
# Complete Clinical Orthodontics®

## Orthodontic Treatment Design

Ryan K. Tamburrino, DMD

# The Goal

The aim of this manual is to provide a systematic, objective, and efficient method for any orthodontic practitioner to formulate a rational, predictable, and comprehensive treatment plan for any patient that may walk through his or her door. Ultimately, this can lead to improved confidence for the doctor, realistic clinical outcomes for the patient, and higher standards of care for the orthodontic profession. Enjoy!

Glossary of Abbreviations

The following list contains abbreviations of terms and concepts that are used throughout this manual:

ACP = Adapted Centric Posture

ANHP = Adjusted Natural Head Position

CAC = Center of the Alveolar Crest

CBCT = Cone-Beam Computed Tomography

CCO = Complete Clinical Orthodontics

FA Point = Facial Axis Point

GVL = Glabella Vertical Line

HPI = Head Positioning Instrument

MIC = Maximum Intercuspation

MGJ = Muco-gingival Junction

MOP = Maxillary Occlusal Plane

SCP = Seated Condylar Position

SL = Self-Ligating

SNV = Subnasale Vertical

SWA = Straight-Wire Appliance

# Table of Contents

# 1. Introduction

Treatment Design is the core of the Complete Clinical Orthodontics (CCO) diagnostic process, and once mastered, will provide the maximum information about a patient's proposed orthodontic treatment with very little effort on the part of the practitioner. This exercise is a three-dimensional simulation of a proposed treatment plan on the lateral headfilm before performing any actual treatment on a patient. While much of the treatment simulation is performed in the sagittal and vertical dimensions, the information from the third dimension (transverse) is incorporated into the decision making process.

By going through the exercise of Treatment Design, the practitioner has the ability to try different orthodontic strategies to determine the one that is the most effective and efficient at achieving the treatment goals. In addition, it allows for improved communication between the doctor and the patient when helping the patient understand the methodology and rationale behind the proposed treatment plan. Most important, however, Treatment Design shows the doctor the necessary mechanics for treatment and gives the doctor confidence that the goals set forth for the patient can realistically be achieved.

With the proposed method for Treatment Design, multiple treatment plans for the same patient can be simulated and either accepted or rejected in a very short period of time. Thus, there will be a minimal burden on clinic, doctor, and staff time, and the patient will certainly benefit from the added effort that was spent in treatment planning. Also, the CCO method will guide the doctor to ideal positions of the teeth, jaws, and soft tissue. Deviations from the ideal, when needed, can be judiciously determined to not negatively effect esthetics, function, airway, or the periodontium.

# 2. The CCO Diagnostic Sheet

At the core of Treatment Design is the CCO Diagnostic Sheet. The sheet's main purpose is to serve as a central hub and easy reference for recording all data that may affect treatment decisions for the patient. Additionally, it serves as reference for the clinician to use as treatment progresses to ensure the treatment goals are being appropriately addressed.

## CCO Patient Diagnostic Sheet

Date: _____

Chart: _____

Patient: _____ Age: _____ Referring Doctor: _____

CC: _____

Goals for Treatment: _____

Obstacles to Ideal Treatment: _____

History of Concerns: _____

_____

_____

### Dental Data

| | |
|---|---|
| Lower Archform | Normal Constricted |
| Spacing/Crowding | None Mild Moderate Severe |
| Upper Archform | Normal Constricted |
| Spacing/Crowding | None Mild Moderate Severe |
| Overbite | Ideal Shallow Open Deep |
| Overjet | Ideal Mild Moderate Severe Negative |
| Crossbite | None Unilateral Bilateral Anterior Skeletal |
| Molar Class | I II div. I II div. II II sub R II sub L III |
| Wear Facets | None Anterior Posterior |
| Excursion Right | Canine Posterior GF Anterior GF NW Interferences |
| Excurstion Left | Canine Posterior GF Anterior GF NW Interferences |
| Protrusive | Anterior Guidance Balancing Interferences |

### Muscular TMJ Data

| *Palpation (1-10)* | Right | Left |
|---|---|---|
| Temporalis | | |
| Masseter | | |
| Submandibular | | |
| Pterygoid | | |
| Occipital | | |
| SCM | | |
| Trapezius | | |
| Intracapsular | | |
| Resistance | Yes | No |

### Periodontal Data

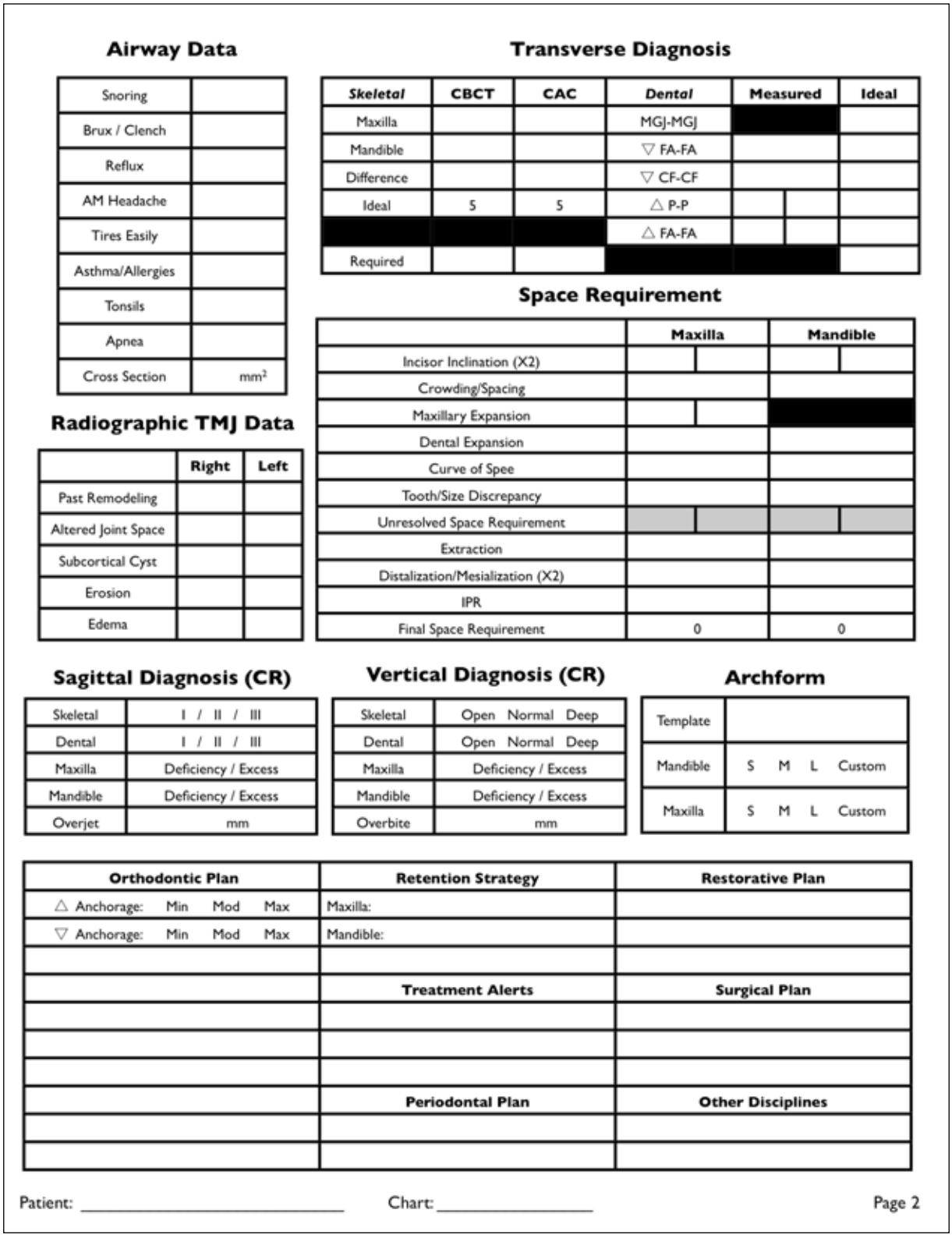
| | |
|---|---|
| Frenum | Max Labial Mand Labial Lingual Buccal |
| Biotype | Normal Thin Thick |
| Recession | None Localized: _____ Generalized |
| Inflammation | Absent Present |
| Visible Plaque | Absent Present |
| Fremitus | Absent Present |
| Occlusal Trauma | None Anterior Posterior |

### Clinical TMJ Data

| | Right | Left |
|---|---|---|
| Opening Click | | |
| Closing Click | | |
| Crepitation | | |
| Deviation | mm | mm |
| Max Opening | mm | |
| Functional Shift | mm | R L A |

Page 1

The CCO Diagnostic Sheet is strategically divided into three parts to easily organize clinical data, records data, and the interdisciplinary treatment plan. However, the scope of this manual will focus only on the data that will impact the Treatment Design portion of the CCO material, mainly the transverse diagnosis and determining the space requirement.



**Airway Data**

| | |
|---|---|
| Snoring | |
| Brux / Clench | |
| Reflux | |
| AM Headache | |
| Tires Easily | |
| Asthma/Allergies | |
| Tonsils | |
| Apnea | |
| Cross Section | $mm^2$ |

**Transverse Diagnosis**

| *Skeletal* | CBCT | CAC | *Dental* | Measured | | Ideal |
|---|---|---|---|---|---|---|
| Maxilla | | | MGJ-MGJ | | | |
| Mandible | | | ▽ FA-FA | | | |
| Difference | | | ▽ CF-CF | | | |
| Ideal | 5 | 5 | △ P-P | | | |
| | | | △ FA-FA | | | |
| Required | | | | | | |

**Space Requirement**

| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Incisor Inclination (X2) | | | | |
| Crowding/Spacing | | | | |
| Maxillary Expansion | | | | |
| Dental Expansion | | | | |
| Curve of Spee | | | | |
| Tooth/Size Discrepancy | | | | |
| Unresolved Space Requirement | | | | |
| Extraction | | | | |
| Distalization/Mesialization (X2) | | | | |
| IPR | | | | |
| Final Space Requirement | 0 | | 0 | |

**Radiographic TMJ Data**

| | Right | Left |
|---|---|---|
| Past Remodeling | | |
| Altered Joint Space | | |
| Subcortical Cyst | | |
| Erosion | | |
| Edema | | |

**Sagittal Diagnosis (CR)**

| | |
|---|---|
| Skeletal | I / II / III |
| Dental | I / II / III |
| Maxilla | Deficiency / Excess |
| Mandible | Deficiency / Excess |
| Overjet | mm |

**Vertical Diagnosis (CR)**

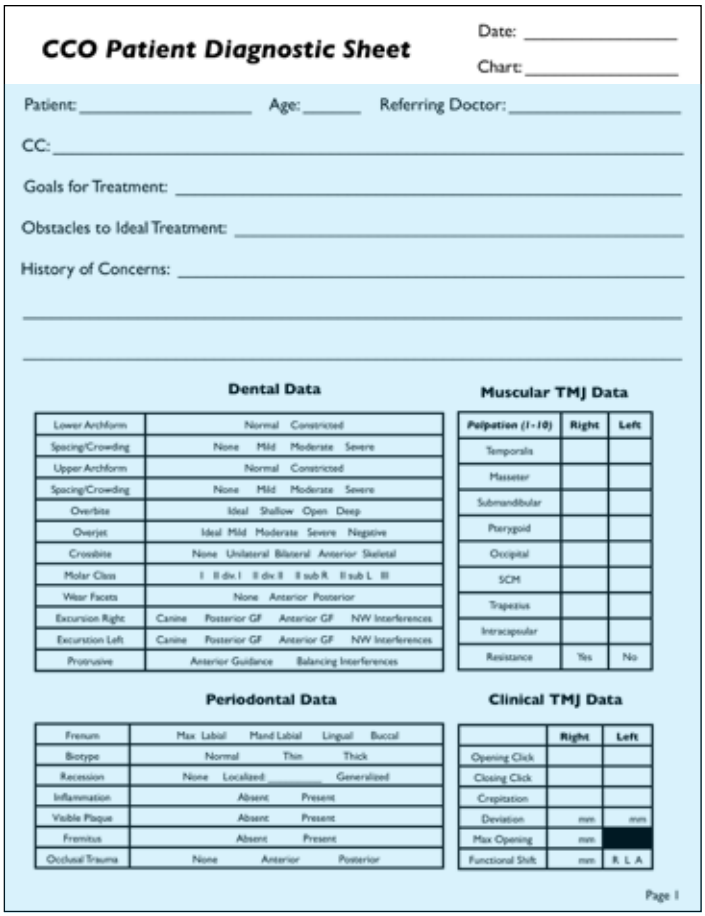
| | |
|---|---|
| Skeletal | Open Normal Deep |
| Dental | Open Normal Deep |
| Maxilla | Deficiency / Excess |
| Mandible | Deficiency / Excess |
| Overbite | mm |

**Archform**

| | |
|---|---|
| Template | |
| Mandible | S M L Custom |
| Maxilla | S M L Custom |

| Orthodontic Plan | Retention Strategy | Restorative Plan |
|---|---|---|
| △ Anchorage: Min Mod Max | Maxilla: | |
| ▽ Anchorage: Min Mod Max | Mandible: | |
| | | |
| | **Treatment Alerts** | **Surgical Plan** |
| | | |
| | | |
| | | |
| | **Periodontal Plan** | **Other Disciplines** |
| | | |
| | | |

Patient: _____ Chart: _____ Page 2



**CCO Patient Diagnostic Sheet**

Date: _____

Chart: _____

Patient: _____ Age: _____ Referring Doctor: _____

CC: _____

Goals for Treatment: _____

Obstacles to Ideal Treatment: _____

History of Concerns: _____

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| Molar Class | I II div.1 II div.II II sub R II sub L III |
| Wear Facets | None Anterior Posterior |
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| Pterygoid | | |
| Occipital | | |
| SCM | | |
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| Resistance | Yes | No |

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| Opening Click | | |
| Closing Click | | |
| Crepitation | | |
| Deviation | mm | mm |
| Max Opening | mm | |
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**Airway Data**

| | |
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| Snoring | |
| Brux / Clench | |
| Reflux | |
| AM Headache | |
| Tires Easily | |
| Asthma/Allergies | |
| Tonsils | |
| Apnea | |
| Cross Section | mm² |

**Transverse Diagnosis**

| Skeletal | CBCT | CAC | Dental | Measured | Ideal |
|---|---|---|---|---|---|
| Maxilla | | | MG|-MG| | | |
| Mandible | | | ▽ FA-FA | | |
| Difference | | | ▽ CF-CF | | |
| Ideal | 5 | 5 | △ P-P | | |
| | | | △ FA-FA | | |
| Required | | | | | |

**Space Requirement**

| | Maxilla | Mandible |
|---|---|---|
| Incisor Inclination (X2) | | |
| Crowding/Spacing | | |
| Maxillary Expansion | | |
| Dental Expansion | | |
| Curve of Spee | | |
| Tooth/Size Discrepancy | | |
| Unresolved Space Requirement | | |
| Extraction | | |
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| IPR | | |
| Final Space Requirement | 0 | 0 |

**Radiographic TMJ Data**

| | Right | Left |
|---|---|---|
| Past Remodeling | | |
| Altered Joint Space | | |
| Subcortical Cyst | | |
| Erosion | | |
| Edema | | |

**Sagittal Diagnosis (CR)**

| | |
|---|---|
| Skeletal | I / II / III |
| Dental | I / II / III |
| Maxilla | Deficiency / Excess |
| Mandible | Deficiency / Excess |
| Overjet | mm |

**Vertical Diagnosis (CR)**

| | |
|---|---|
| Skeletal | Open Normal Deep |
| Dental | Open Normal Deep |
| Maxilla | Deficiency / Excess |
| Mandible | Deficiency / Excess |
| Overbite | mm |

**Archform**

| | |
|---|---|
| Template | |
| Mandible | S M L Custom |
| Maxilla | S M L Custom |

| Orthodontic Plan | Retention Strategy | Restorative Plan |
|---|---|---|
| △ Anchorage: Min Mod Max | Maxilla: | |
| ▽ Anchorage: Min Mod Max | Mandible: | |
| | | |
| | Treatment Alerts | Surgical Plan |
| | | |
| | | |
| | | |
| | Periodontal Plan | Other Disciplines |
| | | |
| | | |

Patient: _____ Chart: _____ Page 2

**Clinical Data**

**Records Data**

**Interdisciplinary Treatment Plan**

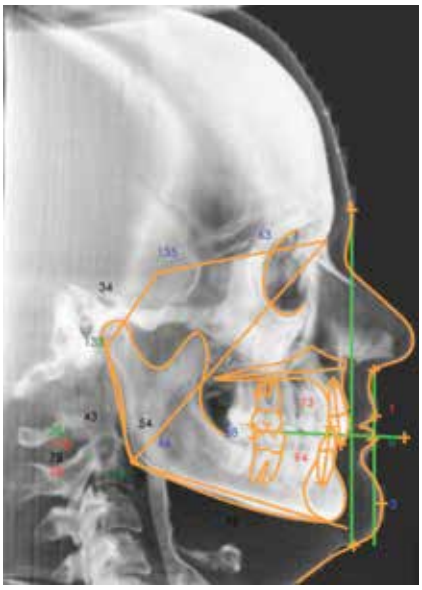
### *Steps for Treatment Design of the Orthodontic Patient*

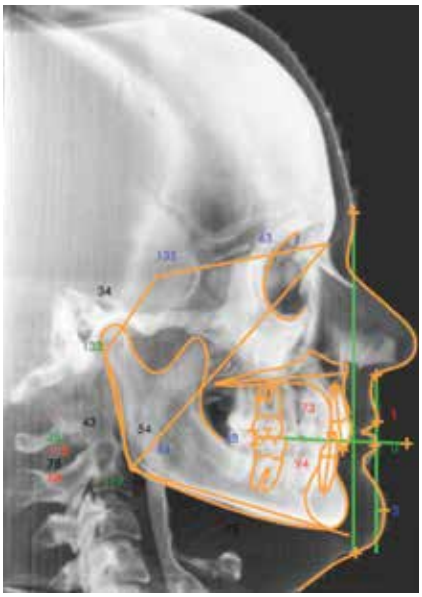
Treatment Design is performed via a series of nine logical steps while simultaneously using and recording information on the CCO Patient Diagnostic Sheet. These steps are followed in the same sequence for every patient in a manner which is extremely efficient. The rest of the manual will be dedicated to elaborating on each of these points in detail.

