



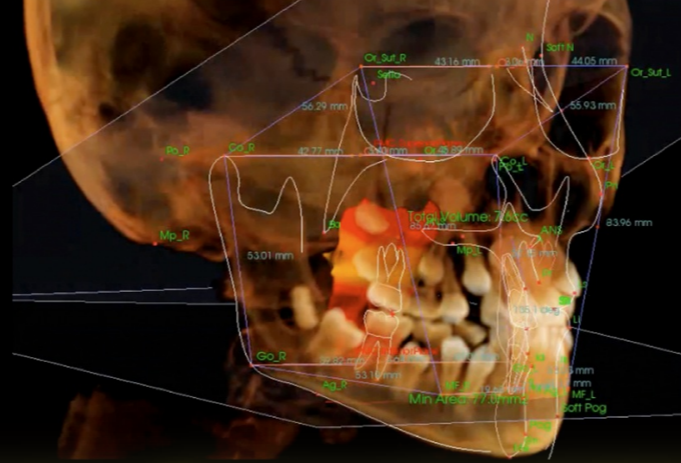
Are Contemporary Occlusion Concepts Valid In An Asymmetric World?

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3D OSA

Orthodontic Symmetry Analysis



OSI 3D

Orthodontic Symmetry Index

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Introduction

Having practiced orthodontics for more than four decades, I have been continually searching for answers! Is there unequivocal evidence of the existence of “ideal occlusion”? Are current or past prosthetic-driven occlusion principals valid? Do anterior guidance, CPO “cuspid protected occlusion” and other occlusion concepts really exist? Why do some orthodontic cases finish with near perfect interdigitation with “ideal” anterior guidance, bilateral balanced or canine protected occlusal schemes? Can occlusion principals really exist without skeletal symmetry?

General dentists and dental specialists can be profoundly influenced by their dental school education, expert-espoused occlusion dogma and personal clinical experiences. In some cases occlusion becomes their obsession or religion. We all strive to create healthy beautiful smiles with the best possible function. Sometimes we may not be able to achieve “ideal occlusion”. Why?

This preliminary study of orthodontic pre-treatment asymmetry is an attempt to “quantify” the “Why”

Evolution of the 3D Symmetry Analysis – Visual 3D OSA

This project started in January of 2008. This was the year I was initially introduced to 3D CBCT imaging by my dental student sons, Jonathan and Jason. Their dental schools were early adopters of CBCT imaging. When developing the orthodontic symmetry analysis (Visual 3D OSA) we consulted several well-known educators and technical experts in their fields. We worked very closely with Anatomage, San Jose, California. At the time, Brendon Bengsten was one of CEO, Jack Choi’s, first Invivo Application Specialists. Brendon was instrumental in helping us design and implement Visual 3D OSA. In addition, we attended several 3D imaging conferences. Doctor Paul Ouellette conducted on site and long distant telephone interviews with CBCT experts such as Ed Lin, DDS, MS, Sean Carlson, DDS, MS, Randy Womack, DDS, Robert Boyd, DDS, MS, Ed Mills, DDS, Scott Ganz, DDS, MS, Marty Levin, DDS, MS and numerous other 3D imaging pioneers. Doctor James Mah, Chairman UNLV Orthodontic Department helped us with the statistical analysis of our data. We attended a Bioblock Orthotropics Symposium that featured the well-known American Anthropologist, Professor Emeritus, Robert Corruccini, Southern Illinois University-Carbondale. We also communicated by email with his esteemed colleague, Peer Moore-Jansen, Chairman Department of Anthropology, Wichita State University. At the Orthotropics Symposium we had the opportunity to consult with Doctors John and Michael Mew from London. Doctor William Hang’s presentation was enlightening and helpful. Selection of anatomical landmarks, analysis protocol and proposed study conclusions evolved using many of our consultant’s clinical experiences and suggestions. Visual 3D OSA is just the beginning of our search for evidence that will hopefully support our conclusions.

Smile Enhancement Therapy

Reference: Marc Ackerman's paperback book, *Enhancement Orthodontics*, Amazon

Dentofacial Traits - Does Ideal Occlusion Exist?

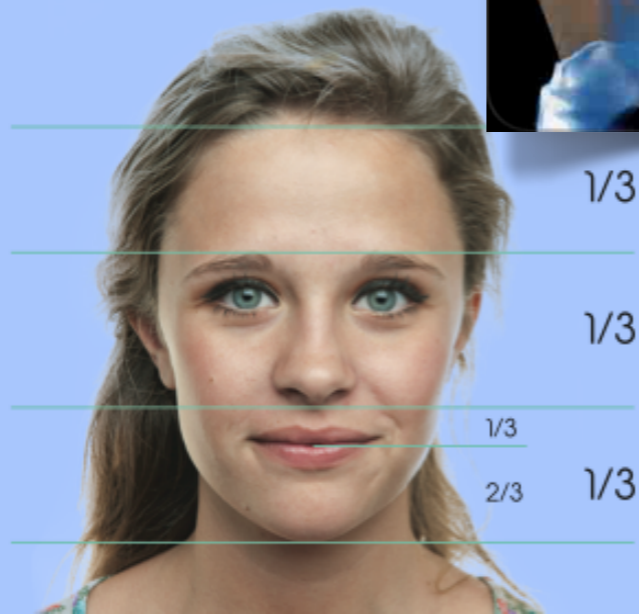
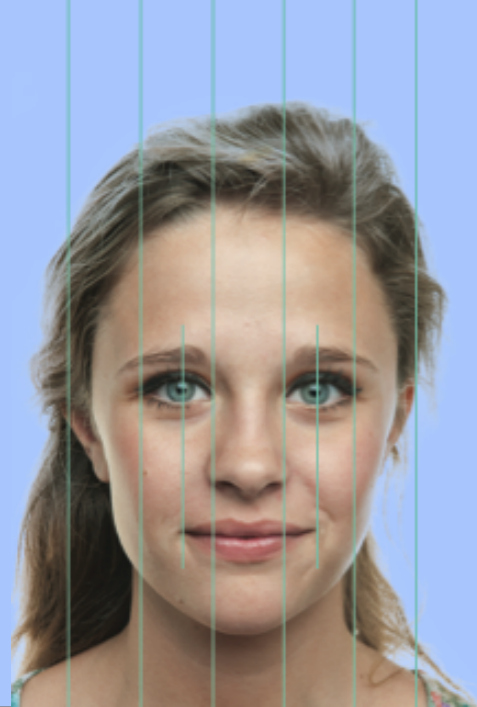
Orthodontic patients present with diverse mixtures of "dentofacial traits". A dentofacial trait is a hard or soft-tissue characteristic, or combination of characteristics, that distinguish an individual's facial appearance and determines their level of oral and social function. Some traits are directly inherited from biological parents, while other traits come from previous generations. These traits make each of us unique and beautiful from within our own personal genome.

The orthodontist attempts to treat every case to the current "standard of care", or to current occlusion (bite) philosophies proposed or mandated by universities, dental literature, clinical studies, textbooks, dental boards, as well as communications with other orthodontic and cosmetic dentist colleagues. Current orthodontic philosophy has evolved from concepts related to Prosthetic Dentistry (replacement and modification of missing or damaged teeth) and to Victorian Era concepts espoused by Edward Angle (Angle 1899) and others.

The concept of what is normal occlusion (a normal bite relationship) by Doctor Angle has been the foundation of the orthodontic and cosmetic dental profession for over 100 years. Previously accepted concepts of occlusion are rapidly changing as we become aware of evidence-based studies and the evolution of contemporary occlusion concepts.

Lindsey's Near Perfect Symmetry

1/5 1/5 1/5 1/5 1/5



Anatmage Invivo5, San Jose, Ca

Malocclusion (Bad Bite) is NOT a disease state! A closer look at occlusion concepts.

For more than 40 years Doctor Ouellette Sr. has had the privilege of modifying and creating more than 15,000 beautiful smiles. Throughout Dr O's career he frequently noticed some cases did not completely correct. "We were not able to achieve ideal occlusion". Why did this happen?

In 2008, the authors began using 3D CBCT imaging with the goals of providing a more comprehensive pre-treatment diagnosis and to identify evidence to document patients' symmetry or asymmetries. Is it possible to predict which cases can be completely resolved to a "perfect bite". Do asymmetries play a role in treatment outcomes? Is it possible to "describe - and **preferably quantify** - variations in occlusion"? (Ref: Isaacson et al, 1975)

Doctor Paul Ouellette and his two sons, Doctors Jason and Jonathan developed a 3D Cephalometric analysis of 121 pre-treatment CBCT images. Their goal was to identify and "quantify" existing asymmetries and create the **OSI - Orthodontic Symmetry Index**.

