1.7	+0.1
-0.5	-0.9	-1.1	-0.4	-1.6	-0.6	-1.7	+0.2
-0.4	-0.5	-0.8	+0.6	-1.4	-0.1	-0.8	+1.6
-0.2	+0.5	-0.5	+0.9	-1.3	+0.1	-0.4	+2.1
+0.2	+0.5	-0.3	+1.2	-1.0	+0.4	-0.1	+2.5
+0.4	+0.6	+0.2	+1.7	-0.7	+0.6	-0.1	+2.6
+1.4	+1.6	+1.3	+2.3	0	+2.0	0	+2.7
+1.6	+3.6	+1.5	+2.4	+0.8	+3.0	+0.4	+3.6
		+1.5	+2.5			+1.2	+3.9

Appendix A
Age Composition of Male Study Cast Sample. N=17

Name	C.S.C I.D.#	Age Mixed Dent.	Age Perm. Dent.
1. J. Barrier	21-1	9-1	14-0
2. Te. Belieu	26	9-0	14-0
3. T. Blickenstaff	27	8-4	14-0
4. A. Carich	56	9-1	14-0
5. J. Chale	60	8-11	14-0
6. D. Evelsizer	82.1	8-0	13-2
7. W. Farnham	89	9-0	14-0
8. J. Ferrarin	89.2	9-1	14-0
9. N. Fink	100	9-0	14-1
10. S. Garner	108	9-2	14-0
11. D. Hicks	126	9-1	14-0
12. T. Kelley	155.2	9-1	14-1
13. D. Moore	193	9-1	14-1
14. C. Moore	194.1	9-0	13-7
15. J. Shindler	254	9-11	15-2
16. J. Winters	309	9-0	14-1
17. C. Woodburn	312	9-0	14-0

Mean Age Mixed Dentition 8 Years 11 Months

Range 8 Years 0 Months - 9 Years 11 Months

Age Permanent Dentition 14 Years 1 Month

Range 13 Years 2 Months - 15 Years 2 Months

Appendix B
Age Composition of Female Subjects. N = 19

Name	C.S.C. I.D.#	Age Mixed Dent.	Age Perm. Dent.
1. J. Beavert	25	9-0	14-11
2. Tr. Belieu	27	9-1	14-0
3. J. Blickenstaff	35	9-0	13-0
4. J. Burgeson	47	9-0	13-2
5. C. Bursel	51	9-0	13-0
6. Sh. Collins	61	10-0	14-0
7. Su. Collins	62	10-0	14-0
8. K. Elesizex	83	8-0	13-0
9. K. Formoso	99	9-0	14-0
10. L. Hill	122	9-0	13-10
11. T. Kennedy	158	9-1	14-0
12. J. Moore	196.1	9-0	15-3
13. E. Morse	206	9-0	13-11
14. M. Morterud	213	9-1	14-0
15. S. Porter	239	9-0	14-10
16. T. Sakarai	250-2	9-0	14-0
17. D. Schoenecker	251-1	9-0	14-6
18. J. Snyder	266	9-2	14-0
19. L. Tegart	290	9-0	15-0

Mean Age Mixed Dentition 9 Years 1 Month

Range 8 Years 0 Months - 10 Years 0 Months

Mean Age Permanent Dentition 13 Years 11 Months

Range 13 Years 0 Months - 15 Years 3 Months