# 3. Orienting the Lateral Headfilm

## 9 Steps for CCO Treatment Design

1. Orient lateral headfilm to adjusted natural head position
2. Perform SCP/MIC conversion of headfilm
3. Construct Target Lines for the hard and soft tissue
4. Set the desired inclination of the incisors
5. Determine tooth spacing requirements
6. Move mandibular molars into desired position
7. Move maxillary molars into desired position
8. Superimpose jaws to determine anchorage requirements
9. Accept result or modify tooth positions to satisfy treatment objectives



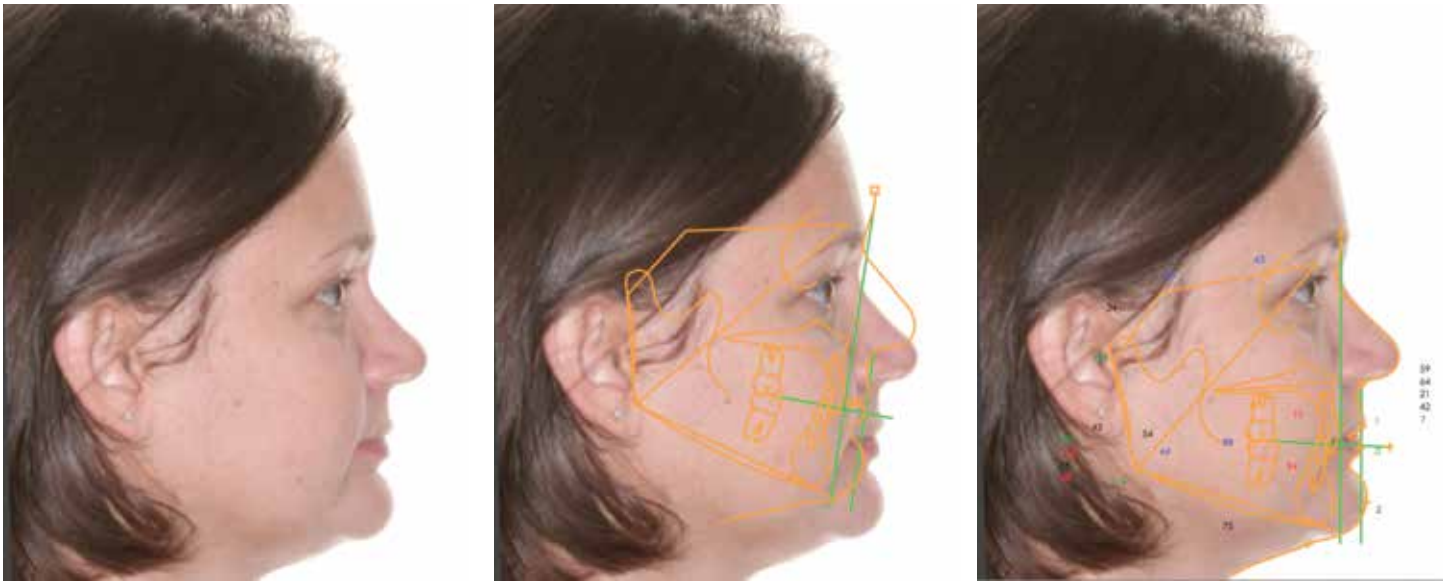


The critical step to accurately completing the Treatment Design exercise is to ensure the lateral headfilm is properly oriented into adjusted natural head position. Treatment Design depends on constructing true vertical lines on the cephalometric radiograph, because the resulting information will not be useful unless the patient's head is correctly positioned. Additionally, while the Treatment Design can easily be performed with a traditional or digital lateral ceph, the most accurate information will be obtained from reconstructed cone-beam CT data, which is free of image magnification and distortion.

There are multiple methods that can be used to transfer and reproduce adjusted natural head position from the patient to the x-ray, and a few will be illustrated in the following section. Acceptable methods described here are aligning the digitized ceph tracing to a property oriented lateral photograph, placing horizontal radiographic markers on the patient, or using the Head Positioning Instrument® (HPI). Once again, using a CBCT to obtain the lateral headfilm will allow for the most accurate diagnosis, but all methods can be successfully implemented with traditional imaging as well. The first way to orient the lateral headfilm tracing is to use a digitized lateral photograph. For this method, the software used for digitization must have the capability to manipulate the tracing. Additionally, it is critical to have the lateral photograph taken with the head oriented in Adjusted Natural Head Position (ANHP). Otherwise, the alignment of the tracing will be inaccurate. The following photos depict the sequence for orientation with cephalometric software that has the capabilities to rotate the tracing.

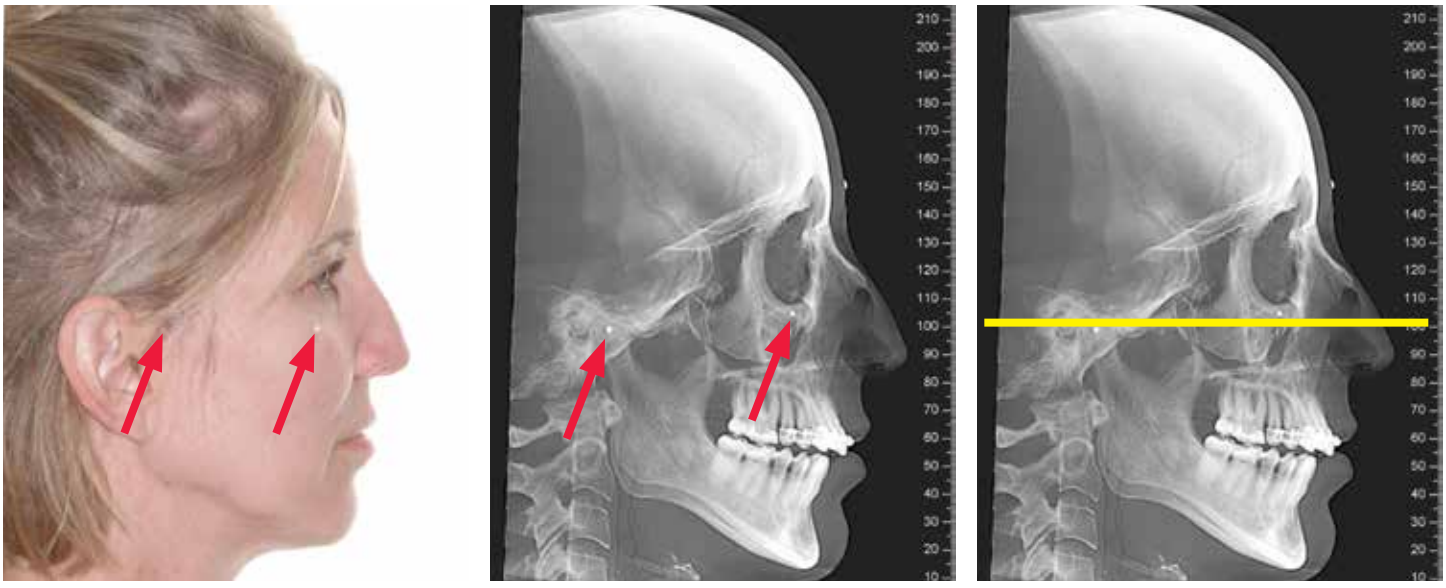
First, the lateral headfilm must first be digitized and traced.

Then, by using the capabilities of the software, the headfilm can be properly aligned by superimposing and rotating the tracing on the photograph.



***Placing Radiopaque Markers on the Face***

A method for orienting the headfilm when a digital tracing package is not available (or the software does not have the capacity to orient the tracing) is to place radiopaque markers, such as barium paste, onto the patient's face. These markers should be oriented to true horizontal with the patient in ANHP. With these in place, the lateral ceph can be taken and easily reoriented to ANHP by aligning the markers. This method is technique sensitive because it requires aligning the dots properly but is still acceptable to use and easily done when other methods are not available.



***Head Positioning Instrument (HPI)*** ®

The HPI® (Steel City Dental Concepts, Philadelphia, PA) allows for objective measurements between fixed points for the most accurate reproducibility. The method will be described below.

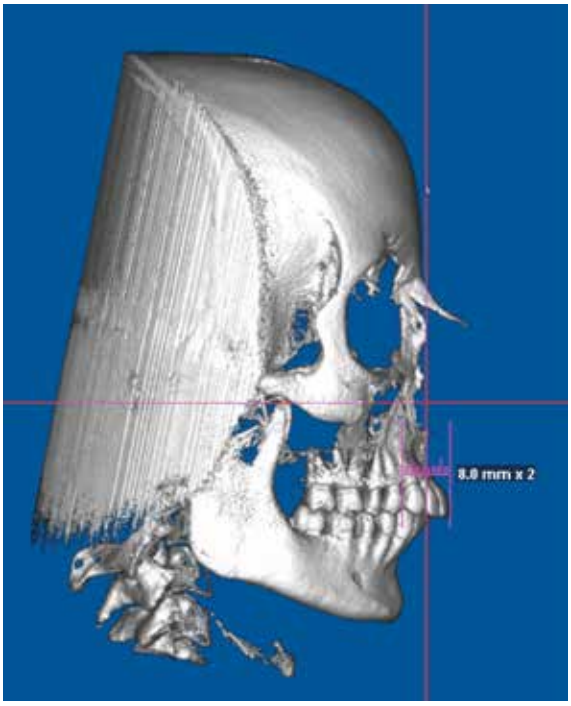
**Step 1:** Using a paintbrush, place a dot (1-2 mm in diameter) of barium paste or any radiopaque material on the forehead. Note: If using a CBCT image, some machines may not have the capability to scan the entire volume of the head. If this is the case, placing a marker on nasion or other easily visualized structure on the midsagittal plane of the face will suffice.

**Step 2:** Zero out the slider and place the patient into the HPI®. Orient the head into operator-determined adjusted natural head position. Place the upper fixed reference point of choosing against the radiopaque marker placed on the head in Step 1.

**Step 3:** Have the patient smile and touch the facial surface of the maxillary incisor with the sliding pointer.


Record the horizontal distance between the two points. Because there are two fixed reference points, the actual location of the points is NOT important. The critical concept is that the two points be fixed and easily identifiable on a radiograph.

**Step 4:** Using this distance information, the headfilm can be appropriately oriented to adjusted natural head position by reproducing this distance between the two fixed points (front of central incisor and radiopaque marker) on the lateral view. The ceph is now ready for tracing.

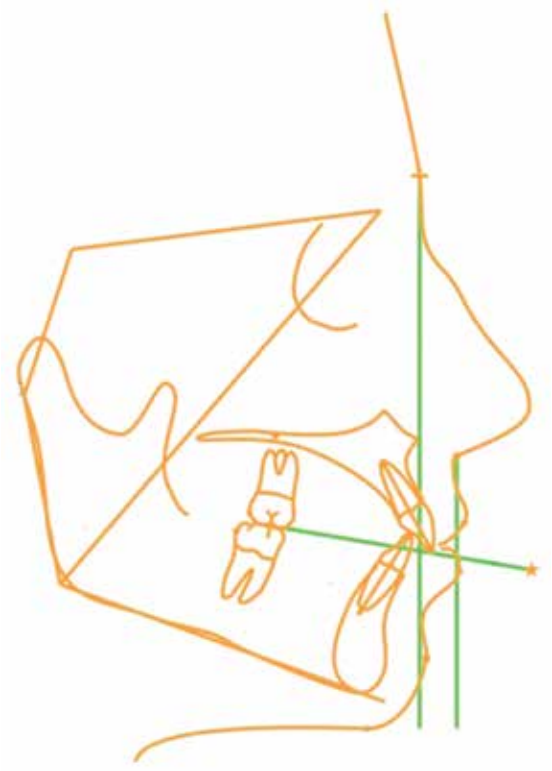



### *The SCP/MIC Conversion of the Headfilm*

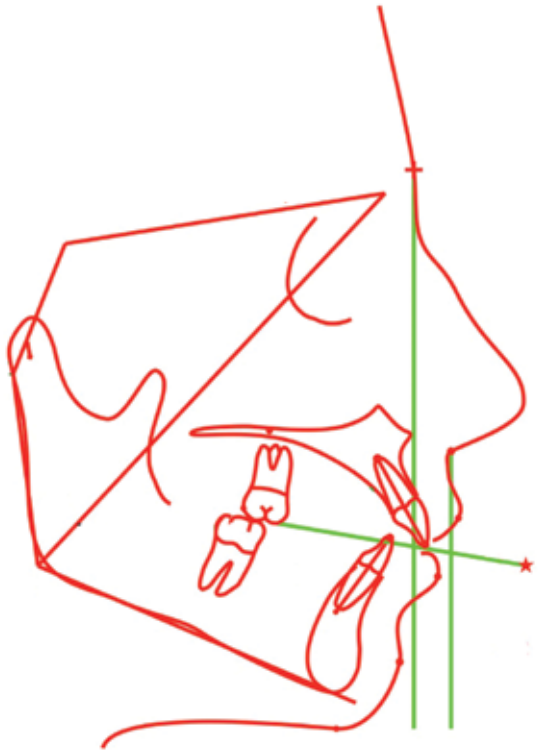
A treatment goal for all patients is to achieve Andrews' Six Keys[1] of occlusion on the arc of closure from a Seated Condylar Position (SCP) or Adapted Centric Posture (ACP)[2]. In order to finish with this desired result, the treatment plan should be formulated from SCP. Often patients will present reasonable intercuspation of the teeth, but, unknown to the practitioner, the temporomandibular joint position is not stable or is distracted from the fossa. For these patients, who also have their initial radiographs taken in maximum intercuspation (MIC), it may be necessary to convert the lateral headfilm to one in SCP for proper treatment planning.

Note: The instructors of the CCO course advise taking the initial lateral headfilm in MIC in order to best view any condylar distraction/disharmonies on TMJ imaging and for difficulty of maintaining a non-deprogrammed patient in a seated condylar position. However, if a patient has been wearing an occlusal appliance or is having progress or pre-orthognathic surgery records, then positioning the patient into SCP and holding it at the first point of contact with a wax registration before taking the lateral headfilm is advised. Also, some digital treatment planning software packages require orientation prior to conversion, and some others will allow after. You will need to read the software manual to determine the capabilities of your software.

The graphics below illustrate a patient who presented with a large initial SCP/MIC discrepancy on mounting the models and shows how converting the ceph to SCP allowed for better representation of the occlusal disharmony for treatment planning purposes.



***MIC Ceph***

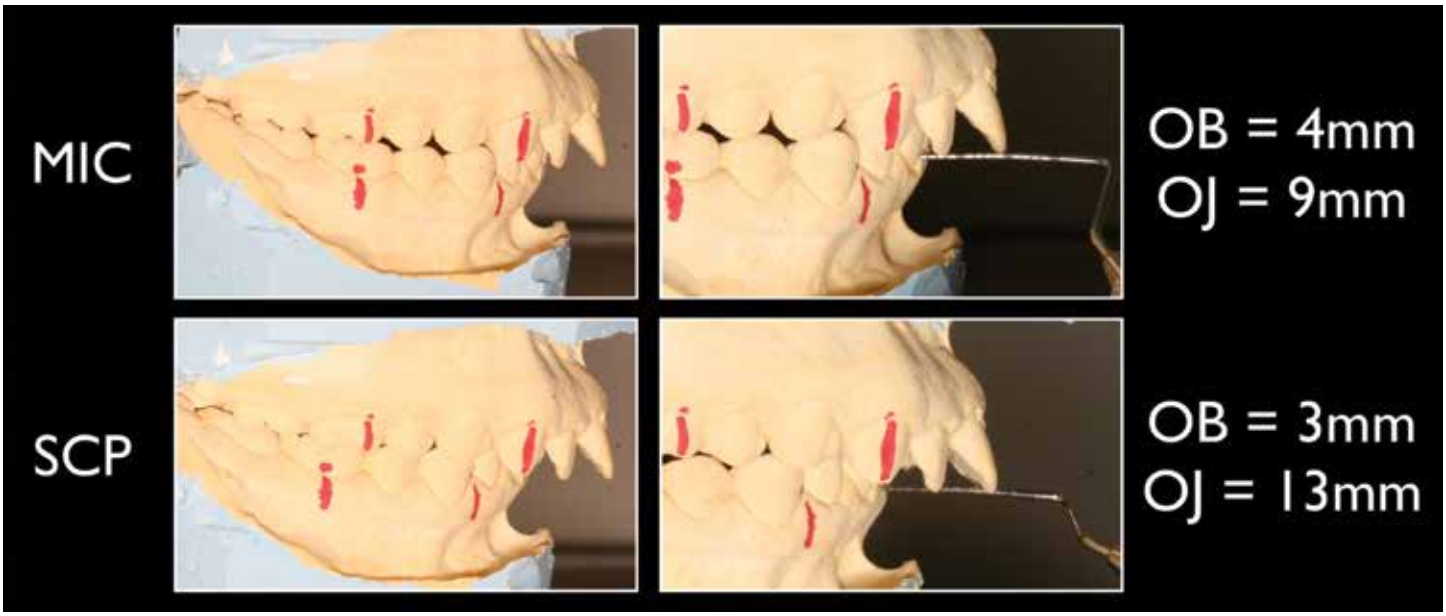


***SCP Converted Ceph***

For cases which present with a SCP/MIC discrepancy, like the one below, the first step is to use a millimeter ruler or perio probe to measure the overjet and overbite on the mounted casts at the first point of posterior contact and compare that to the models in MIC. Additionally, the molar relationship should be denoted.