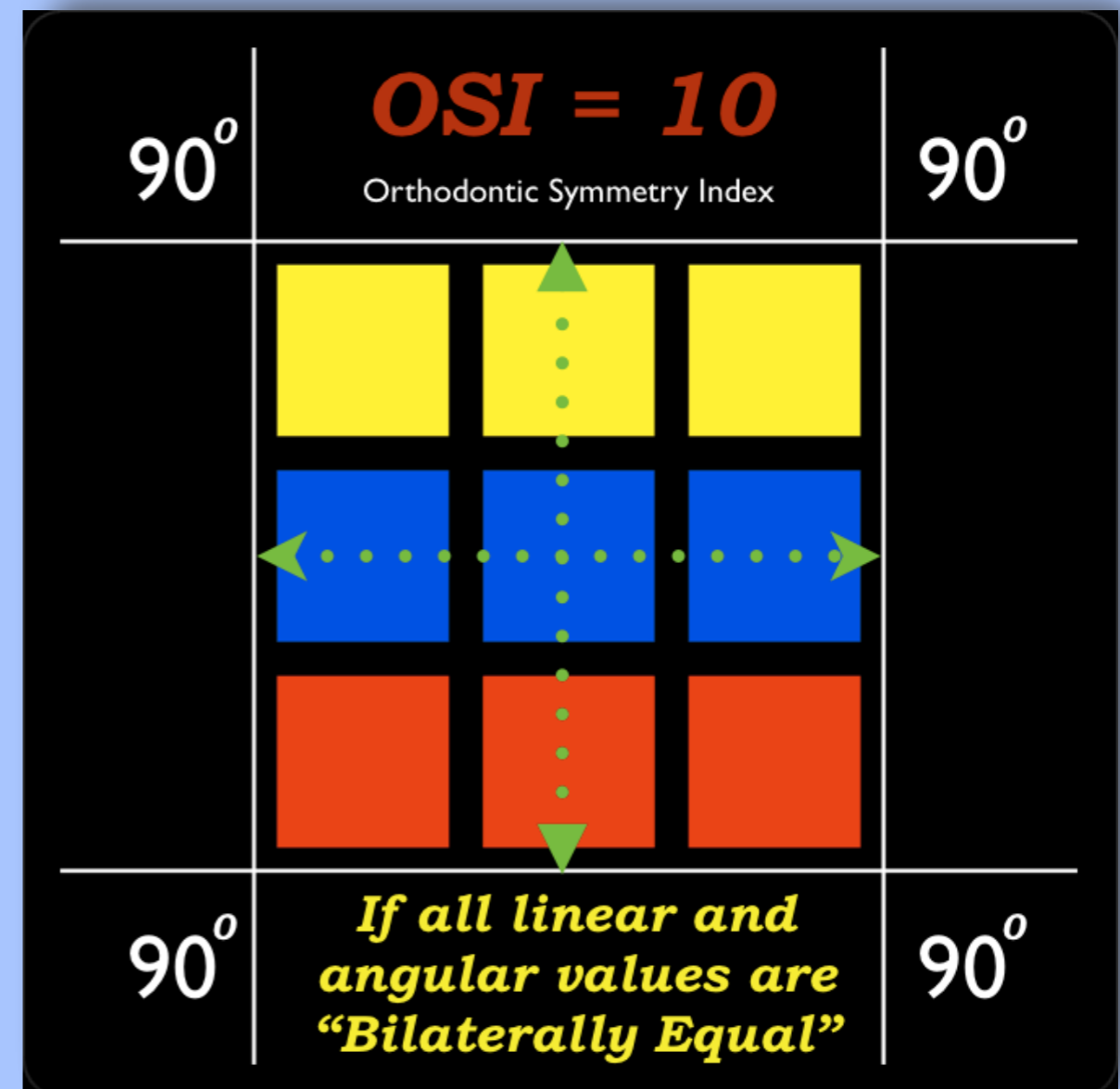
Does the perfect 10 exist?