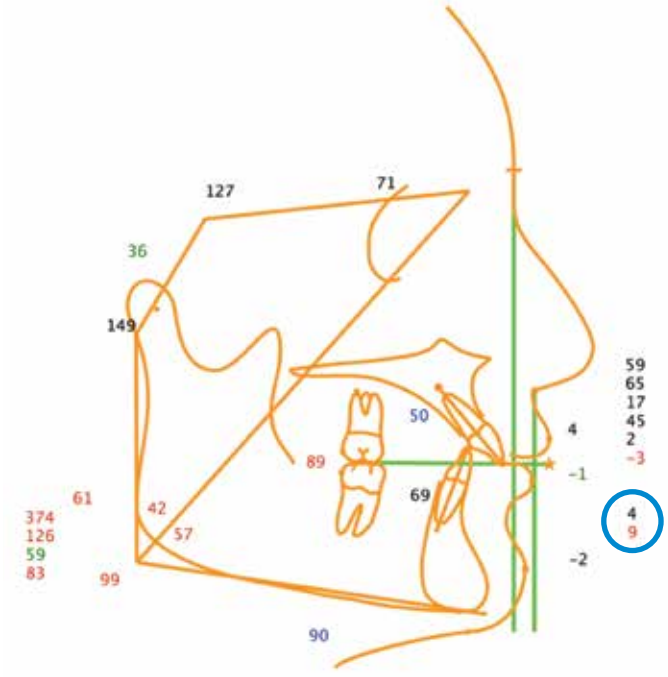
[1] Andrews LF. The six keys to normal occlusion. Amer J Orthod. 1972; 62: 296-309.

[2] Dawson PE. New definition for relating occlusion to varying conditions of the temporomandibular joint. J Prosth Dent. 1995; 74(6):619-627.

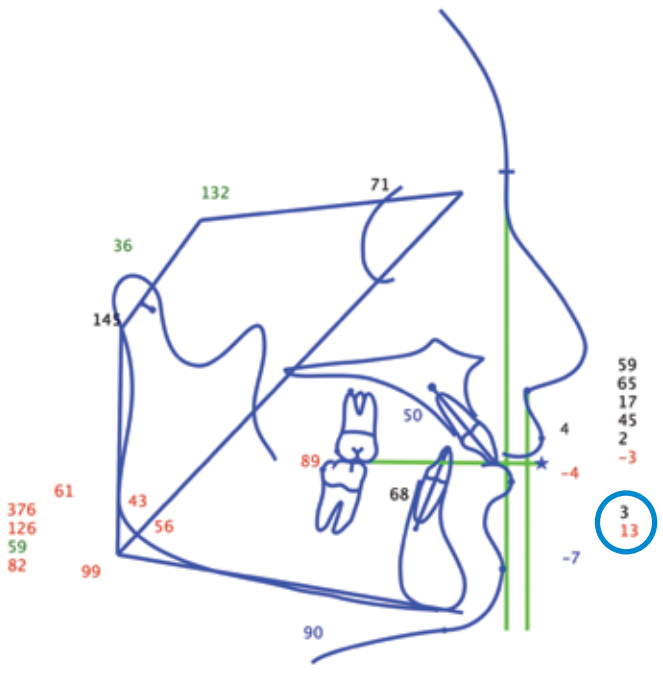



Secondly, trace the MIC ceph with the tracing program of your choosing. Be sure to note the OB/OJ.

Using the ceph conversion feature of your tracing software, move the mandible until the ceph mimics the SCP mounted casts with respect to overjet, overbite, and molar relationship. You will need to refer to the software manual for information specific to your program as to how this is accomplished. This adjusted ceph is now ready to use for the treatment planning process since the models and tracing are both oriented to the same reference position and the data correlates.

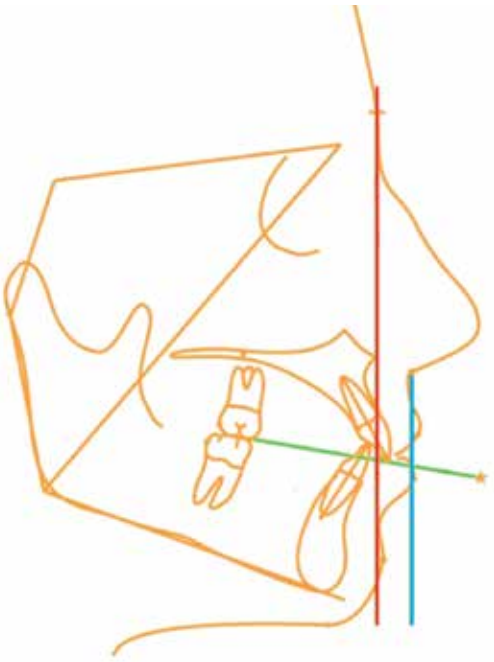



***MIC Ceph***




***SCP Converted Ceph***

# 4. Target Line Construction



Placing Target Lines on the lateral headfilm is the critical aspect and foundation of Treatment Design. These lines are meant to assist the orthodontist in visualizing the ideal positions of the teeth, jaws, and soft tissue. They do not signify absolute requirements for the location of these components, and that is the crucial concept to remember. Instead they are used to guide the orthodontist in making appropriate treatment decisions that will work towards achieving esthetic and functional goals, not moving away from them. Since many patients do not have "ideal" naturally occurring skeletal and/or dental harmony, the guidelines will also help the orthodontist and the patient visualize the limits of treatment needed to protect the roots and periodontium, as well as preserve soft tissue support. Additionally, the graphical nature of the exercise will aid in determining an objective, sensible, and easily understood treatment plan with the patient if compromise or camouflage treatment is desired.

Using a properly oriented lateral headfilm, which is critical for this analysis, the following three Target Lines constructed: Glabella Vertical Line (GVL), Subnasale Vertical Line (SNV), and the Maxillary Occlusal Plane (MOP). These will be targets for, respectively, the hard tissue, soft tissue, and the dentition.

**Hard Tissue Target**
Glabella Vertical Line (GVL)

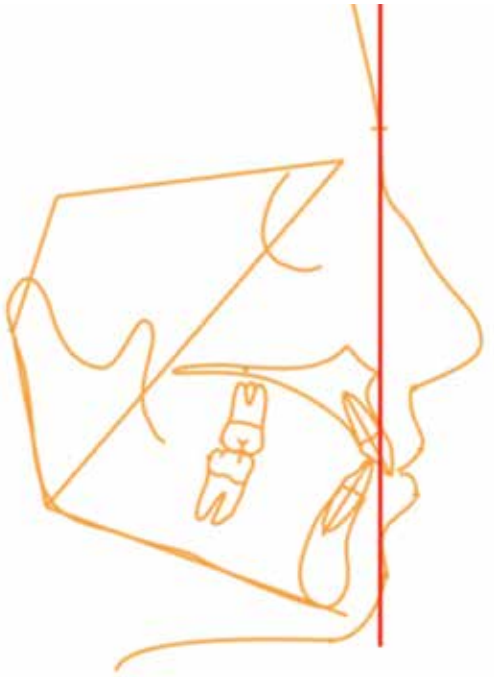
**Soft Tissue Target**
Subnasale Vertical Line (SNV)

**Dentition Target**
Maxillary Occlusal Plane (MOP

***Hard Tissue Target (Glabella Vertical Line)***

The Glabella Vertical Line (GVL) is constructed as a vertical line extending downward from soft tissue glabella and is used to evaluate the anterior-posterior (A-P) position of the maxilla. In an optimal scenario, the facial surface of the maxillary central incisor will lie on or slightly ahead of this line when it is centered in the alveolus and is also ideally inclined relative to the occlusal plane (to be discussed later).

The rationale for this Target Line can be illustrated via a publication by Dr. Will Andrews. This paper evaluated the position of the maxillary central incisor, in profile smile, on a sample of "attractive" people[3]. The result found that 96% of the "attractive" population had the facial surface of the maxillary central incisor ahead of the center of the forehead and/or slightly anterior to glabella. Given the esthetic preference of modern society for a "fuller" profile and clinical goal of not impinging on the airway or tongue space via excessive anterior retraction, the results of this study reflect this esthetic and functional ideal.



[3]Andrews WA. AP Relationship of the Maxillary Central Incisors to the Forehead in Adult White Females. Angle Orthod. 2008; 4:662-9.

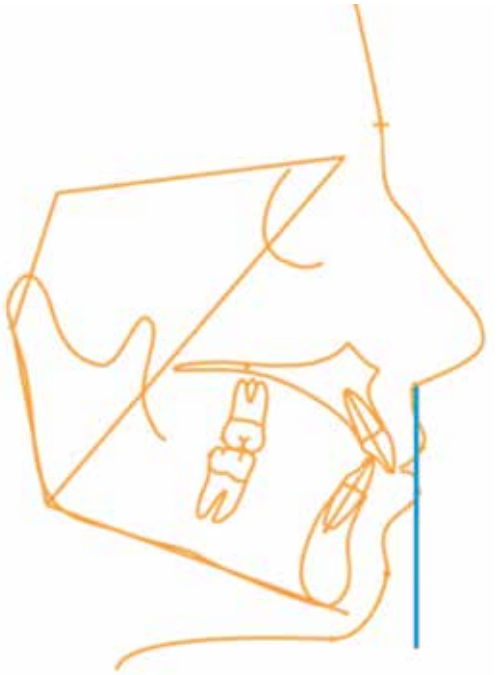
When comparing a patient with an ideal A-P maxillary incisor positioning (3 left pictures) with one that is either retrusive (4th picture) or protrusive (5th picture) with respect to the GVL, the esthetic effects are apparent.

Andrews' study suggests that when developing an orthodontic or surgical treatment plan, the goal should be to position the maxillary central incisor in a way that enhances the esthetics of the smiling profile, not detract from it. While the ideal target is the facial surface of the incisor lying directly on the GVL, positioning the incisor slightly ahead or behind the line is also acceptable. For most cases, positioning the incisor excessively behind or in front of the glabella vertical line may negatively alter the smiling profile and thereby affect lip support. The main idea is that this reference allows the clinician to have a visual starting point and make subsequent clinical decisions with the hard tissue and teeth that will either be positive or neutral with respect to the patient's pre-treatment condition, and also help the clinician rule out treatment options which would possibly have a negative esthetic effect.

***Soft Tissue Target (Subnasale Vertical Line)***

While the GVL helps to evaluate the position of the maxillary incisor and hard tissue, the Subnasale Vertical Line (SNV) is used to evaluate the balance of the soft tissue profile of the lips and chin in repose. The line parallels the GVL and is constructed through subnasale.

The purpose of the SNV is to evaluate the prominence of the upper lip, lower lip, and chin. However, for the most accurate analysis, the lips must be relaxed and fully in repose upon imaging. Excessive lip strain will produce an incorrect relationship due to distortion of the soft tissue through the underlying muscle activity, as shown on the next page.

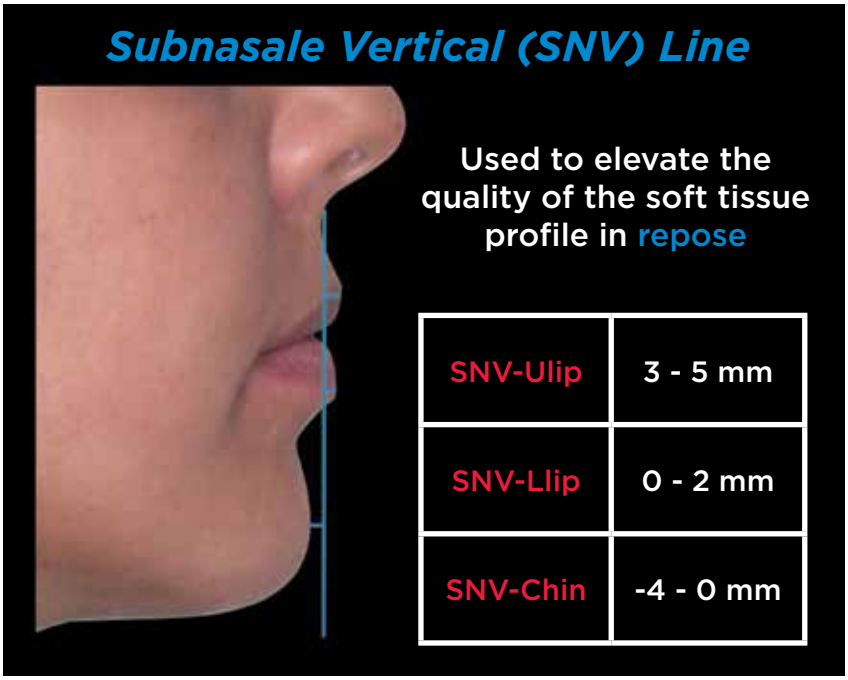


**Soft Tissue Target**
Subnasale Vertical Line (SNV)

***Relaxed musculature***

***Excessive mentalis strain***

To evaluate the soft tissue profile, three lines are constructed perpendicular to the SNV and extend to the most prominent portion of the upper lip, lower lip, and chin. The horizontal distance from the SNV is then recorded. The values below represent ideal soft tissue positions[4].




As was conceptualized when using the GVL, these numbers are ***NOT*** absolutes, only guidelines. The important concept is the relationship and hierarchy of position among the components; mainly that the upper lip is the most prominent of the three and should fall ahead of the SNV. The lower lip is not as prominent but still slightly ahead of the SNV. Finally, the chin point should be slightly behind the line.

[4]Arnett GW, Jelic JS, Kim J, et al. Soft tissue cephalometric analysis: diagnosis and treatment planning of dentofacial deformity. Am J Orthod Dentofacial Orthop 1999;116:239-53.

The photographs below illustrate several patients, all having different soft tissue relationships to the SNV. As you can see in the first picture, slight deviations from ideal can be quite esthetic and acceptable. However, correction of gross discrepancies can be beyond the capabilities of orthodontics alone and may require adjunctive treatment modalities or surgical intervention.

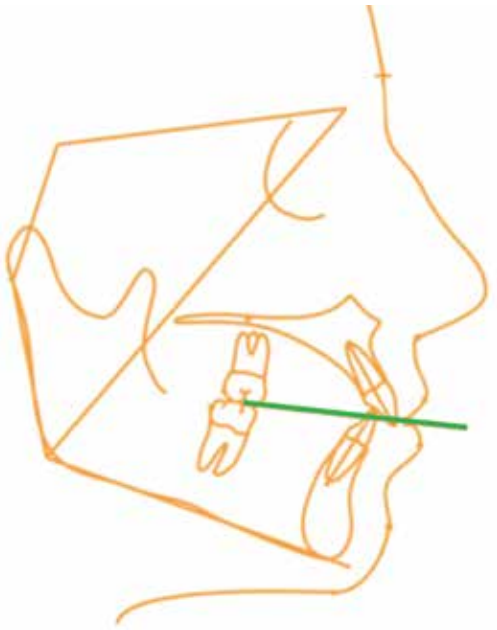
When patients do not present with ideal soft tissue relationships, once again, it is not an absolute requirement to achieve optimal proportions. However, if "ideal" treatment is attainable in conjunction with the patient's esthetic desires, the measurements and relationships discussed are the universally accepted soft tissue positional goals to achieve. Additionally, by having these guidelines, an orthodontic treatment plan can be designed to enhance or maintain the patient's esthetics, even when "ideal" is not possible or desired.

At this point, we have discussed the construction and rationale of references for both hard and soft tissue esthetics. In an ideal world, optimizing the position of the hard tissue would automatically harmonize the soft tissue. While this does happen in many instances, sometimes there are outliers where it does not. In these instances, the soft tissue position ALWAYS trumps the hard tissue. Therefore, if the hard tissue is idealized, but the soft tissue still does not meet the esthetic preferences of the clinician or the patient, then the treatment plan should be modified to ensure the soft tissue goals are met, irrespective of the hard tissue position to the GVL.

***Dentition Target (Maxillary Occlusal Plane)***

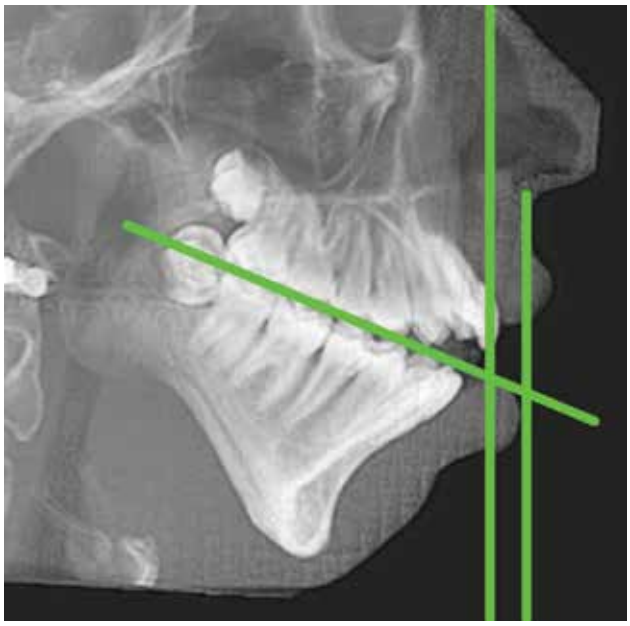
The third target line is the Maxillary Occlusal Plane (MOP) and is constructed through the cusp tips of the maxillary first molar and premolars.

The MOP provides a reference position to set the inclination of the maxillary and mandibular incisors for Treatment Design purposes. Additionally, the MOP inclination is important for optimizing the function of the dentition with respect to the anatomy of the temporomandibular joint complex and plays a significant role for harmonizing esthetics in orthodontic/orthognathic surgery cases. While these are important aspects in their own right and deserve through discussion, the scope of this manual will be limited only to the aspect of relating the dentition to the occlusal plane.

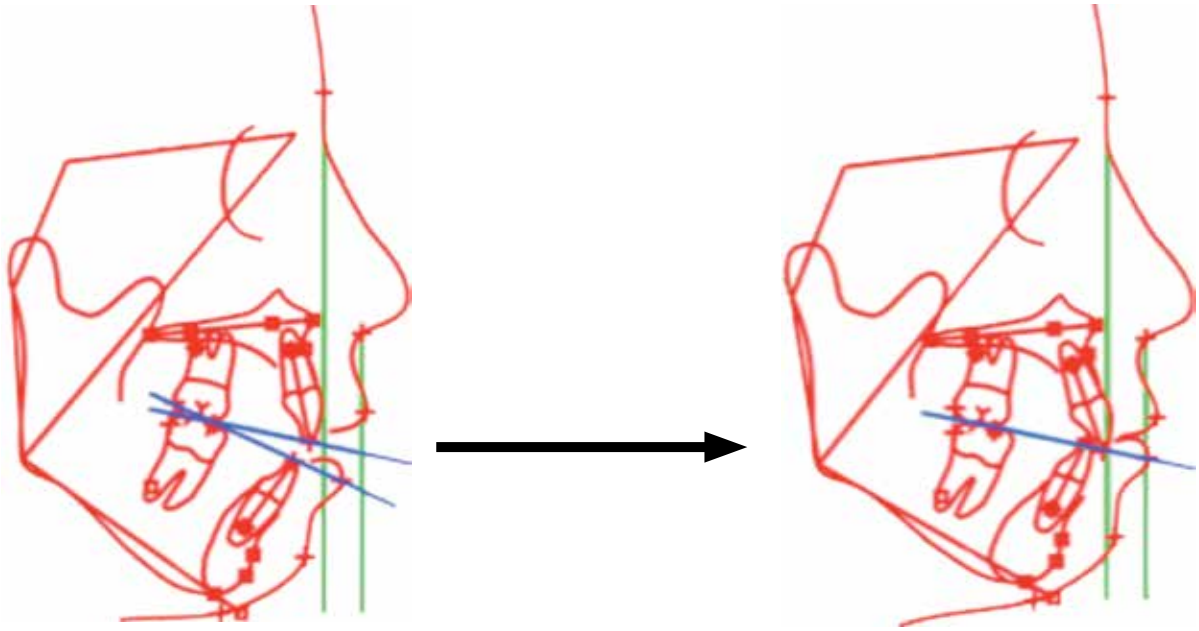


**Dentition Target**
**Maxillary Occlusal Plane (MOP)**

Due to potential vertical variations of the pre-treatment maxillary incisors, especially in anterior open bite cases where there is an exaggerated Curve of Spee, the incisal edge is not used for construction of the MOP, as this may misrepresent the patient's condition being used for diagnosis and Treatment Design. Therefore, the functional occlusal plane utilizing the cusp tips of the maxillary molar and premolar is more clinically accurate, as shown below.



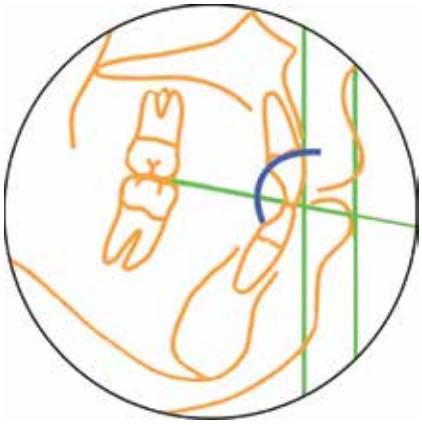
In cases where a patient presents with an anterior and posterior open bite, often due to contact on the terminal molars, using the maxillary occlusal plane only to evaluate the position of the lower anterior teeth (to be discussed later) is not appropriate. Therefore, two occlusal planes must be drawn to evaluate the teeth independently; one for the maxillary dentition and one for the mandibular dentition. However, this text will focus only on the quantifiable inclination of the maxillary occlusal plane. Because the ultimate treatment goal will be for both planes to coincide with the maxillary plane with the incisors in the proper overbite/overjet relationship at the end of treatment, as shown below, there is no need to record a pre-treatment value for the mandibular plane.



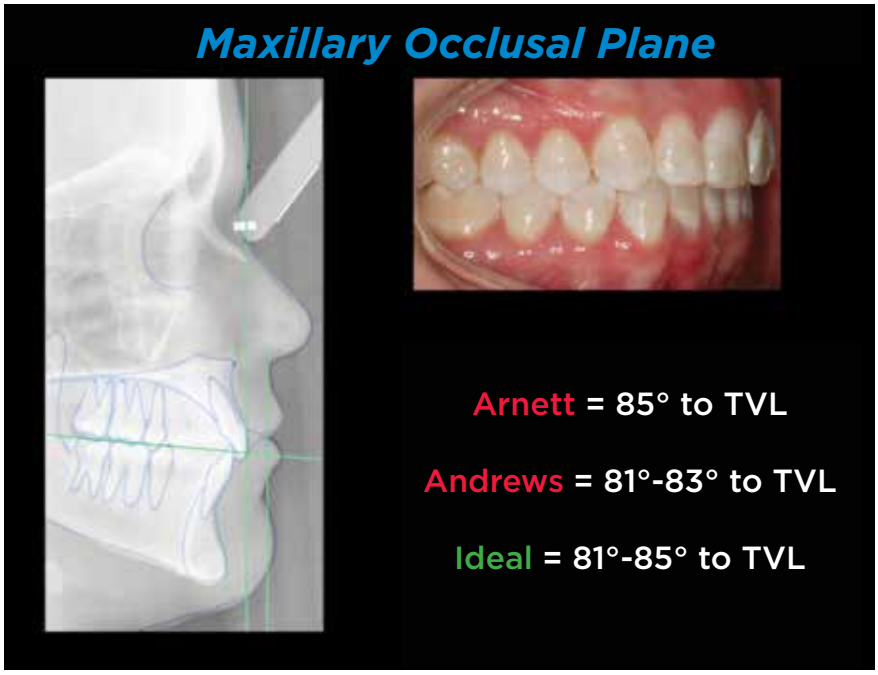
***Initial*** ***Treated***

For CCO Treatment Design, the MOP inclination is measured as the acute angle between the MOP and the GVL, SNV, or any other true vertical reference line. Based on previous research, as shown below, the "ideal" MOP inclination should measure between 81-85˚ to the True Vertical Line (TVL)[5,6], with an average of 83˚.

Several prominent clinicians have proposed normal values for an ideal MOP inclination. Due to using a true vertical reference for CCO Treatment Design, as opposed to a true horizontal used by these clinicians, the numbers shown below may vary from the actual values published in the quoted literature. The measurements cited in this manual are adjusted to reflect this difference reference but are clinically equivalent to previously published values of those authors



***Maxillary Occlusal Plane Measurement***



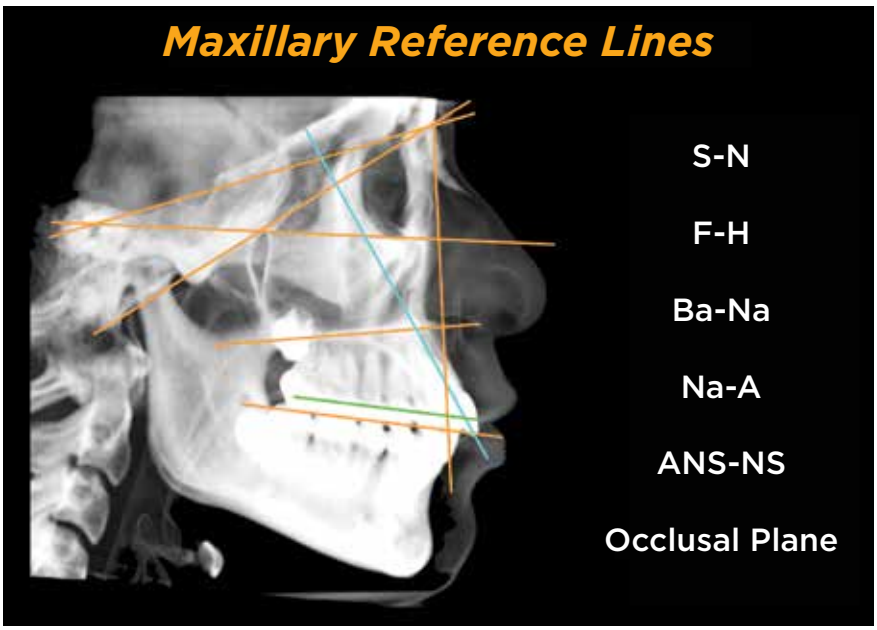

Properly constructing the MOP is critical for Treatment Design, as this will affect many of the clinical decisions that will be made going forward, specifically with respect to determining the inclination of the incisors.

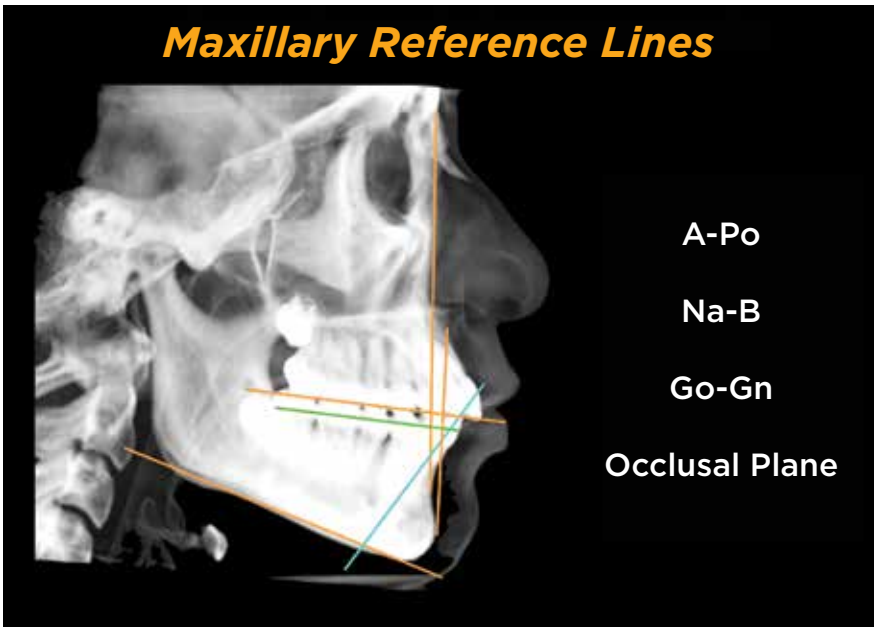
[5]Arnett GW, Jelic JS, Kim J, et al. Soft tissue cephalometric analysis: diagnosis and treatment planning of dentofacial deformity. Am J Orthod Dentofacial Orthop 1999;116:239-53.

[6]Andrews LF, Andrews WA. Andrews analysis. In: Syllabus of the Andrews Orthodontic Philosophy. 9th ed. Six Elements Course Manual; 2001..

# 5. Faulty Diagnoses from Using Intracranial References

Before discussing how to use the MOP to determine our incisor position for Treatment Design, we need to understand the rationale for using this reference over other commonly used references. While there are many potential reference positions for measuring existing and treated incisor inclination, most traditional analyses use intracranial references that are anatomically unique to each patient but yet have "normal" or "ideal" values attached to them for diagnosis. So, how is that possible? The following images illustrate many references which are used to denote incisor position, but which one is correct? More important than being "right", however, is which reference can provide measurements which have consistent and reliable diagnostic information for every patient, irrespective of anatomical variations?



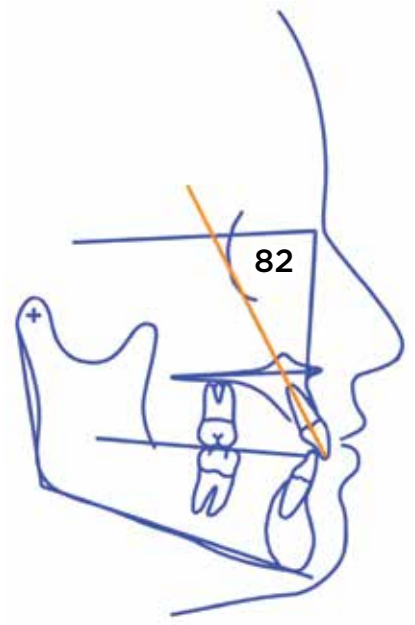



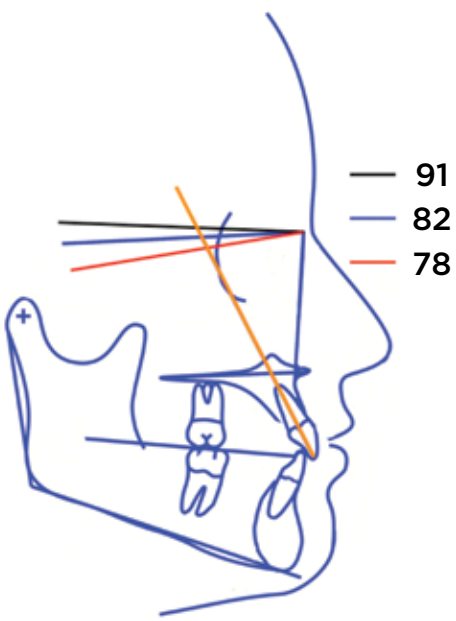

Consider, for example, the following patient. A popular cephalometric measurement, SNA, is used to diagnose the pre-treatment A-P position of the maxilla. In a "normal" patient, like the one shown below, the SNA measurement is 82˚. Values greater than 82˚ suggest the maxilla is protrusive, and values less than 82˚ suggest a retrusive maxillary position, irrespective of any other hard or soft tissue criteria.

However, let's consider the cephalometric landmarks used for this measurement, namely Sella and Nasion, and examine how anatomical variations can affect the diagnosis. First, if the position of Sella is improperly identified or varied among an ethnic population, how would this affect the measurement of SNA, the diagnosis for the A-P position of the maxilla, and, ultimately the treatment planning decisions and mechanics that will be based on this information?

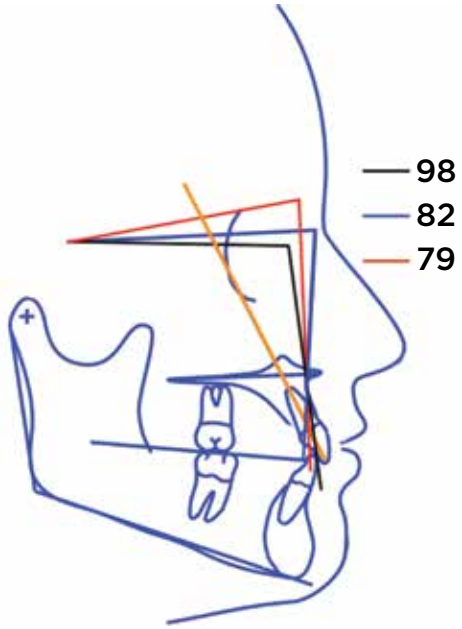
The example below shows the previous patient but with varied positions of Sella, which subsequently changes the SNA measurement and maxillary A-P position "diagnosis" for the patient. Additionally, let's consider variations in Nasion's position to see how that also could affect the SNA measurement and "diagnosis".