The Polymorphic Cuboidal Analysis

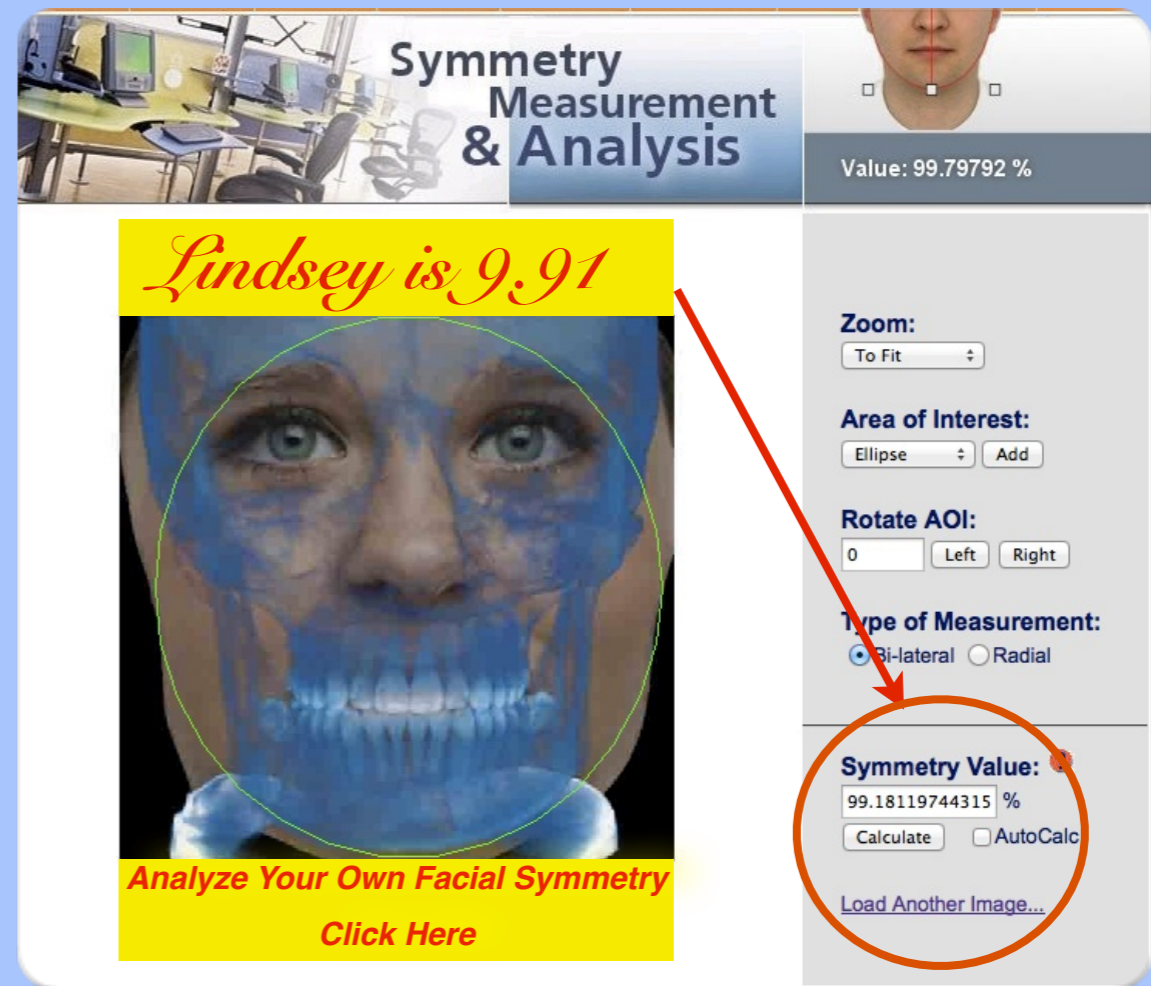
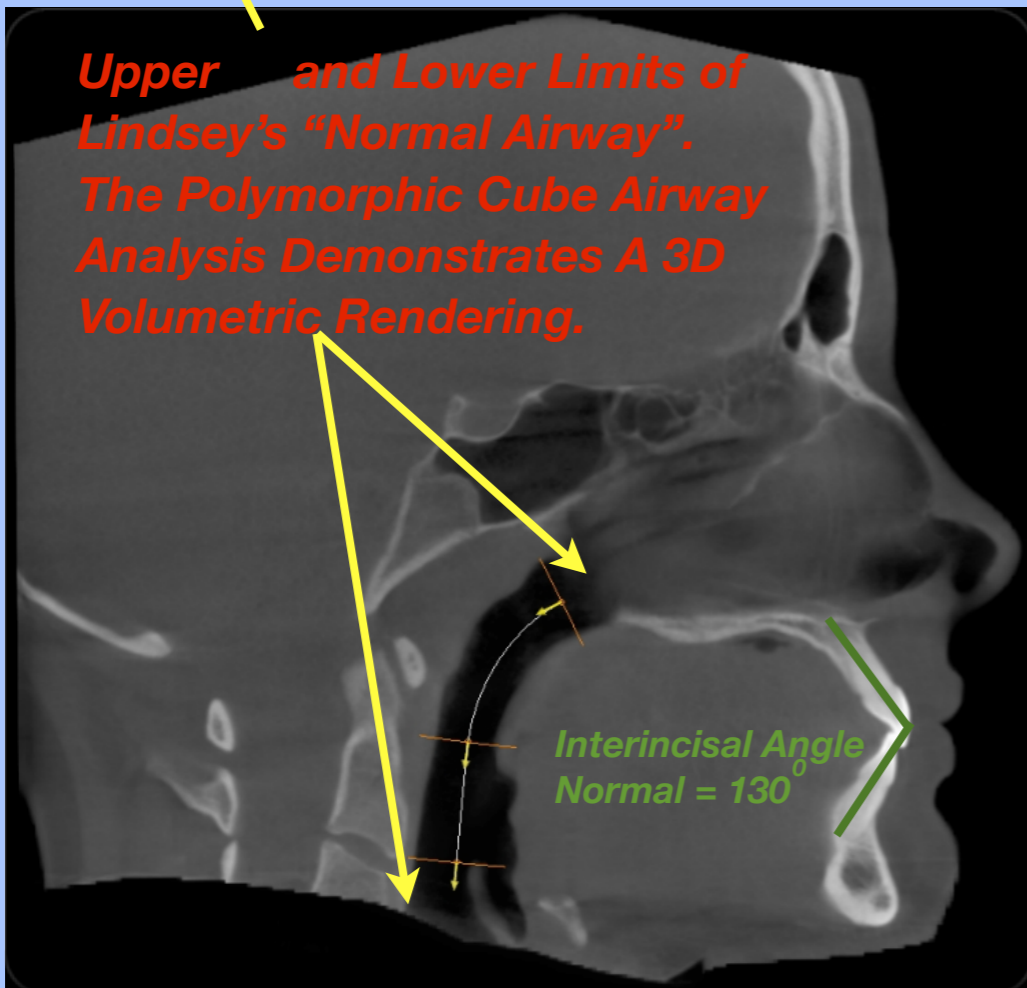
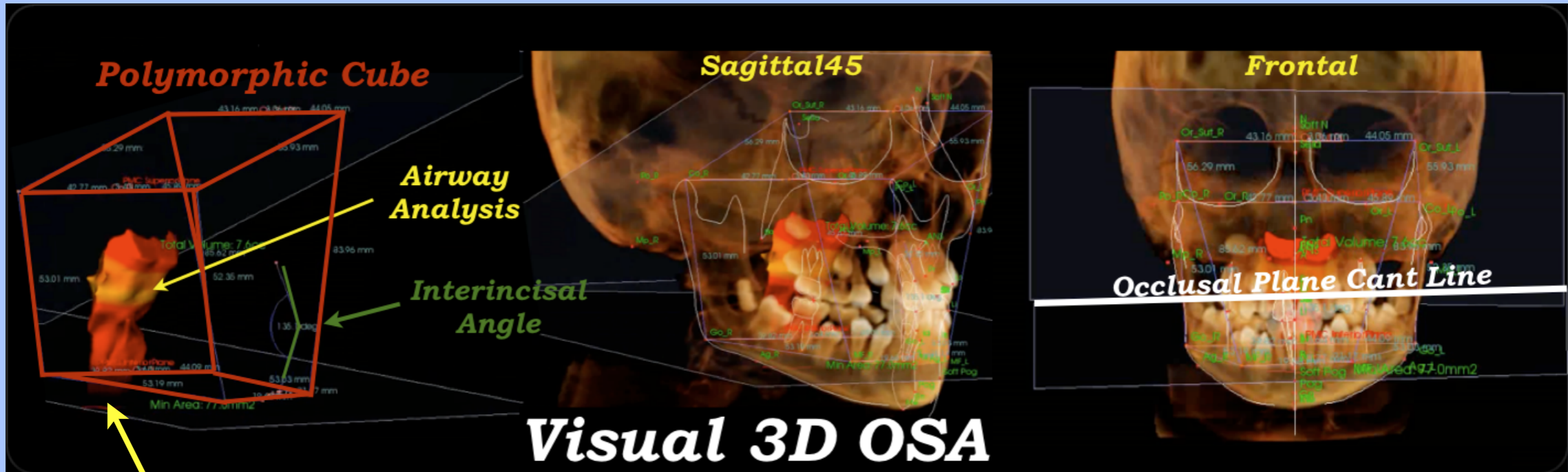
Cephalometrics (Cephalo = Skull; Metrics = Measure) is the scientific analysis of anatomical dimensions of the human skull using medical type radiographs. Orthodontists, Oral and Plastic Surgeons are the biggest users of cephalometrics. For more than 70 years orthodontists have used 2D cephalometrics to measure and treatment plan 3D problems. The advent of 3D CBCT imaging has now made it possible to use 70 years of 2D cephalometric research to aid in the development of modern 3D cephalometric analyses. 3D imaging has taken much of the "guesstimating" out of orthodontic diagnosis and treatment planning.

When developing the **OSA- Orthodontic Symmetry Analysis** the concept of the "**Polymorphic Cube**" was proposed by the authors. Utilizing bilateral (both sides of the skull) paired (same landmark on each side of skull) anatomical landmarks, a virtual Rubik's-like Polymorphic cube is constructed in the maxillary and mandibular anatomical space. If one exhibits "perfect symmetry", ALL cuboidal measurements would be equal in ALL planes of space. In addition, the "Polymorphic Cube" would be precisely positioned at right angles (90 degrees) in the space it occupies between the right and left condyles of the mandible. Our interpretation of a patient's orthodontic problem also takes into consideration the influence of genetics, postural and environmental influences. The Polymorphic cube is subject to changes or "**morphing**" and it can be quantified in exact measure.

Polymorphic Cube "**Anterior**" the position of the maxillary and mandibular central incisors is analyzed. 3D OSA measures the interincisal angle using right upper and lower central incisors. Polymorphic Cube "**Posterior**" the patient's airway is easily viewed and analyzed. Total airway volume and the most constricted point is measured in the 3D OSA. Thus, we screen our patients for potential OSA problems (Obstructive Sleep Apnea). See images that follow:

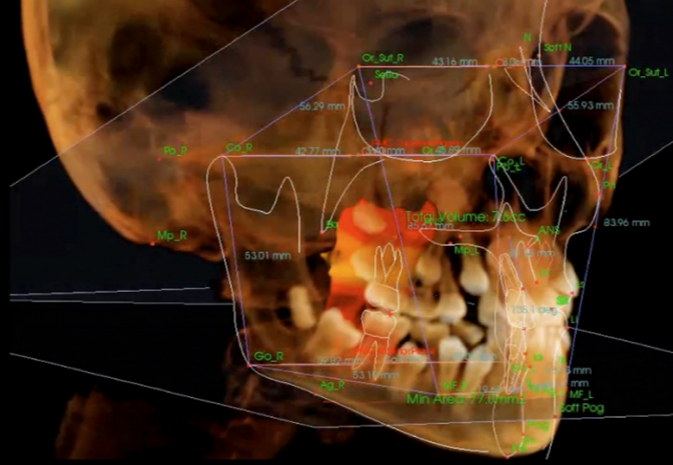


3D Orthodontic Symmetry Analysis includes the "Polymorphic Cube", Airway Analysis and Interincisal Angle Assessment. 3D OSA of the patient's pre-orthodontic symmetry gives us the ability to identify occlusal plane tips or cants, maxillary and mandibular tipping or torsion of a patient's anatomical components that may affect the preliminary diagnosis, treatment plan and final treatment result.