Even though there are different numerical values for SNA, the physical position of



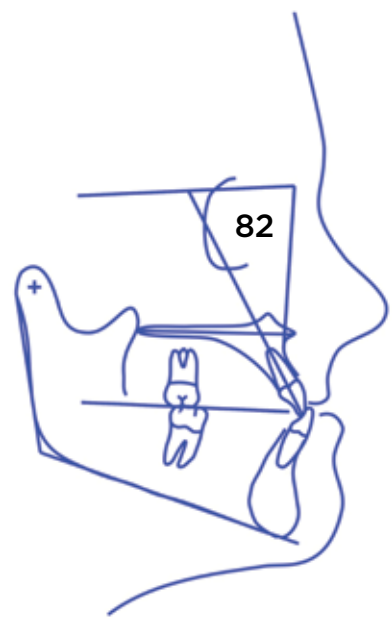

***Variations of Sella on SNA***

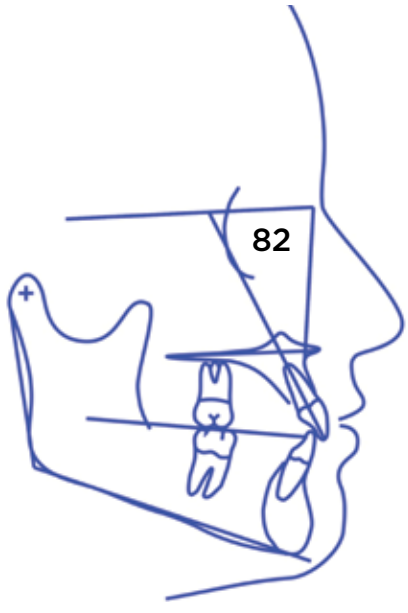


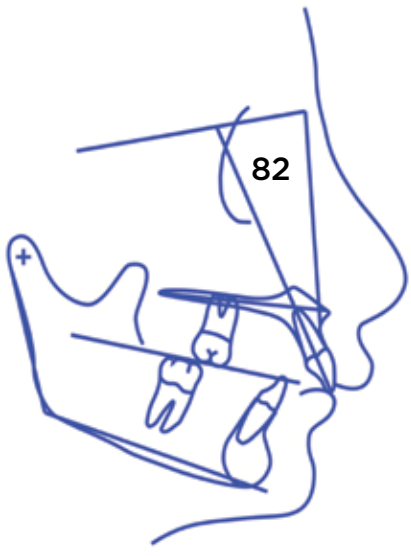

***Variations of Nasion on SNA***

the maxilla has not changed, and neither has the face of this patient. So, for this theoretical patient, an identically positioned maxilla in space could be "diagnosed" as normal, protrusive, or retrusive depending on how the landmarks used are anatomically positioned in the skull. More importantly, though, the SNA information (in all the variations as well) does not relate any information about the patient's face or esthetics, nor does it qualify how treatment should or should not affect it.

Finally, and most importantly, can this information be relied upon for definitive, universal diagnosis of subsequent patients? Consider the following example of three patients, all with SNA measurements of 82˚. The maxillary A-P position for all three patients, while considered "normal" solely by the SNA number, esthetically does not coincide to the clinical presentation of maxillary retrusion/normal mandible of the left patient, normal maxilla/mandible of the center patient, and the combination of maxillary protrusion/mandibular retrusion of the right patient. Also, the SNA measurement does not help quantify the discrepancy or facilitate treatment decisions for esthetic and functional normalization.

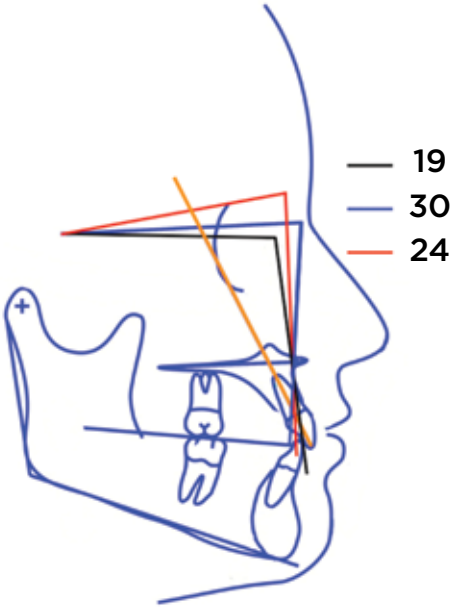


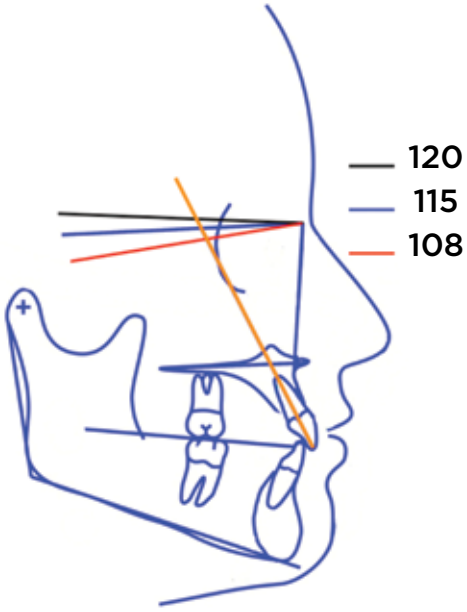



The previous example illustrated one way how intracranial landmarks cannot be relied upon for skeletal positional diagnosis with relation to the patient's face. However, in addition to skeletal criteria, these landmarks are also traditionally used to determine a universal dental "normal", formulate a dental diagnosis, and quantify the amount of dental change needed. Because it was demonstrated previously that these landmarks can affect the skeletal measurement/diagnosis, is it valid to assume variations will affect the dental measurements/diagnosis as well?

Using the same landmarks of Sella and Nasion, two popular measurements for measuring the inclination of the maxillary central incisor are U1-NA line and U1-SN line. The normal values for these measurements are 22˚ and 102˚, respectively. Let's consider measuring the U1-NA line inclinations with variations of Nasion, and the U1-SN line with variations of Sella.




***U1 Inclination using the U1-NA line***

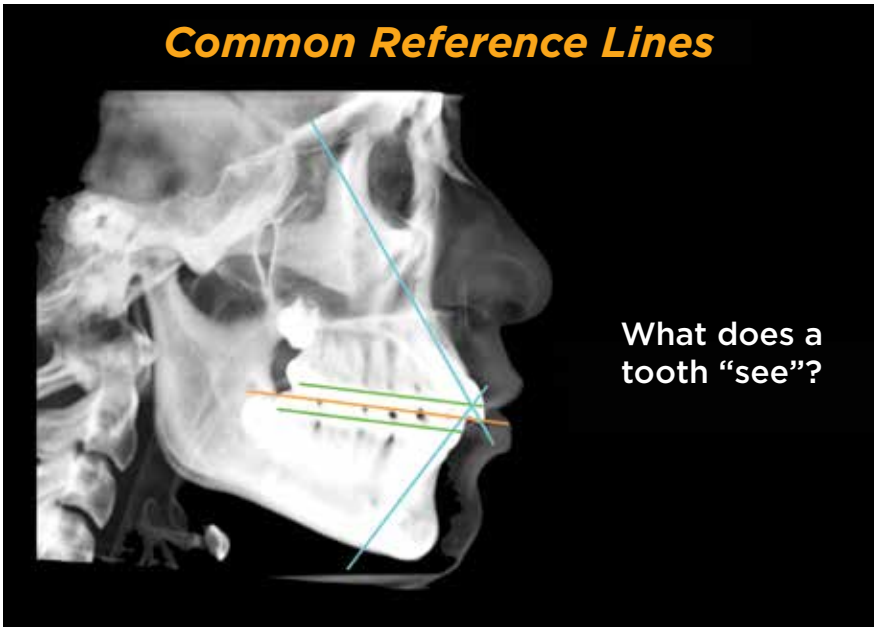



***U1 Inclination using the U1-SN line***

Similar to the skeletal measurements, there is significant "variation" of the inclination of the central incisor depending on how the reference line is anatomically positioned for both of these examples. In reality, though, the position of the incisor is the same, yet the diagnosis and potential plan for "correction" is different for each variation. Therefore, similar to being unreliable for a skeletal diagnosis, intracranial landmarks are not the best reference choice for dental diagnosis either.

***The MOP as an Ideal Dental Reference Line***

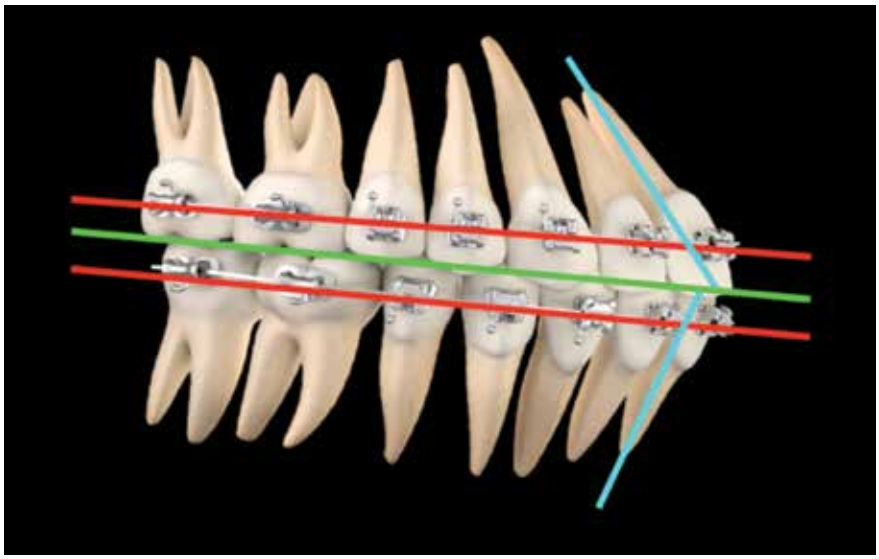
The previous information has already shown that the GVL and SNV lines are acceptable to use as global skeletal and soft tissue references that are non-patient specific and delineate quantifiable treatment goals. Additionally, the previous information showed how intracranial reference lines can lead to faulty information regarding skeletal and dental positions for diagnosis and treatment. So, for the dentition, what does a tooth "understand" and what does a tooth "see"?




The most basic premise of orthodontic treatment is that the wire's deflection and its return to a previous shape is what provides the power to move a tooth. The

bracket, which is cemented to the tooth, is the vehicle to attach the wire to the tooth. However, this bracket has a rectangular slot cut at a 3D predetermined position (bracket prescription), which interacts with the shape of the archwire passing through it. Given that Andrews' research showed little variation in the surface contour of the incisors, we can conclude that the 3D position of these teeth is essentially governed by the interaction of the archwire and the bracket slot. To take this concept a step further, if one uses a true Straight-Wire Appliance (SWA), then all of the bracket slots, when the brackets are ideally positioned on the Facial Axis (FA) point of the tooth, will align and the teeth will be at the optimal inclinations and 3D positions.


Since the treatment goal is to have both archwires parallel to the maxillary occlusal plane prior to debond, then we can infer that the inclination of an incisor will then be dependent only on the interaction of the bracket slot with the archwire. Additionally, because anatomic tooth variations are minimal, then we can further postulate that specific interactions of wire size and slot size will also be universal, predictable, and transferrable. This understanding how the inclination of a maxillary/mandibular incisor in a straight wire appliance relates to the maxillary occlusal plane is a cornerstone of the CCO Treatment Design process.

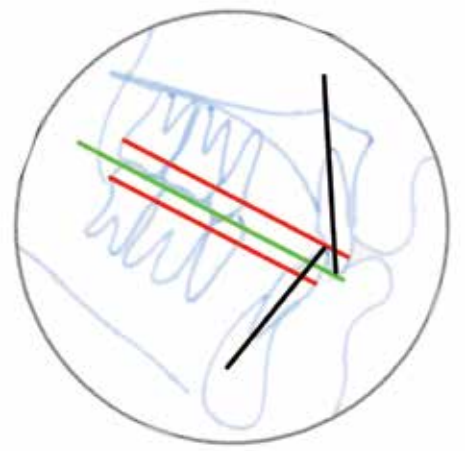


***MOP Inclination and "Torque" Expression***

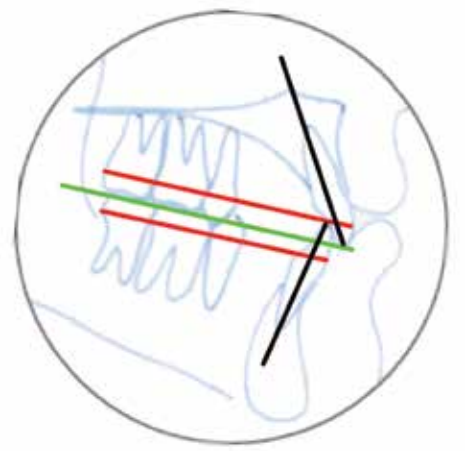
The fundamental concept of Treatment Design is virtually, and more importantly, realistically simulating the orthodontic outcome prior to ever placing a bracket. Unless one knows what will happen consistently with good bracket placement and treatment mechanics, this can be a difficult exercise that may or may not coincide with the actual outcome of the case.

As was demonstrated previously, incisor inclination is related to the maxillary occlusal plane inclination. Therefore, varying the occlusal plane inclination with the same bracket prescription/wire size would not have any effect on the actual inclination, or "torque", of the tooth - only the perceived inclination.

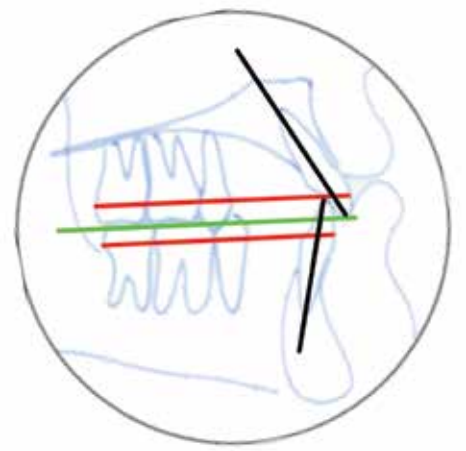
With the above rationale, given the identical wire size and bracket prescription for each of the scenarios below, altering only the occlusal plane can give the appearance of incisors being "retroclined" or "proclined". Therefore, it is appropriate to conclude that "torque" in the bracket prescription is expressed relative to the occlusal plane and not another internal or external reference.



***Steep MOP***



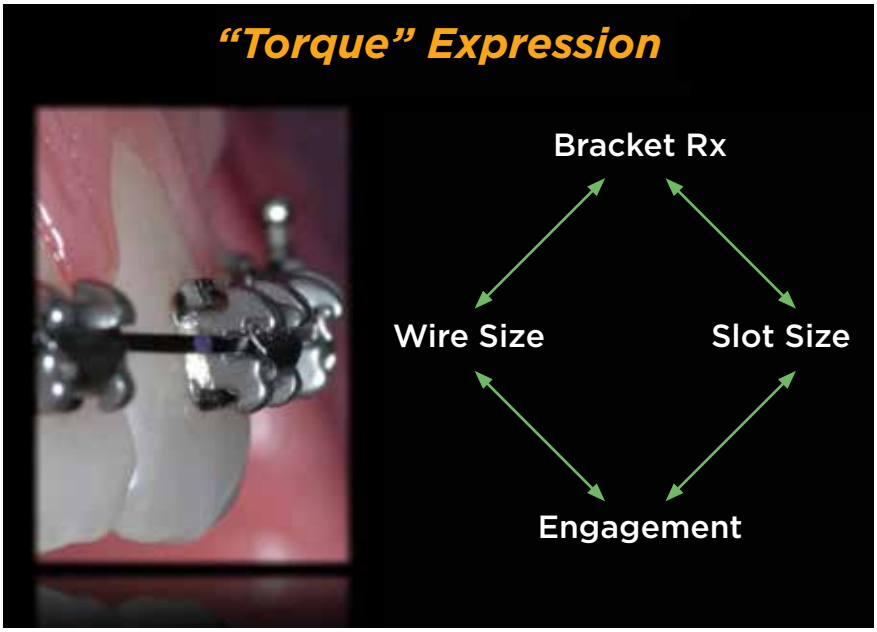
***Ideal MOP***



***Flat MOP***

***Expression of Dental Inclination / "Torque"***

Understanding how dental inclinations are expressed with respect to the appliance used has little importance unless it can have predictive value. Therefore, for Treatment Design, the practitioner has to know what inclination the appliance is capable of delivering CONSISTENTLY and PREDICTABLY in order to have a starting point for analysis. Without this ability or knowledge, treatment planning is no better than a guess and can prove to be a frustrating exercise, or one that is simply done "on the fly", neither of which is in the best interest of the patient.