3D OSA

Orthodontic Symmetry Analysis



OSI 3D

Orthodontic Symmetry Index

Pre-Study Email Communications

Subject: 3D CBCT Study
Date: Fri, 22 Oct 2010 22:05:18 PM

Hi Doctor Corruccini:

I really enjoyed your presentation today. My sons (both future orthodontists) and I are doing a study using Anatomage Invivo5 software (Anatomage.com) San Jose, Ca) to analyze 120+ Cone Beam Volumes (Orthodontic patients) to study anatomical variation. We plan to use paired bilateral landmarks to be measured in relation to the midsagittal plane. Our thesis is "Anatomical Variation is the Norm". Class I occlusion may be the treatment goal for all orthodontists. but in nature Class I may not be the norm. Only a small percentage of the population has "ideal Class I occlusion".

As you know the lateral cephalogram has been historically used as the "gold standard" in orthodontic cephalometric analysis. Many of the speakers at the Orthotropics Symposium this week stated that conventional cephalometrics using a lateral cephalogram is not a dependable measure of true anatomical morphology. Our 3D CBCT analysis will hopefully create a new "standard of care" for cephalometric analysis. Initially, we want to create the "Symmetry Index" for the orthodontic patient using 3D CBCT scans.

As I said to you after your presentation, I would hope you could help us create an accurate 3D cephalometric analysis that would quantify the degree of anatomical variation an orthodontic patient has prior to the orthodontist formulating his preliminary diagnosis and treatment plan. You mentioned the "F" / Variation test in your presentation today. Would it be possible to create a "symmetry index" for an orthodontic patient prior to formulating a treatment plan?

With your permission, I plan to spotlight your previous contributions to the orthodontic literature in our study. In addition, I have been communicating with one of your colleagues, Doctor Peer Moore-Jansen. We also hope to work with Doctor Moore-Jansen as we design our study and report our results to our colleagues.

Thank you again for any help you can provide.

Paul

Paul L. Ouellette, DDS, MS

On 9/10/2010, Doctor O wrote:

Hi Peer:

Again thank you for your comments! The only reason I use Basion is due to the widespread acceptance in my profession of this landmark as one of the tried and true (probably not true) landmarks in cephalometrics. I am very open to considering other more easily reproducible landmarks. I will start looking for hornion in my next 3D tracings. If it is easier to find than basion I will use it in our analysis.

I have a teleconference with Brendon at Anatomage this week. I will discuss your suggestion with him. In addition, what would you suggest for the most easily reproducible "paired landmarks"...i.e....R L mental foramen, R L gonion, R L condylion, R L zygomatic lateral landmarks, etc.?

Have a great weekend!
Paul



We used an "out of the box" research protocol to gather information for our study. In addition to a thorough online literature search, we visited several universities and practices of early adopters of CBCT imaging. We attended every possible 3D imaging meeting. Telephone interviews, exchanging emails and live interviews with pioneers in 3D technology were performed by Dr. O Sr.

Sent: Fri, Sep 10, 2010
Subject: Re: landmarks/asymmetry

Paul:

I watched the video you sent me. I am definitely interested in providing you with whatever help I can. You refer to basion as your 2rd point for the plane, and I suggest that you consider my comments about the differences among the definitions of basion and select the more reproducible and consistent of them. Have you considered hormion at the base of the vomer? It is more anterior than is basion, but it is easy to define.

Peer

Peer H. Moore-Jansen

Subject: Re: landmarks/asymmetry
Date: Tue, 7 Sep 2010 09:07:36 AM

Hi Peer,

Thank you for your help as we navigate through our project. I like the idea of the transmeatal axis as a transverse plane. Orthodontists in the past used the ear positioning rods on the Cephalometer as a cephalometric landmark -- Porion. With the 3D analysis (and 2D Digital Images) we now use the superior rim of the external auditory meatus for Porion Right and Porion Left..."paired landmarks." In order to create a plane in the Anatomage 3D software you have to choose a third point, probably basion. What do you suggest?

I do not want to begin the tracing of all our volumes until Anatomage creates a way of adjusting landmark positions at the end of the tracing session prior to saving the data. As I stated before, my sons and I were not able to produce consistent tracings from one operator to the other, at least in our hands.

I contacted Brendon at Anatomage last week and asked if he and one of his colleagues, Roger would be able to trace the 120 volumes using our Orthodontic Symmetry Index analysis. Prior to outsourcing the volume tracing to Anatomage I would like to work with you and your team to select the most reproducible "paired landmarks" for the analysis.

I will put together a list of our proposed landmarks and have you give us your feedback. Of course, we will give you and your department full credit in any future publications for your contributions to the study.

Thank you again for your help!

Paul

Sent: Mon, Sep 6, 2010 11:58 PM
Subject: RE: landmarks/asymmetry

Paul:

If you stay in touch. I will work with you along the way. What did you think of the "transmeatal axis" as a transverse reference plane? Either way I am glad to know you are in receipt of my email.

Peer

Peer H. Moore-Jansen

Subject: Re: landmarks/asymmetry
Date: Sun, 5 Sep 2010 11:01:44 AM

Hi Peer,

Thank you for your comments.

I will carefully read your email and take all your suggestions into consideration. I agree with your suggestion to use the Basion Nasion sagittal plane as one of our main reference planes. My problem has been to consistently & accurately locate Basion with the current version of the Anatomage 3D Cephalometric application. When the user completes his or her landmark inputs in the 3D application selected planes can be displayed on the monitor screen. Most of my early 3D analysis tracings exhibited landmarks that were slightly off by 1 to 3 mm. Currently, the user can not easily adjust the position of a "missed landmark" without starting all over at the beginning of the 3D analysis. I have talked with Brendon at Anatomage about this problem and the Anatomage development team will eventually provide a fix.

When your time permits please send me the links to the Forensic Databank and any other pertinent research. Prior to publishing our results I want to make sure that our study is not flawed in any way.

If you have any reference or published papers that are not available online, I would be glad to pay your research assistant the cost of duplicating the materials.

Again, THANK YOU!

Paul

Re: landmarks/asymmetry
September 10, 2012 10:47 AM

Hi Peer:
Thank You ! for remembering me. My colleagues and I have compiled data on 121 orthodontic patient CBCTs and have fully developed the 3D Orthodontic Symmetry Analysis (OSA). OSA is "fully" developed pending any suggestions from you and other collaborators.

See YouTube link for most recent OSA video: <http://www.youtube.com/watch?v=VcWlwg2IXqM>

My sons and I also developed a preliminary 3/4 CT analysis. There is much controversy in our field today related to higher (than 2D image) absorbed dose values used in orthodontic imaging. In addition, children are prone to more potential problems from excessive radiation (ie thyroid and brain exposures). The 3/4 analysis has a smaller FOV and radiation levels are dramatically less. Imaging Sciences (iCat) is steadily reducing exposure with changes to their CT generation 3 imagers (27-36 mSv versus over 100 mSv for older machines). In the future, 3D CBCT imagers will have radiation exposure values the same or less than 2D x-rays.

In our to be soon published study in Orthotown (pending acceptance) we will reference your 1994 work as we found in the Standards paper (see below). Brendon is compiling our data case by case due to a glitch in the Anatomage application. At this time Anatomage's data export to Excel is not functioning. He promises to be finished in two weeks. At that time I will evaluate the data and would like to talk with you about running statistical analyses. In addition, I recently presented a lecture at UNLV two weeks ago and talked with Dr. James Mah, Ortho Chair about our project. He agreed to help us with analyzing the data and make his suggestions.

In our publication, we plan to give proper credit to all collaborators.

Thank you again, for your help!

Paul

Subject: Re: landmarks/asymmetry
Date: Wed, 20 Jun 2012 12:31:36 PM

Hi Peer...
We are nearing completion of our first 121 volume CBCT symmetry study. We have several more volumes to analyze, but want to get our preliminary study published ASAP. The Lawrence Andrews Straightwire study used 120 orthodontic study models. We plan to present our first paper using a similar number of patients (121). When I was in my orthodontic residency at Loyola, Chicago our department provided several of Dr. Andrew's ideal occlusion cases.

My colleague, Brendon Bengsten, formerly with Anatomage as the one of the developers of their 3D cephalometric analysis, has done all the 3D cephalometric tracings. We are looking for your guidance in analyzing the data. Would you have a statistics grad student or other experts in your department that could help us look at our data to come up with a meaningful contribution to orthodontic cephalometrics. My initial goal was to come up with an Orthodontic Symmetry Index (OSI), e.g.. 1 to 3 (or 4,5). If a patient has little variation between the right and left sides the Symmetry Index would be 1. A moderate variation would be 2 and severe 3. I hope to keep the concept simple and useful for the user.

I have also coined the term / concept "polymorphic cube"... Bilateral paired landmarks create a polygon / cube or the "skeletal base" in the center of the patient's Maxillo-Mandibular complex. Recently, we added an airway analysis to our study. The airway is conveniently positioned at the bottom of the cube and is in most cases centered. We also added the interincisal angle using the right upper and lower central incisors. (125-130 norm). My thought process includes a quick analysis of the position of the anterior teeth, the initial status of the airway volume and is there asymmetries that may affect our predicted final result.

We also want to create a volumetric analysis of the polymorphic cube, mapping each side and comparing the volumes in mm² or cm²; Like a finite element analysis, skeletal mapping or a grid analysis of an object. Perhaps you can think of a way to do this using your experience in scientific research. After 40 years in private orthodontic practice my scientific method needs major help!

If your time permits, please give us your suggestions and guidance.

Thank you for your help!
Paul

Hi James,
Brendon Bengston of iHub3D completed the compiling of our 3D OSA study data this week. We analyzed 121 FFOV 3D CBCT orthodontic patient volumes. As we discussed during my recent visit to UNLV, I would like your guidance in the statistical analysis of our data. There are approximately 430 cephalometric measurements. We used Excel spreadsheet columns to organize the data into bilateral paired landmarks. We measured anatomical skull landmarks in millimeters to the midsagittal plane. In addition, we measured several bilateral paired landmarks to construct the proposed "Polymorphic Cube". The virtual 3D polymorphic cube is located within the maxillary-mandibular center of the skull just below the cranial base. If a patient exhibits an asymmetry from one side of the skull to the other it will be evident if there is a difference in mm and/or angular measurements. If a patient has a tilting or cant of a constructed plane such as the occlusal, mandibular or condylar planes the "paired angles" will be significantly unequal. We also included airway volumes and most constricted AW point measurements for each volume.

The last time I analyzed a data set was more than 40 years ago. (Ref: TMJ sound prints: electronic auscultation and sonographic audio-spectral analysis of the temporomandibular joint, Paul L Ouellette, JADA September 1, 1974 89(3): 623-628). I used the Sonagraph, Bell Laboratories, Chicago, to analyze right and left temporomandibular joint sound waves. Sound was recorded using bone conduction hearing aids (transducers). The FBI prior to advancements in computer sound analysis used the Sonagraph to analyze human voice sound waves. The capture of Pablo Escobar in Medellín, Colombia, December 2, 1993 utilized this technology during the surveillance operations. When analyzing TMJ data individual patient "Sound Prints" were organized into four distinct groups. Perhaps a similar protocol could be considered for the 3D OSA study.

Brendon and I used 2 mm and 2-degree ranges on each side of a visual representation of the measurements. For example, condylion right may be 50 mm to the midsagittal and condylion left could be 44 mm, a 6 mm difference. If we use a range of 2 mm per side or a 4 mm total range, the patient would have one of the sides 2 mm outside the range. Brendon used a color spectrum guide (e.g.: red = asymmetry) to visually display asymmetries (outside the 4mm range).

Our goal is to create an easy to diagnose and locate areas of asymmetry by "Visual Representation" (i.e.: Rickett's VTO) of significant differences in mm and angular measurements. Hopefully, your vast experience in research, data organization and analysis will help us find a simple solution. Brendon will be sending you the data set for your review. Please call or email to discuss this project when you have time.

My sons and I would be honored to include you as one of the principal authors or give you credit as a contributor. Let me know if you have the time and want to participate in this study. Thank you for your time and help!
Paul

Dr. Mah's response:

Hi Paul, in order to design appropriate statistical approaches to analyzing the data, we'll need to know your hypothesis(es) with respect to what is the reference standard and which variable is being tested. In other words, is it the correlation between difference in the paired landmarks and angle to respective plane (occlusal, mandibular, condylar) that you are after? Or is it the difference between the paired measurement and landmarks on the cube.

Regards,

James Mah

Dr. Ouellette's response:

Hi James,

Thank you for your quick response.

My original hypothesis, subject to modification:

Every orthodontic patient has multiple asymmetries and unequal angular values that may result in tipping or cants of anatomical planes (occlusal, mandibular, condylar, etc).

Human asymmetry (anatomical variation) is the Norm !

The purpose of quantifying a patient's asymmetry(s) is to provide our dental colleagues accurate CBCT evidence that further challenge, "Occlusion Dogma" such as the possibility that anterior guidance, canine protected occlusion and other gnathological principals (concepts) can not exist in an asymmetrical patient. Patients have to ADAPT to the occlusal scheme they have inherited and/or the environment created when modified by treatments such as corrective orthodontics or full mouth reconstruction.

References: [Rinchuse's papers that question "evidence" of occlusion dogma.](#)
[Akerman's papers and book that state, "Malocclusion is NOT a disease", "Modification of dentofacial traits" and "Roll, Pitch and Yaw"](#)

Brendon used the difference between landmark measurements to the midsagittal plane. He used the same protocol for the angular measurements.

What would you use if you designed the study?

Paul

Subject: Re: Dr. Mah's response to statistic question

Date: Tues, 23 Oct 2012 12:50 PM

Hi Everyone,

After reviewing the research description and looking at the examples provided by Brendon, it appears that you have interval data drawn from a normally distributed population. Paired t-tests are appropriate since the measurements are within the same individual. Paired t-tests could be run for the left and right differences and the left and right distance to the constructed cube measurements. If the hypothesis calls for a correlation between measurements to estimate asymmetry of another region, linear regression or Bland-Altman analyses may be performed. But I am not sure if this is needed since one could simply measure the distance rather than predict it from another.

James

Hi Peer:

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I have also coined the term / concept "polymorphic cube"... Bilateral paired landmarks create a polygon / cube or the "skeletal base" in the center of the patient's Maxillo-Mandibular complex. Recently, we added an airway analysis to our study. The airway is conveniently positioned at the bottom of the cube and is in most cases centered. We also added the interincisal angle using the right upper and lower central incisors. (125-130 norm). My thought process includes a quick analysis of the position of the anterior teeth, the initial status of the airway volume and is there asymmetries that may affect our predicted final result.

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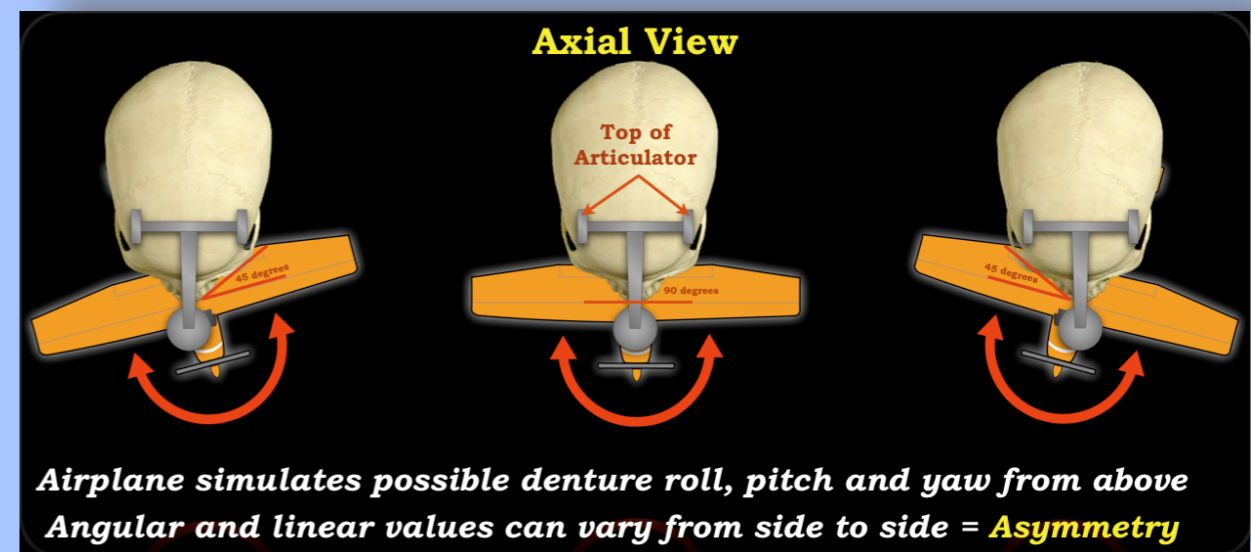
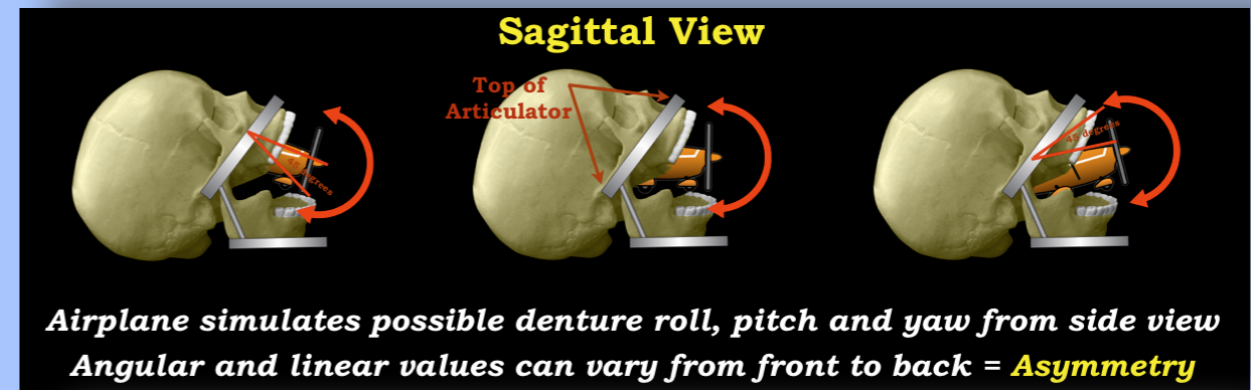
If your time permits, please give us your suggestions and guidance.