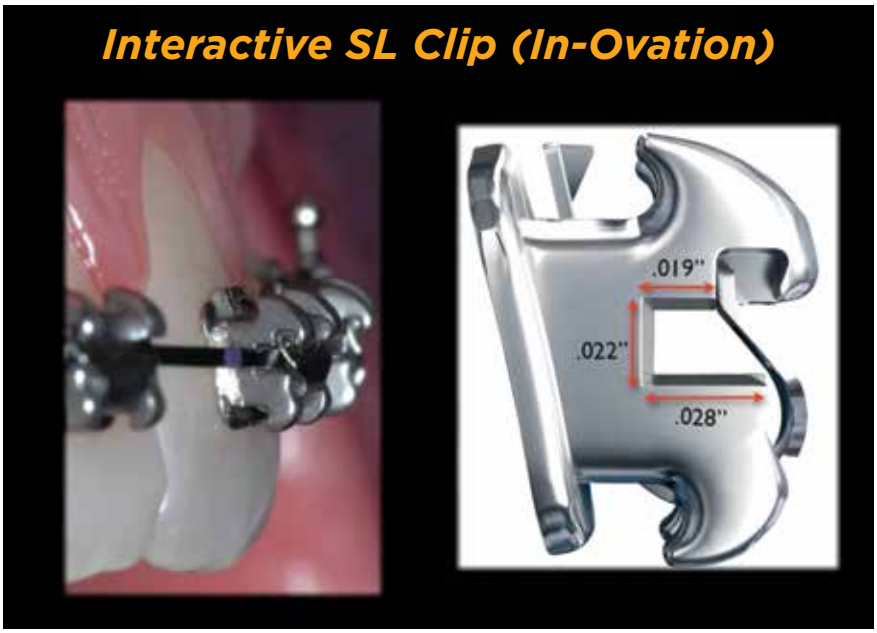

Assuming the bracket is placed correctly, the inclination of a tooth is dependent on four factors – the "torque" prescription of the bracket, the wire size used, the slot size used, and the amount of engagement.

The “torque” portion of the bracket prescription is self-explanatory. The higher the torque value, the more torque the bracket has the potential to express. For this manual, the CCO prescription is used with the following standard “torque” values.

**Maxillary Central Incisor: 12° torque**
**Mandibular Central Incisor: -6° torque**

The wire size and slot size go hand in hand, no matter if the practitioner uses 0.018” or 0.022” slot brackets. The larger the wire size placed in a given slot, the more it fills the slot, and the more the torque value of the bracket will be expressed.

The key variable in torque expression, however, is the engagement of the wire with the bracket slot. A loosely engaged wire will have less interaction with the bracket slot, especially if it is less than the full dimensions of the slot. This is commonly referred to as “slop”. In order to minimize “slop,” the wire must either be engaged tightly or a larger wire size must be used. Engaging the wire tightly with ligature ties at every patient visit is time consuming and the ligature wire can fatigue in between appointments. The alternative of using larger size wires is often not appealing because they are harder to engage and can be more uncomfortable for the patient.




The solution is an interactive clip mechanism as is present on the In-Ovation self-ligating (SL) bracket. With this bracket design, the gingival wall of the bracket is a smaller dimension than the incisal wall. Since the clip flexes and “pushes” the wire into the slot, full engagement is possible with a less than full slot size wire and without ligature ties.

Studies have shown that with interactive SL brackets full “torque” expression of 0.022” slot brackets can be achieved with any wire that is 0.019” x 0.025”” or larger. This is an important concept and feature that is the key to CONSISTENT bracket prescription expression for Treatment Design purposes.

## Torque Expression of Mandibular 2nd Premolar (22° Interactive SL Brackets)

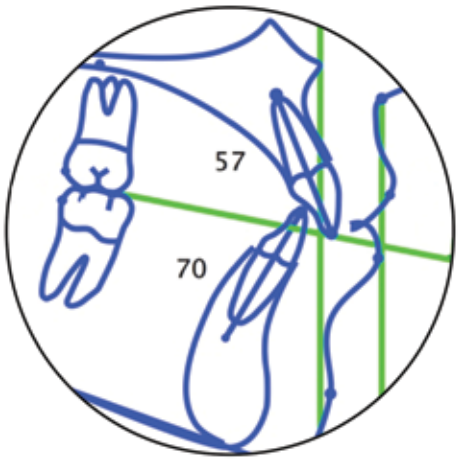
| In-Ovation | Effective Torque |
|---|---|
| 17” x 25” | 17° |
| 18” x 25” | 19° |
| 19” x 25” | 22° |
| 21” x 25” | 22° |

Gick MR, Nóbrega C, Benetti JJ, Jakob SR, Zucchi TU and Arsati F. Orthodontic Science and Practice. 2012: 5(17):37-46.

***Setting the Incisor Inclination***

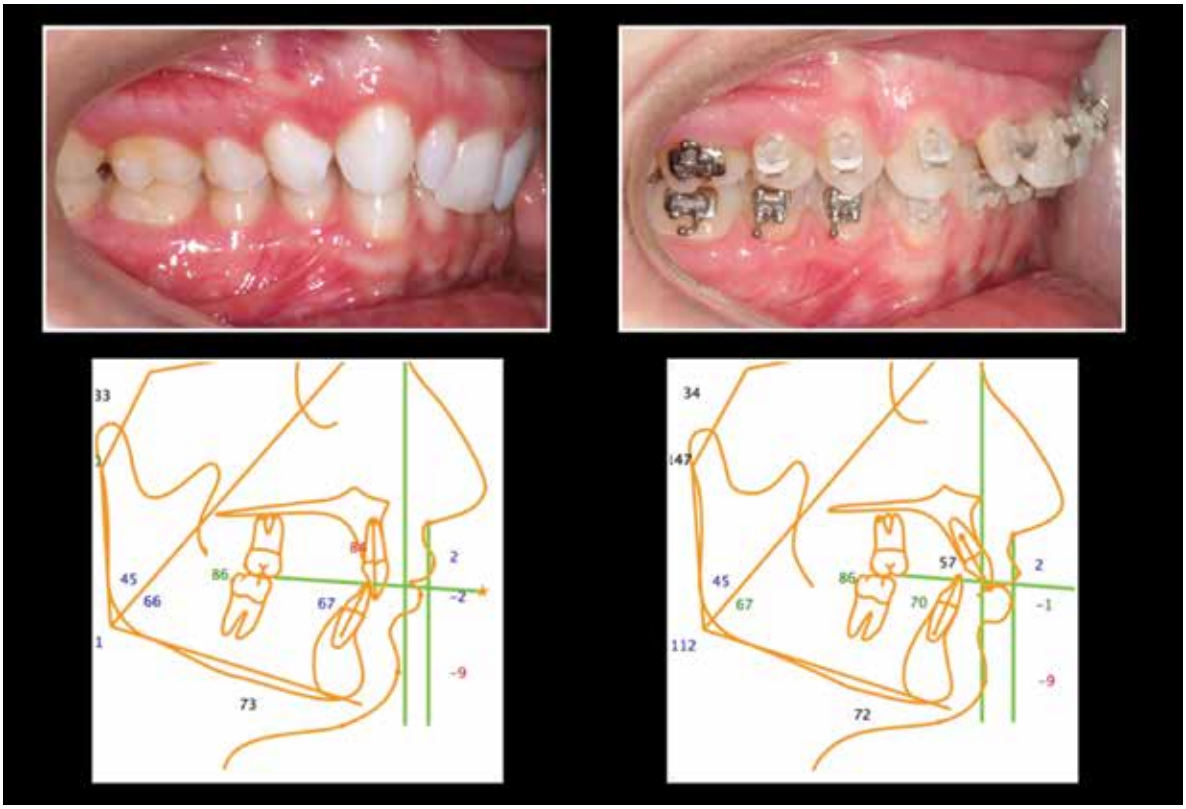
One of the goals of the Treatment Design is to first evaluate the patient from an optimal treatment perspective. Therefore, before decisions on treatment or potential treatment compromises can be made, the orthodontist must first evaluate the patient as if full bracket prescription values have been expressed. This provides a frame of reference to what "ideal" treatment is, and then the plan may be modified as needed to accomplish the individual goals for the patient.

For the In-Ovation bracket with the CCO prescription fully expressed in a 0.019"x0.025" wire, the maxillary incisors will be at 57˚ to the MOP, and the mandibular incisors will be at 65-70˚ to the MOP.



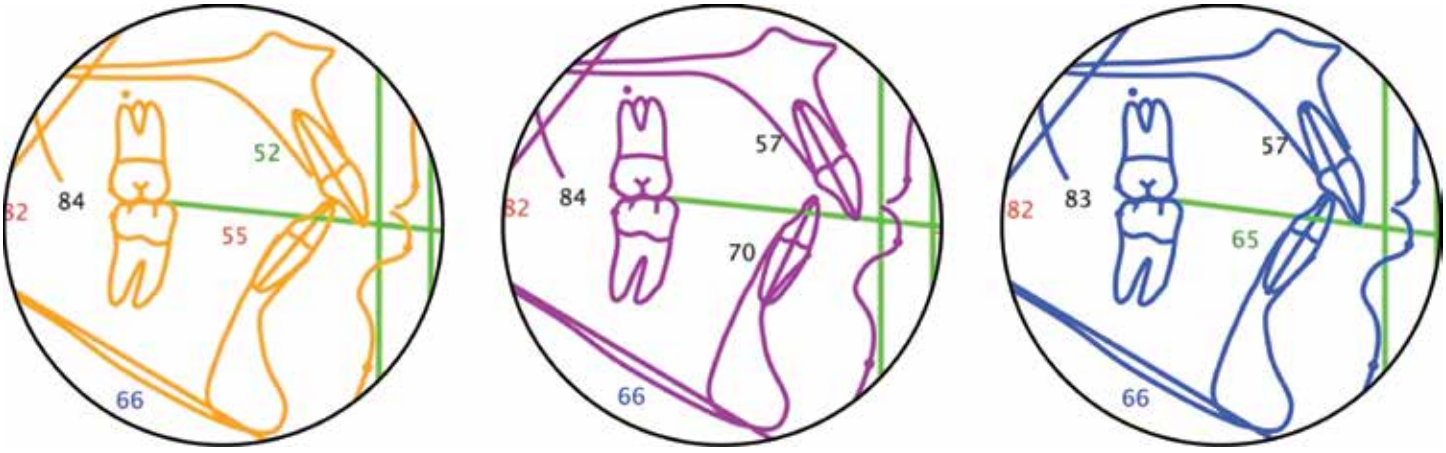

**Maxillary Central Incisor: 57˚**
**Mandibular Central Incisor: 65-70˚**

The following example is a pre-surgical decompensation case. No mechanics other than changing wires were used up to U/L 0.019"x0.025" steel wires. Note the inclinations of the incisors to the MOP with full bracket expression.



With the CCO prescription and 0.019”x0.025” finishing wire, the post-treatment maxillary incisor inclination value has been shown to be exactly 57˚ for many cases. However, the mandibular incisor inclination has shown more of a normal “range” instead of an single value. The rationale for this is due to the anatomical limitations and dimensions of the symphysis (versus the maxillary alveolus being larger) of some patients as well as additional factors acting on the mandibular teeth, such as the tongue, that can prevent full uprighting to 70˚ over basal bone in every case.

The following example shows a case where there is very little width to the alveolus. If the lower incisor was fully inclined to 70˚ to the MOP, the root would be fenestrated, off of basal bone, and unable to couple with the maxillary incisor. Additionally, this could not happen anatomically due to the restrictions to tooth movement. Instead, having the incisor at 65˚ to the MOP facilitated it remaining in the alveolus, positioned over basal bone, and coupled with the maxillary incisor.




***Initial Incisor Inclination*** ***Unrealistic Incisor Inclination*** ***Realistic Incisor Inclination***

The importance of understanding what inclination of the incisors can CONSISTENTLY be achieved and how this ideal inclination relates to the hard tissue esthetics and soft tissue esthetics of each patient is the starting point of the entire Treatment Design process.

There may be cases where the practitioner chooses to not have an “ideal” inclination to the incisors in order to camouflage a skeletal discrepancy or because of anatomical limitations to tooth positioning. However, this decision for where to place and incline the incisors still needs to be framed within the realm of good esthetics, periodontal viability, and realistic movements for stability.

Additionally, by knowing where “ideal” should be, these compromises can be quantified and visualized to see how far from “ideal” the case may finish, as well as realize the potential side effects of doing so. Ultimately, whatever position the practitioner chooses to be appropriate for the incisors needs to be consistent with the rest of the Treatment Design process in order for the treatment plan to have meaning and validity.

The rest of this manual will focus on how to use this information to formulate a realistic, predictable, and physiologic ideal treatment plan for a patient and also determine how to make rational compromises should they be indicated or needed.

[7]Andrews LF, Andrews WA. Andrews analysis. In: Syllabus of the Andrews Orthodontic Philosophy. 9th ed. Six Elements Course Manual; 2001.

# 6. Determining Tooth Space Requirements

Once the Target Lines are placed on the lateral headfilm and the maxillary and mandibular incisors are ideally inclined and centered in the bone, the posterior teeth can be moved in order to determine the anchorage requirements. The objective is to have no spacing or crowding remaining at the conclusion of treatment. Therefore, the amount of needed movement of the posterior teeth, which will allow the incisors to remain at their ideal position, is easily calculated.

The space requirement for the dentition and associated changes of space with tooth movement can be derived from research performed by Andrews[7]. This analysis has proven to be comprehensive and accurate, and modification of Andrews' original concepts is not warranted. The space requirement is then calculated as a sum of six individual components, all of which either contribute to net spacing or crowding of the dentition of transversely coordinated arches, followed by methods for creating or closing space, for a final space requirement of zero.

These components are measured to determine the overall crowding/spacing for an arch:

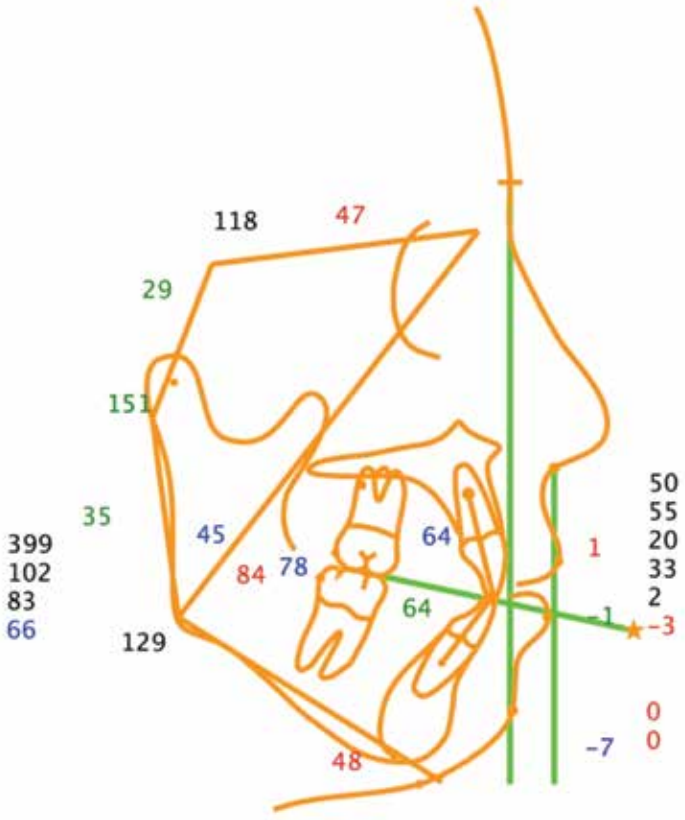
1. **Change in inclination of incisors**
2. **Crowding/spacing physically present**
3. **Change in maxillary jaw width**
4. **Change in dental arch width**
5. **Leveling the Curve of Spee**
6. **Tooth/size discrepancy**

These components contribute to relieving the overall crowding/spacing

1. **Tooth extraction**
2. **Molar distalization/mesialization**
3. **Interproximal reduction (IPR)**

***Case Example***

For illustration purposes and for consistency, the tooth spacing requirements and movements will follow the diagnosis of one patient. The case is a non-growing female with a non-contributory medical history, no TMJ symptoms or pathology, and minimal SCP/MIC discrepancy on the mounted models. The intraoral images represent the SCP occlusion well, and the lateral headfilm did not require conversion.




***SCP Ceph = MIC Ceph (no conversion needed)***

### *Diagnostic Sheet*

For each patient, the space requirement portion of the diagnostic sheet will be used. As this text progresses with the Treatment Design for the patient above, the CCO Diagnostic Sheet will be populated with data based on the positions of the incisors and the molars. This will allow for decisions to be made for the treatment plan as well as the mechanics needed to successfully complete the case.

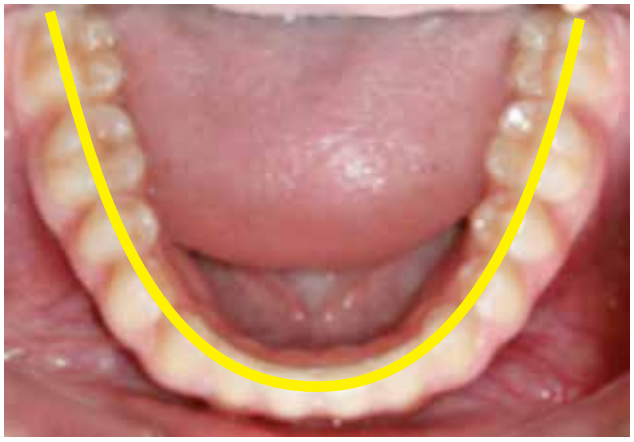
***Space Requirement***

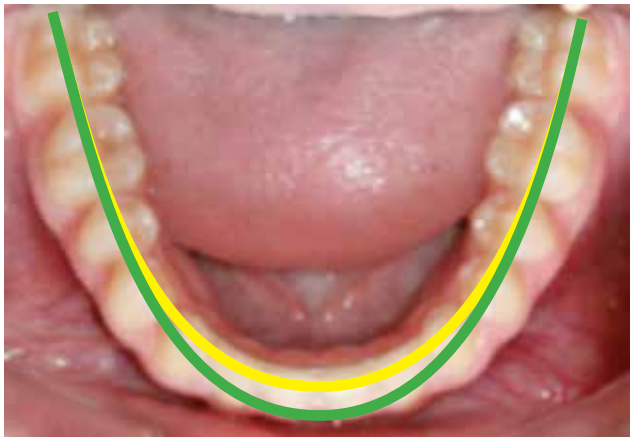
| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Incisor Inclination (X2) | | | | |
| Crowding/Spacing | | | | |
| Maxillary Expansion | | | | |
| Dental Expansion | | | | |
| Curve of Spee | | | | |
| Tooth/Size Discrepancy | | | | |
| Unresolved Space Requirement | | | | |
| Extraction | | | | |
| Distalization/Mesialization (X2) | | | | |
| IPR | | | | |
| Final Space Requirement | 0 | | 0 | |

### *Incisor Inclination*

As previously discussed, one objective of tracing the lateral headfilm is to ideally position the incisors within the alveolus and at the proper inclination to the occlusal plane. As the inclination of the incisor changes, however, the amount of available space for the dentition will either increase or decrease. Proclining the incisors will create additional space, while retroclining the incisors will require space.