Thank you for your help! Paul (End of Email Communications)

"FUNCTIONAL ADAPTATION"

Roll, pitch, yaw, cants of the Polymorphic Cuboidal area may cause the maxilla or mandible to be asymmetrically oriented in the human articulator. Majority of patients adapt and function normally.

Dentists use articulators to simulate "estimated positions" of the maxillary and mandibular dental arches in the skull. The 3D CBCT view of the human skull makes it possible to measure bilateral dimensions and angulations related to the center of or mid-sagittal plane of the skull. In the "Perfect 10" all linear and angular measurements would be equal.



Abstract

This study is focused on the statistical analysis of orthodontic symmetry based on pre-treatment evaluation of 121 randomly selected orthodontic patients using Anatomage 3D cephalometric Analysis of full volume (FFOV) CBCT images. Cephalometric measurements, linear and angular, were obtained from anthropologically recognized anatomical bilateral paired landmarks. Hub 3D diagnostic services performed 3D cephalometric analysis using for the study.

Allowing $H_0: \mu_0 = 0$ to represent perfect orthodontic symmetry as measured by the virtual construction of a Polymorphic Cube (def: multi-sided object subject to morphological change). $H_1: \mu_1 \neq 0$ to represent orthodontic asymmetry, we are testing to what statistical significance, if any, we can reject or not reject the null hypothesis.

Study Design

Brendon Bengston was one of the first Anatomage software engineers that helped develop the Anatomage 3D Cephalometric application and trained orthodontists to use 3D CBCT analysis. Brendon helped my sons and I learn how to use Invivo5 3D Cephalometric Analysis. Brendon subsequently left Anatomage to form Conebeaminfo.com, a CBCT knowledge-base website and iHub3D.com, a 3D diagnostics portal for orthodontic case workups. Our practice exclusively uses iHub3D for every orthodontic patient. iHub3D provides a very affordable menu of diagnostic services and his partner, Larry Chan, MD, Radiologist, provides radiological reporting services. Prior to initiating an orthodontic treatment plan it is important to know the degree of asymmetry a patient possesses. Also if a case does not finish with an ideal occlusion, the orthodontist could order the 3D Orthodontic Symmetry Analysis (OSA) to look for areas of asymmetry. iHub3D also provides 3D animations that we use for patient education and practice marketing.

When developing OSA we asked Brendon to make our analysis easy for the non-professional to understand. An “outside the norm” color spectrum “wobble-gram” is used to clearly demonstrate asymmetrical areas of the patient’s maxillo-mandibular complex. (see Wobble-gram Image) We do not emphasize linear or angular values with patients or referring doctors. Visually identifying areas of asymmetry allows us to create a pre-treatment disclaimer, “We may not be able to finish this case with an “ideal” bite, but we will do the best we can considering your “genetic” traits and asymmetries. Our goal is to fully inform the patient and assign “ownership” of the orthodontic problem to the patient.

OSA steps using Anatomage 3D Cephalometric Analysis

1. Establish the Cartesian coordinate system: MidSag plane = Ba, N, A point; Horizontal plane = Po_R, Or_R, Perp to MidSag
2. Establish bilateral key source landmarks: Po, Co, & Go
3. Establish key MidSag source landmarks: Ba, Pr, & Id
4. Establish secondary landmarks and planes to measure key source landmarks to
Planes - MidSag plane, FH plane, & Frontal Plane
Landmarks - Ba, Sella, Or, Or_Sut (Zygomatic Process), Po, Go, A, B, Pog, Me, Pr, Id, ANS, & PNS
5. Create singular measurements then compare them bilaterally to corresponding measurements. i.e. Co_R to Go_R and Co_L to Go_L - then measured the Difference between the two.
All measurements are Right minus Left
Norm = 0 SD = 2mm (built in user tracing error)
6. Estimate PMC (Polymorphic Cube): Or_Sut, Co, Go, MF - Bilateral difference measurements distance angular
7. Colored wobble-gram - ALL measurements are R minus L

Polymorphic Cube Linear Measurements

Analyzing 121 samples (patients) we used two-tailed, paired t-tests to analyze eight significant differences in distances between corresponding landmarks and the appropriate plane of symmetry in each sample.

We allowed the null hypothesis for each difference to read,

$$H_0: \mu_0 = 0,$$

and tested against the alternative hypothesis,

$$H_1: \mu_1 \neq 0.$$

We found that for 6 of the 8 differences, there is statistically significant data to suggest that we should reject the null hypothesis (samples are symmetric) at an $\alpha = .10$ significance level and accept the alternative hypothesis (samples are asymmetric). It should be noted that in the remaining 2 measurements, we have failed to reject the null hypothesis at the stated $\alpha = .10$ significance interval.

The data tables in the associated spreadsheets contain the p-value for each of the 8 distance differences. If the p-value is less than .10 then we reject the null hypothesis and accept the alternative.

Polymorphic Cube Angle Measurements

Measurements of angles created by the surfaces of the Polymorphic Cube can likewise be compared to their corresponding opposites in order to assess orthodontic symmetry. We analyzed the differences between corresponding angles in the same way we analyzed the distances. We allowed the null hypothesis to read,

$$H_0: \mu_0 = 0,$$

and tested against the alternative hypothesis,

$$H_1: \mu_1 \neq 0.$$

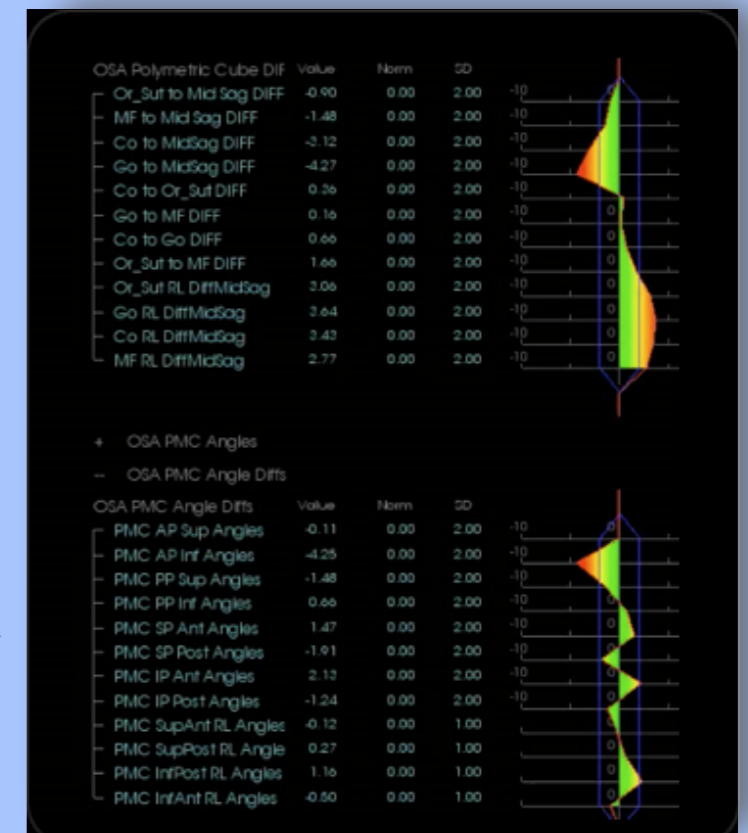
In this case, we found far less statistically significant data to reject the null hypothesis. In fact, using the $\alpha = .10$ significance interval, we found that only 2 of 12 measurements were significantly different enough for us to reject the null hypothesis. Therefore, we must state that we failed to reject the null hypothesis in 10 of 12 angle difference measurements.