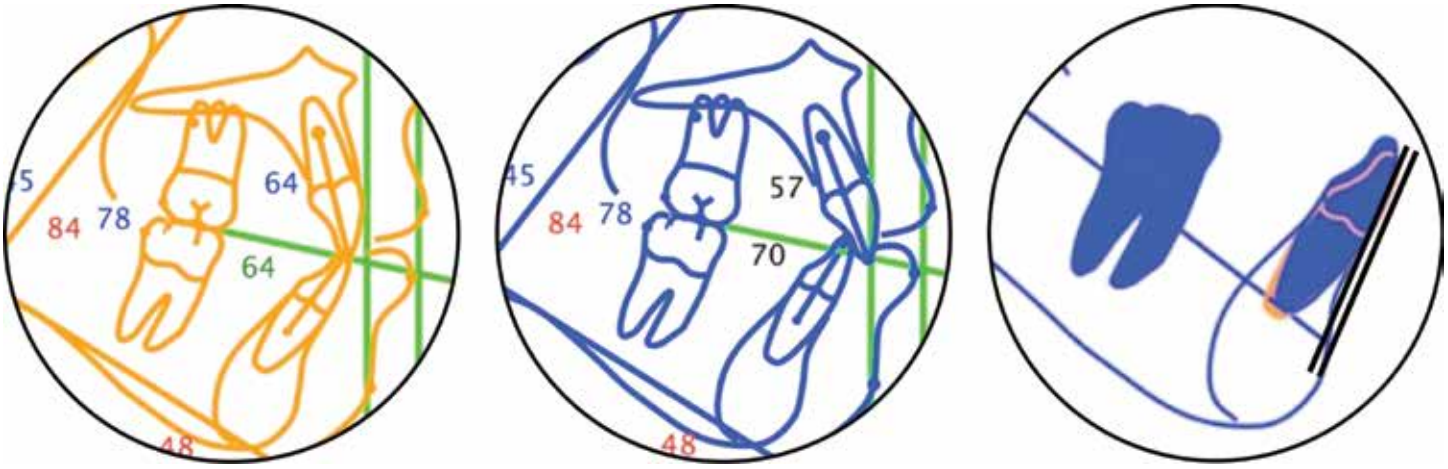
The rationale for this can be illustrated by the following photographs. Increasing the archform along the cusp tips and incisal edges (by proclining the teeth) makes the effective “line” connecting the teeth longer, thereby increasing the space available to accommodate the dentition.



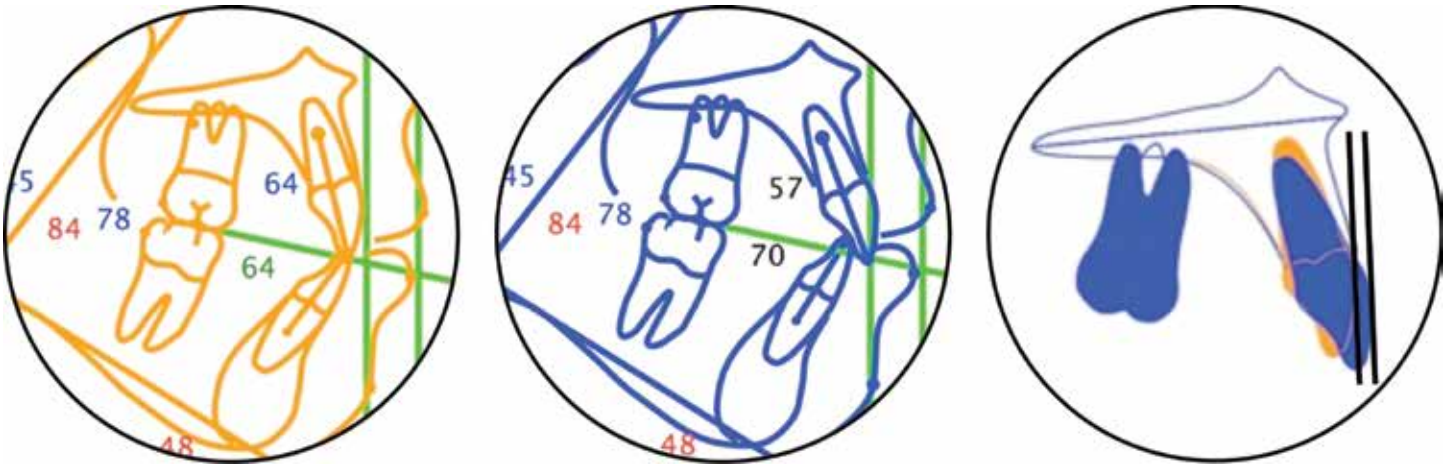


Through Andrews' research, the approximate change is 1 mm of space gain/loss per 1 mm of FA point change of the incisor from its initial to desired position. Because this only accounts for one quadrant, the measured change must be doubled in order to realize the whole-arch effect.

Looking at the case example above, the maxillary incisors were initially inclined at 64˚ to the MOP. By placing them with optimal inclination of 57˚ to the MOP the FA point is slightly ahead of the GVL with the tooth centered in the alveolus. For this to happen, the FA point moved facially 2 mm.




For the mandibular teeth, the initial inclination was 64˚ to the MOP. Idealizing their inclination to 70˚ to the MOP allows them to couple with the maxillary incisors at the ideal OB/OJ and still be centered within the alveolus. For this movement, the FA point moved lingually 0.5 mm.




Looking at this incisor position with respect to the Target Lines, the esthetic requirements for this case are satisfied. Also, the incisors are centered in the alveolus over basal bone, so the periodontal goals are achieved. Finally, the incisor inclination is achieved with full expression of the bracket prescription, so the movements are achievable and realistic. This also shows that the skeletal diagnosis is Class I and no compromise to the incisor position is needed.

The values entered into the diagnostic sheet are as follows:

**Maxillary arch: 2 mm FA point change X 2 = 4 mm of space gained**
**Mandibular arch: -0.5 mm FA point change X 2 = -1 mm of space needed**

***Space Requirement***

| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Incisor Inclination (X2) | **4** | | **-1** | |
| Crowding/Spacing | | | | |
| Maxillary Expansion | | | | |
| Dental Expansion | | | | |
| Curve of Spee | | | | |
| Tooth/Size Discrepancy | | | | |
| Unresolved Space Requirement | | | | |
| Extraction | | | | |
| Distalization/Mesialization (X2) | | | | |
| IPR | | | | |
| Final Space Requirement | **0** | | **0** | |

If changes to the ideal inclination were desired, then the compromise position would be used for the space calculation. On the diagnostic sheet, the box for incisor inclination values is divided into 2 for this purpose. The first box represents the "ideal" space", while the second box would be used for a "compromise" should it be desired.

***Limits of Sagittal Camouflage***

The rationale for setting the maxillary and mandibular incisors at 57˚ and 70˚ to the MOP, respectively, and centering them within the alveolar bone was previously discussed. This is the base understanding of what will be achieved via orthodontic treatment with only using brackets and wires, specifically 0.019"x0.025" wire on an In-Ovation active self-ligating central incisor bracket with the CCO prescription.

If the teeth couple at the proper OJ after this exercise, this tells the practitioner that there are ideal sagittal skeletal relationships present. Additionally, this shows that minimal adjunctive work will be needed to achieve the simulated result. The wires and bracket clip just need to work to allowing the full bracket prescription to express itself.

Many times, however, the teeth set at 57˚/70˚ to the MOP will NOT couple ideally on the simulation. The practitioner will instead see residual OJ (signifying a Cl. II skeletal pattern) or overlapping incisor tips/negative OJ (Cl. III skeletal pattern) remaining. Understanding this phenomenon is critical from a treatment planning perspective, as well as setting realistic pre-treatment orthodontic expectations for patient and/or the patient's parent with what can be accomplished with braces alone.

When the teeth don't couple at the optimal inclinations, measuring the residual OJ along the MOP quickly quantifies the underlying skeletal discrepancy for the practitioner. Once the amount of the sagittal discrepancy is known, then the Target Lines are used to objectively qualify which jaw(s) is (are) contributing to the discrepancy, and also quantify by how much they deviate from the ideal.

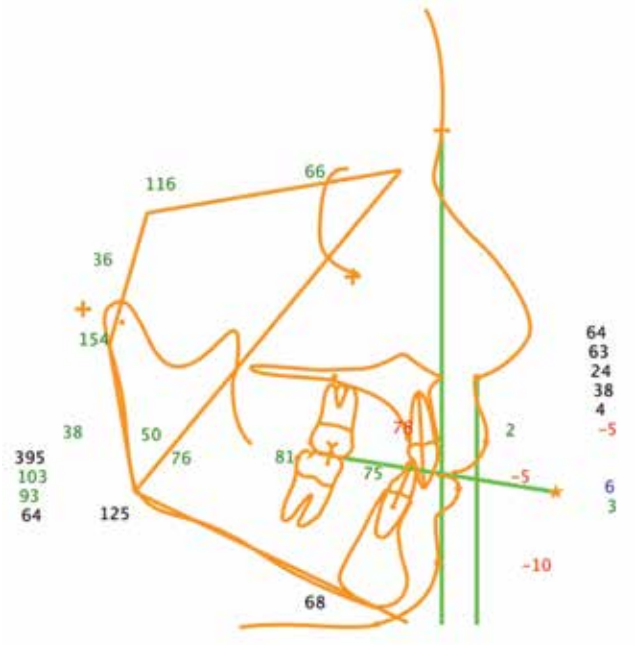
From here, the practitioner may now make rational treatment decisions, based on his own comfort level and experience, for how to resolve the discrepancy.

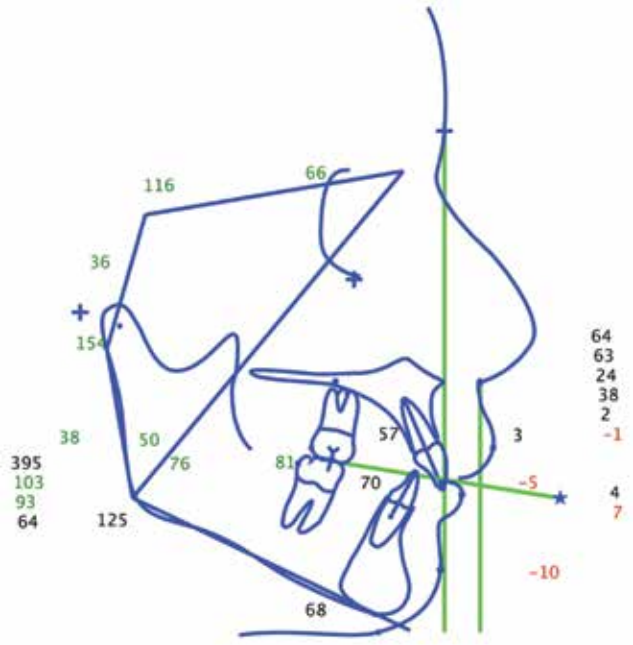
In non-growing patients, the Target Lines for the hard and soft tissue, as well as the anatomy of the alveolus and pre-existing periodontal biotype, will all need to be considered when deciding on sagittal limits of

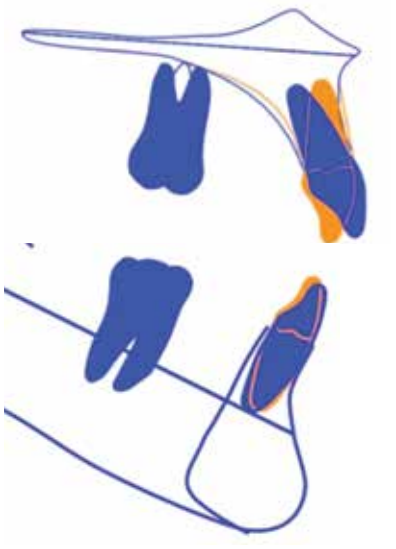
camouflage. In growing patients, the growth potential along with the growth modification potential (realized from the Jarabak cephalometric numbers on tracing) will be used to realistically decide what may or may not be possible with orthodontic/orthopedic treatment alone.

***Case Example #1:***

The initial ceph tracing reveals a Cl. II skeletal deep bite with retroclined incisors. Currently, there is "6 mm" of overbite, "3 mm" of overjet, and a Cl. II molar relationship. However, this information is meaningless because we do not have a reference to understand what is going to happen with treatment. Therefore, the first step toward realizing the abilities of braces-only treatment for this patient is to set the incisors ideally at 57˚/70˚ and center them within the alveolus.



| *Space Analysis* | | | | |
|---|---|---|---|---|
| | **Maxilla** | | **Mandible** | |
| Incisor Inclination (X2) | **5** | | **2** | |
| Crowding/Spacing | | | | |
| Maxillary Expansion | | | | |
| Dental Expansion | | | | |
| Curve of Spee | | | | |
| Tooth/Size Discrepancy | | | | |
| Unresolved Space Requirement | | | | |
| Extraction | | | | |
| Distalization/Mesialization (X2) | | | | |
| IPR | | | | |
| Final Space Requirement | **0** | | **0** | |

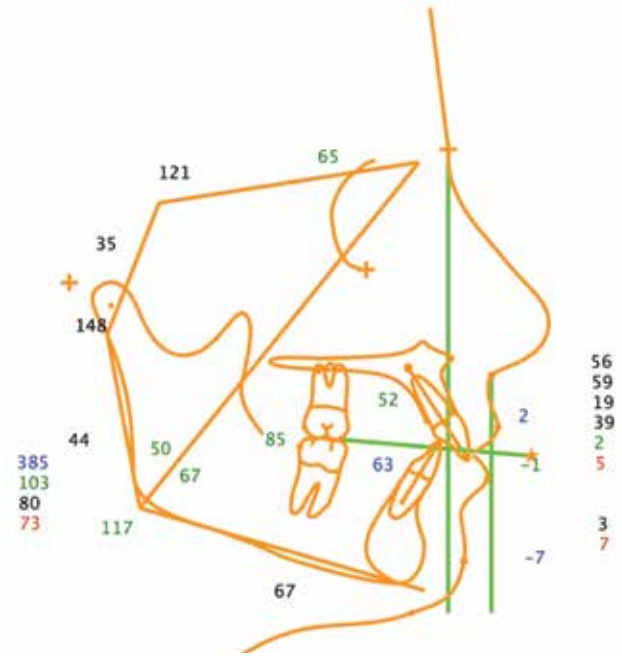
This virtual "decompensation" of the incisors helps to better visualize the case. First, there is actually 4 mm of overbite and 7 mm of overjet present (not 6 mm of OB and 3 mm of OJ). Secondly, the facial of the ideally inclined "treated" maxillary incisor falls directly on the GVL. This indicates that the maxilla is optimally positioned at baseline, and 100% of the overjet/Cl. II pattern is due to a retrusive mandible. Thirdly, evaluation

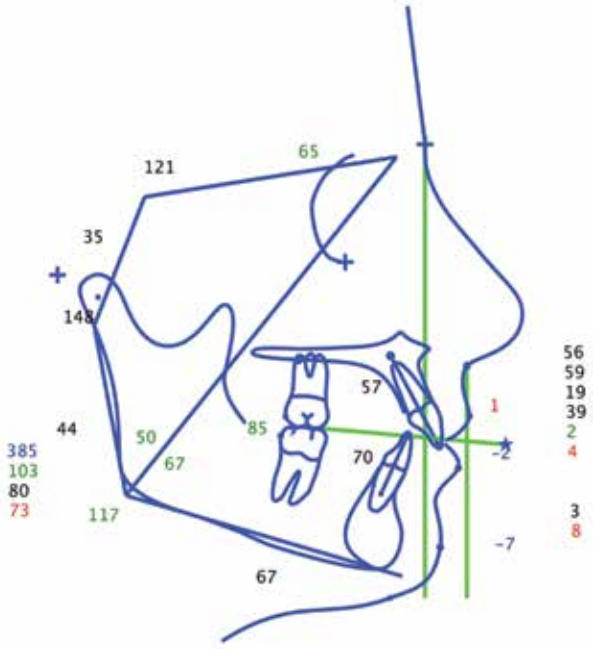
of the soft tissue esthetics with the SNV line confirms the Cl. II skeletal pattern with optimal upper lip support and a retrusive lower lip and chin. This case can now be qualified in the sagittal dimension as a "Cl. II skeletal/ dental pattern due to a retrusive mandible and normally positioned maxilla". Most importantly, the sagittal discrepancy can now be quantified as 7 mm.