The data tables in the associated spreadsheets contain the p-value for each of the 12 angle differences. If the p-value is less than .10 then we reject the null hypothesis and accept the alternative.

Symmetry Index based on the Polymorphic Cuboidal Analysis

Along with ascertaining the statistical significance of different distances between landmarks, we evaluated the data to arrive at a "Symmetry Index" based on the 121 samples. Our evaluation of the data found the mean of 8 difference measurements used in the Polymorphic Cube for linear distance of each patient. We then found the sample mean and sample standard deviation of the 121 difference means. Since the difference means approximately follow a Normal distribution, we assigned a scale score according to the Normal curve. That is, if a patient had a difference mean that fell between 1 sample standard deviation of the sample mean in either direction, we assigned them a 9, which indicates "average orthodontic symmetry." If the patient had a difference mean that fell between 1 and 1.5 sample standard deviations in either direction, we assigned them a 8, which indicates "moderate orthodontic asymmetry". If the patient had a difference mean that fell outside of 1.5 sample standard deviations in either direction, we assigned them a 7, which indicates "severe orthodontic asymmetry".

Colored "Wiggle-gram" visually demonstrates asymmetries



Statistical Analysis of OSA Polymorphic Cube Data

Doctor James Mah, UNLV Orthodontic Chairmen, gave us assistance in designing the OSA statistical analysis. To assure the accuracy and validity of the statistical formulas we also utilized the services of a local mathematics expert, Mr. Chad Pinnick. Below is a chart that illustrates the mathematical parameters used to compute the **OSI** - Orthodontic Symmetry Index.

Score OSI	Polymorphic Cube distance difference mean (In mm)	Asymmetry Scale Score Definition
10	If the mean of the patient's differences is 0	10-Perfect orthodontic symmetry (0)
9	If the mean of the patient's differences is between -.987 to .496	9-Average orthodontic asymmetry (1)
8	If the mean of the patient's differences is between -.988 to -1.358 or .497 to .866	8-Moderate orthodontic asymmetry (2)
7	If the mean of the patient's differences is below -1.358 or above .866	7-Severe orthodontic asymmetry (3)

Macro Analysis

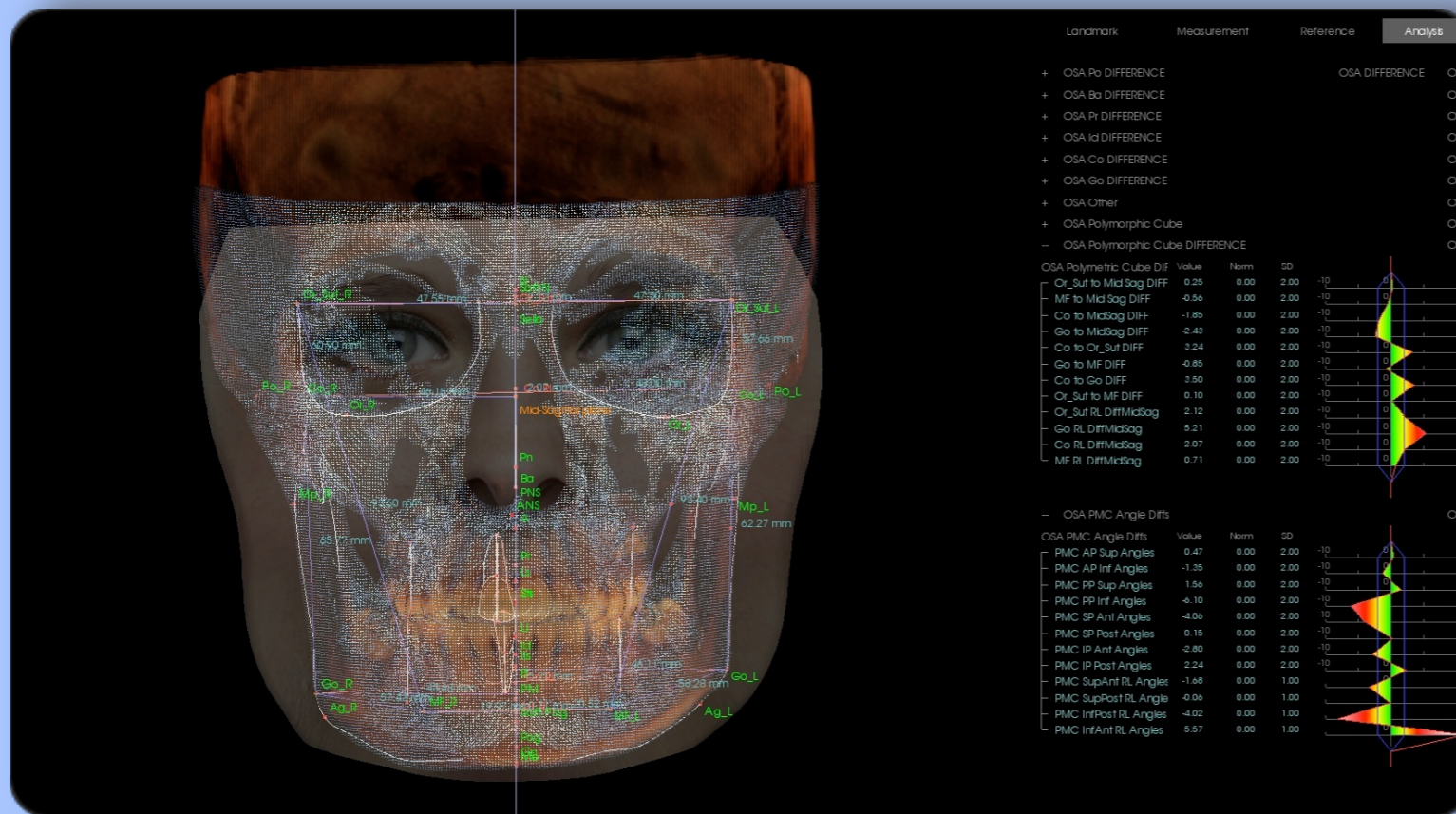
When analyzing an orthodontic case we ask patients to upload their frontal image to the website www.symmeter.com. The free online symmetry tool allows the patient or doctor quickly identify the degree of facial asymmetry present. Patients can see for themselves they are not perfectly symmetrical. Anatomage also has a superimposition tool that visually demonstrates bilateral right and left skeletal variations.

Mini Analysis

The OSA analysis uses a series of cephalometric landmarks to construct the virtual polymorphic cube. This study of 121 subjects yielded data that we organized into four levels of asymmetry. Level 0 = Perfect Symmetry, Level 1 = Minor Asymmetries present, Level 2 = Moderate Asymmetries present and Level 3 = Severe Asymmetries present. For purposes of patient communication we substituted 10, 9, 8 and 7 because our society rates good-looking people as “perfect 10s”. As anticipated there were no perfect 10s in our study!

Micro Analysis

In future articles we will present, The “Three-Quarter 3D Symmetry Analysis” for MFOV CBCT Volumes and another study of “Pointcloud Topographic Skull Mapping” that will demonstrate the presence of “pockets of asymmetry”. The image below demonstrates Pointcloud Skull Mapping. Colored areas of asymmetry are visually illustrated in the Wiggle-gram.



Discussion

Considering the data and the results of the analysis, we do not expect the patient to have orthodontic symmetry based on the differences in corresponding distances measured on the Polymorphic Cube. The data generally indicates that while the distances significantly vary to demonstrate general skeletal asymmetry in the population; whereas angular values on the surfaces of the Polymorphic Cube do not significantly vary. We are not saying that there is no difference in corresponding angle measures, simply that the difference is not sufficient to reject the hypothesis of perfect symmetry among angle measures at the chosen $\alpha = .10$ significance interval.

We must also address the creation of the Orthodontic Symmetry Index. OSI was created as a guide for the user to quickly access a patient’s overall level of pre-treatment asymmetry. It is based on the mean of the differences in distances observed between anatomical landmarks used to create the Polymorphic Cube. The index is there as a tool to assist the user in deciding the overall severity of asymmetry, not to evaluate the cause of the asymmetry or anatomical variation (i.e. enlarged growth on one side versus lack of growth on contralateral side).

Conclusion

Visual 3D OSA helps one better communicate with patients and referring doctors by putting all on notice that ideal occlusion may NOT be always obtainable. The majority of patients have an innate ability to functionally adapt to the esthetically modified occlusion. Failure to functionally adapt may result in future problems that require additional modification. I have had “occlusion-passionate” referring doctors instruct me to NOT remove braces without a “little more CPO, group function and/or anterior guidance”. Can there be ideally engineered occlusion if the patient has substantial asymmetry, especially angular variations that may create occlusal cants, tips, rolls, yaw (ref: Ackerman) or unequal condylar linear measurements to the midsagittal plane? Visual 3D OSA now makes it possible to identify and quantify a credible reason for less than ideal occlusion.



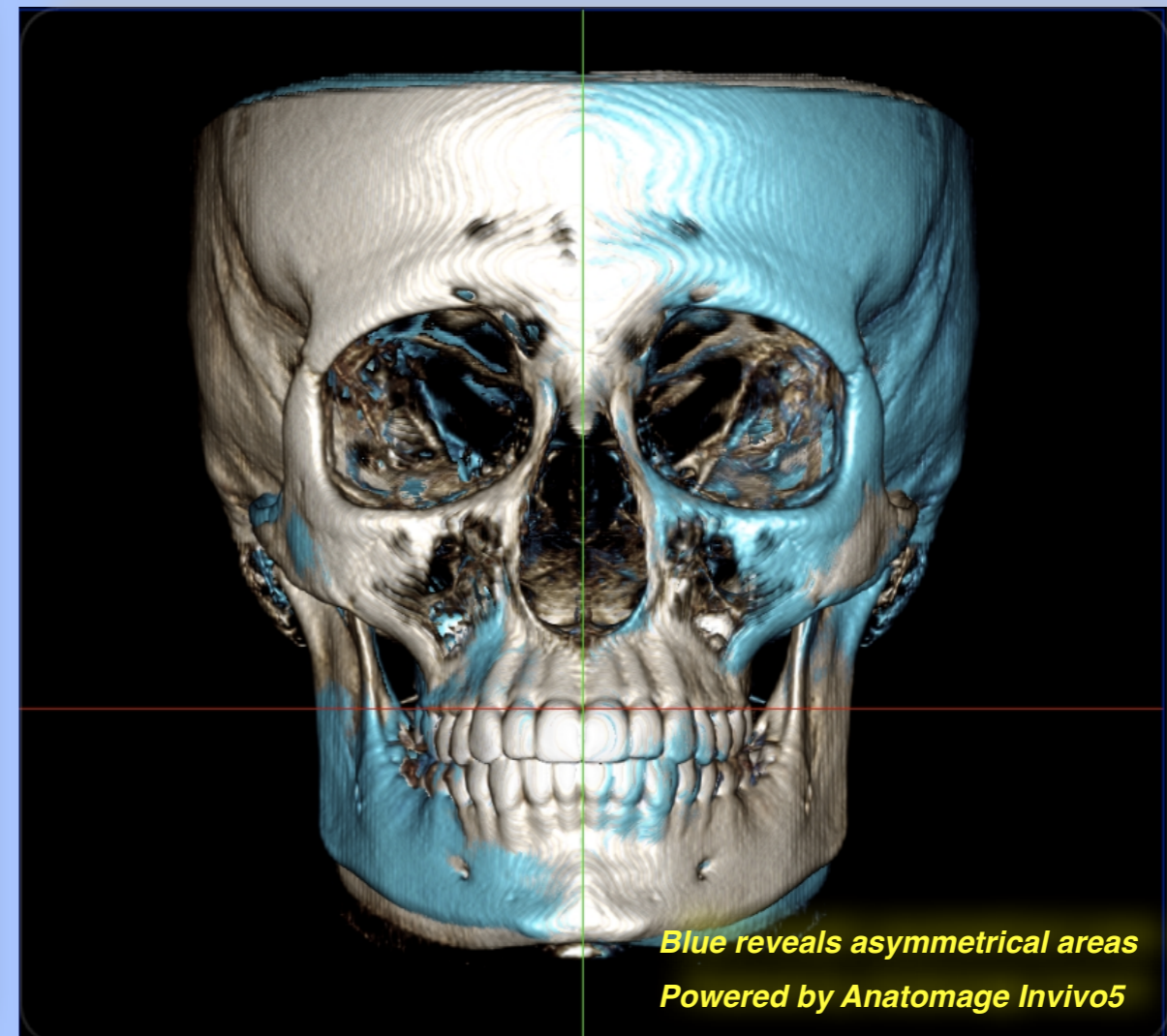
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About

3 Adjust the centerline

- Click on the image where you'd like to place the centerline
- Hint: use the middle of the nose for placement of the line
- Then just click 'Next' to continue, and in a few seconds a new window will open.

< Back Next >



Occlusion Concepts Are Nonetheless Very Important!

Evidence that old concepts may not be valid in an asymmetrical world does not lessen the importance of using time-tested “occlusion engineering principals” as guidelines, not absolutes, when treatment planning an orthodontic or reconstruction case. Occlusion engineering concepts can be compared to general building principals. A building properly designed should have squared walls with all structural components in balance or equilibrium. Occlusion modification by the dentist uses similar construction guidelines everyday. Construction principals such as fulcrums, levers, moments, resistance, stress relaxation, static equilibrium, inclined planes, constant force, working, balancing, parallelism, cantilever, resultant force theory, vector analysis, tension, material strength, deformation, resilience and other principals are universally used by dentists, the architects of the maxillo-mandibular space. Most important, a building structure, like the human denture, has to have a sound foundation. The “**Polymorphic Cube**”, if symmetrical and stable (little or no morphing), is the foundation for functional adaptation to homeostasis.

3D Cephalometrics - Occlusion Concepts References - Recommended Reading List

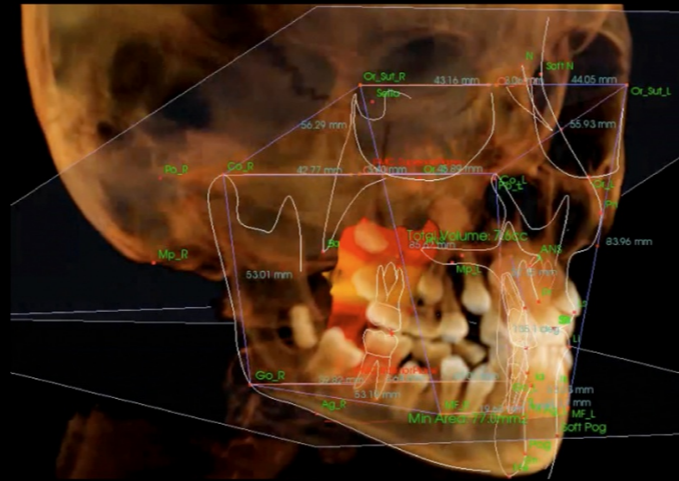
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3D OSA

Orthodontic Symmetry Analysis



OSI 3D

Orthodontic Symmetry Index

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A TRUE DENTAL FAMILY - Doctor Paul Ouellette works with his two sons, Doctors Jason and Jonathan of the **DentalSpecialists.com**. Jason is a senior orthodontic resident at Jacksonville Florida University. Jonathan is a senior AEGD resident at University of Florida, Miami. Jonathan has been accepted to a one year implant dentistry fellowship in Alabama. The doctors have developed a practice model that includes Orthodontics, Implant Dentistry and Prosthetic Rehabilitation of complex cases. Doctor Ouellette's daughter, Danielle, a college senior pre-dental student, applied her creative writing talents to help the family develop the first 700 page interactive ebook, "**3D Dentists: The Future of Dentistry is Now!**" Being so close-knit as a family who literally work and play together, they felt compelled to create a book geared to first year dental students and experienced healthcare professionals new to or considering acquisition of 3D imaging technology. **3D Dentists** is written for inquisitive dental patients that want to be fully informed before making a life changing decision for themselves or a family member. 3D Dentists is available for download at www.EarnYourSmile.org.