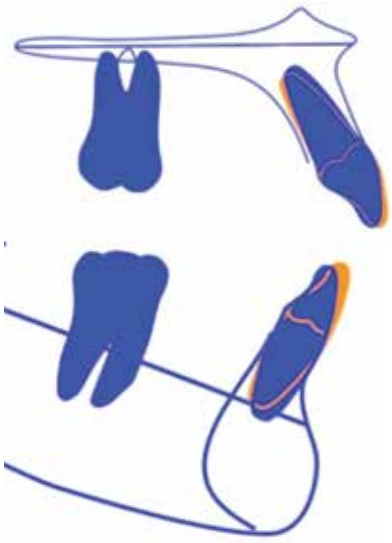
Think of how powerful this realistic, qualified, and quantified information is when deciding on treatment decisions and instilling confidence into the practitioner. Subsequently, when presenting objective options to parents/patients, no speculation or guessing is needed.

Going forward, the aim for this hypothetical case would be to maintain the position of the maxilla and allow the upper incisor to be optimally inclined. If the patient has mandibular growth remaining, and it is favorable, then the practitioner's preference for strategies to take advantage of this differential jaw growth could be employed. If the patient is a non-growing individual, then gingival biotype, periodontal limits of the alveolus, and quality of the soft tissue will determine the ability to confidently propose camouflage vs. orthognathic options.

***Case Example #2***:



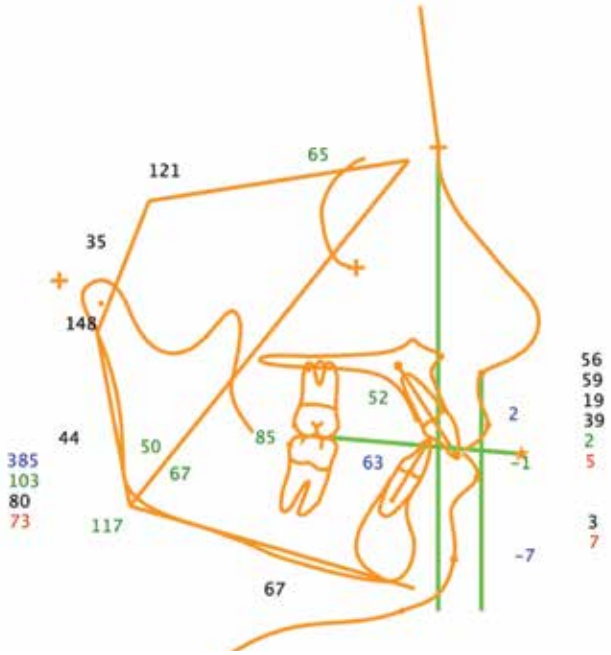



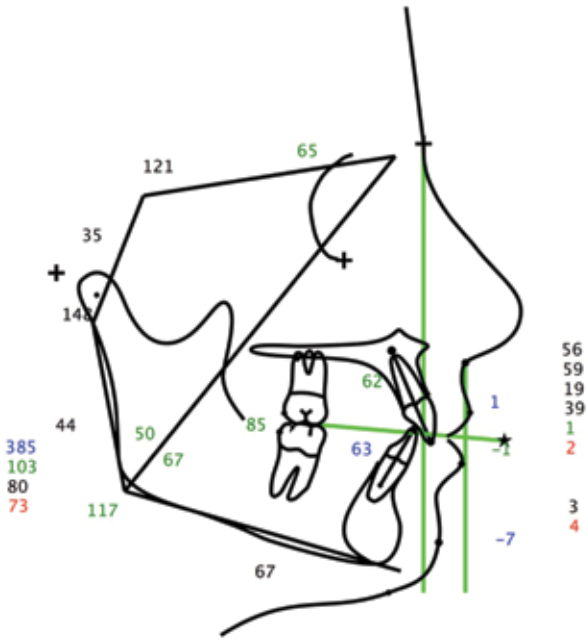
| *Space Analysis* | | | | |
|---|---|---|---|---|
| | **Maxilla** | | **Mandible** | |
| Incisor Inclination (X2) | **-1** | | **-3** | |
| Crowding/Spacing | | | | |
| Maxillary Expansion | | | | |
| Dental Expansion | | | | |
| Curve of Spee | | | | |
| Tooth/Size Discrepancy | | | | |
| Unresolved Space Requirement | | | | |
| Extraction | | | | |
| Distalization/Mesialization (X2) | | | | |
| IPR | | | | |
| Final Space Requirement | **0** | | **0** | |

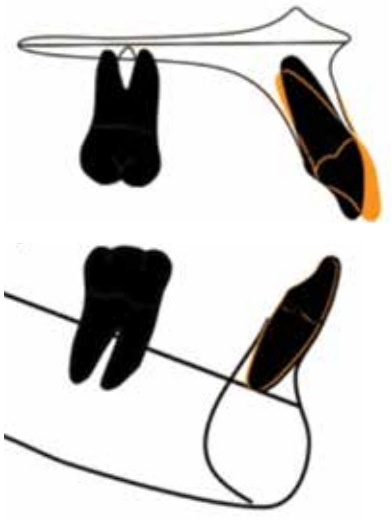
Idealizing the inclination of the incisors to 57˚/70˚ to the MOP reveals a Cl. II skeletal pattern with a combination of a protrusive maxilla/retrusive maxilla according to the GVL Target Line. However, the soft tissue reveals a nearly optimal upper and lower lip structure with a mildly retrusive chin. Therefore, maintaining this soft tissue relationship will be a goal of treatment, regardless of the underlying skeletal relationship to the GVL.

When optimizing the incisor position for this case, the FA point of the maxillary incisor retruded 0.5 mm (for a total space loss of -1 mm), and the mandibular incisor uprighted 1.5 mm (for a total space loss of -3 mm). Residual OJ is present, thus indicating an underlying skeletal disharmony. While an "ideal" treatment plan might involve orthognathics to optimize the dental inclinations as well as the skeletal bases, this is not possible for many patients, nor is it warranted for every case. Therefore, understanding how to simulate camouflage via changing incisor inclinations within the periodontal and esthetic limits is extremely important.

A possible camouflage situation for this case is below:



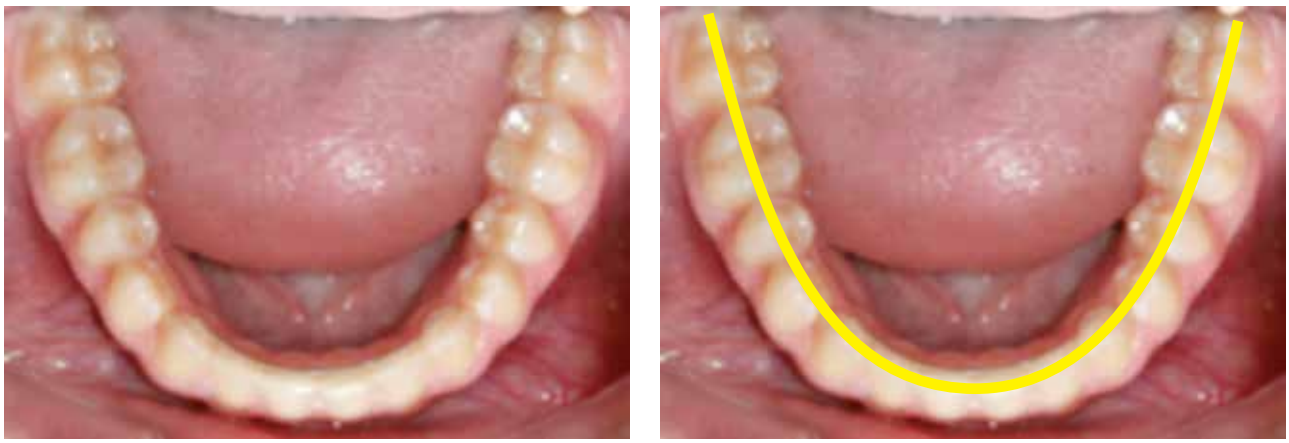
| *Space Analysis* | | | | |
|---|---|---|---|---|
| | **Maxilla** | | **Mandible** | |
| Incisor Inclination (X2) | **-1** | **-4** | **-3** | **0** |
| Crowding/Spacing | | | | |
| Maxillary Expansion | | | | |
| Dental Expansion | | | | |
| Curve of Spee | | | | |
| Tooth/Size Discrepancy | | | | |
| Unresolved Space Requirement | | | | |
| Extraction | | | | |
| Distalization/Mesialization (X2) | | | | |
| IPR | | | | |
| Final Space Requirement | **0** | | **0** | |

In this camouflage plan, the maxillary incisor uprighted/retracted for a change of -2 mm at the FA point (-4 mm total space change), the mandibular incisor inclination remained unchanged, the teeth are well positioned in their respective alveoli, and the esthetic change is negligible – all which are acceptable to the overall treatment.

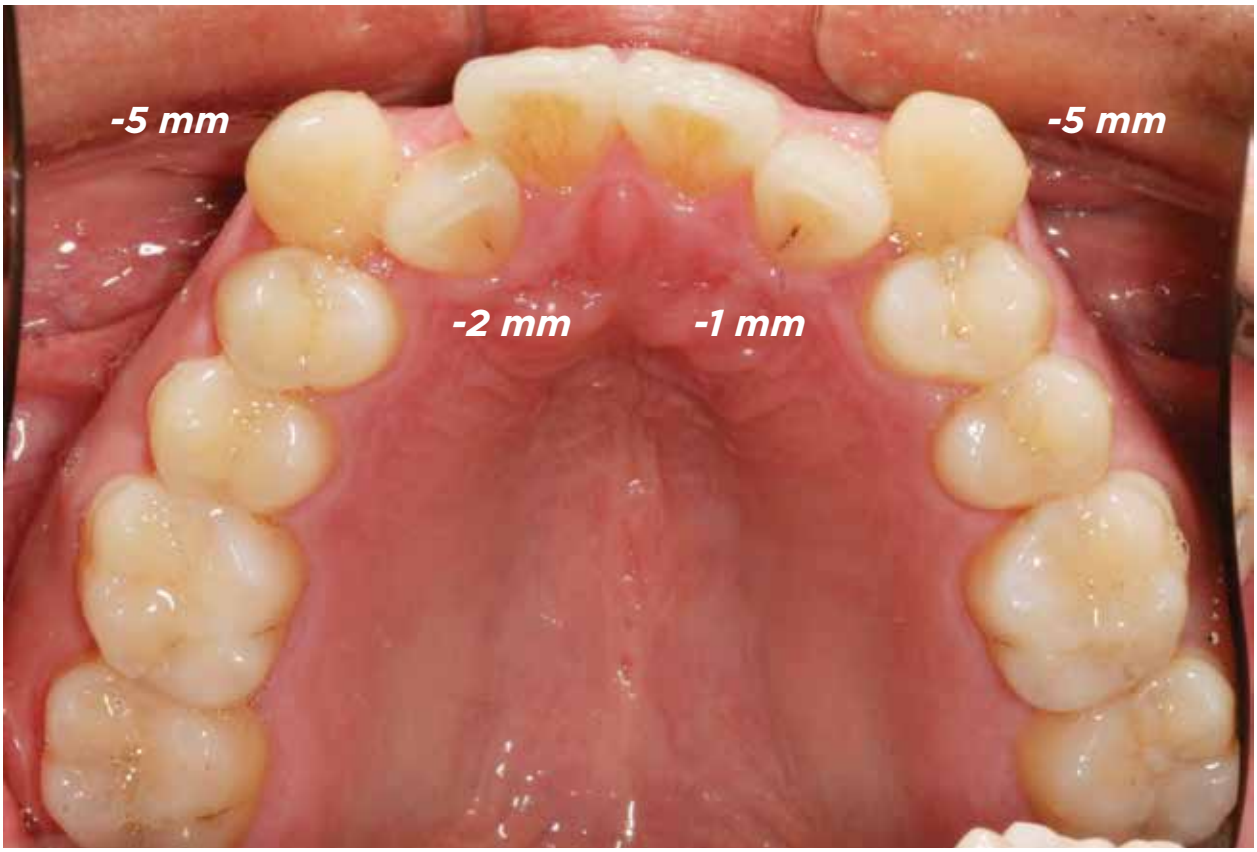
It is critical in these camouflage cases to have the numbers used for the space analysis actually reflect the proposed treatment. Therefore, while the optimal space change of the maxillary/mandibular incisors would be -1 mm/-3 mm, these numbers are inappropriate to use. The proposed camouflage treatment calls for -4 mm/0 mm. These numbers (in red) are placed in the second column of the space analysis table and are the ones to be used for the calculations going forward.

***Crowding/Spacing***

The crowding or spacing is determined by the amount of space needed to accommodate the dentition with no rotations or residual crowding/spacing present. An optimal (treated) arch is shown below along with illustration of the archform.



When determining the amount of crowding/spacing, the objective is to measure or estimate only the space necessary to accommodate the dentition of the patient's optimal archform. No allowances need to be made for expansion, leeway space, etc. at this time. The following example illustrates both the untreated and treated arches of the same patient and treatment archform is superimposed on the pre-treatment picture. The larger picture identifies the 13 mm of space needed to align the teeth to the desired archform.




Using our patient example, the measured amount of crowding for the maxillary arch is 17 mm, and the mandible presented with 4 mm of crowding. These values are entered as negative numbers in the space requirement portion of the Diagnostic Sheet because they are values that "take up" space.

***Diagnosis of the Transverse Dimension***

The goal for transverse normalization is having teeth that are upright in the alveolus, centered in the alveolus, and well-intercuspated at the conclusion of orthodontic treatment. For this to occur, ideally the patient should have a maxillary skeletal base that is 5 mm wider than the mandibular skeletal base.

Several methods have been previously suggested to determine if these skeletal proportions exist naturally or if the patient would benefit from maxillary expansion. However, due to variations of human anatomy, it is difficult to force patients to conform to accepted "normals" of "standard" skeletal base measurement

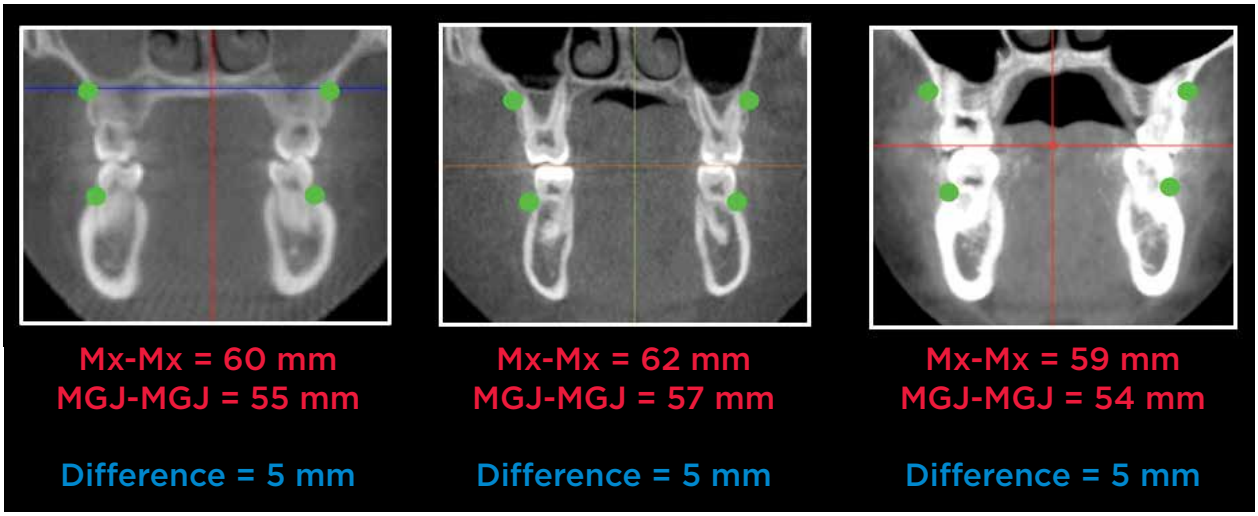
***Space Requirement***

| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Incisor Inclination (X2) | 4 | | -1 | |
| Crowding/Spacing | -17 | | 4 | |
| Maxillary Expansion | | | | |
| Dental Expansion | | | | |
| Curve of Spee | | | | |
| Tooth/Size Discrepancy | | | | |
| Unresolved Space Requirement | | | | |
| Extraction | | | | |
| Distalization/Mesialization (X2) | | | | |
| IPR | | | | |
| Final Space Requirement | 0 | | 0 | |

averages[8]. Additionally, using pre-treatment interdental measurements to determine a skeletal expansion need can lead to false negatives of an actual underlying skeletal issue[9].

The contemporary transverse paradigm needs to consider each patient as their own "normal" and instead optimize the individual's relationship between the jaws. In other words, given that mandibular skeletal base proportions are genetically determined and not easily modifiable through conventional orthodontic treatment, this dimension serves as the reference position. The orthodontist's role involves determining when the patient would benefit from modifying the maxillary transverse dimension to achieve corresponding, individualized harmony.

In the image below, three unique patients are presented with pre-treatment posterior dental relationships where the teeth are upright in the alveolus, centered in the alveolus, and well-intercuspated. Note the numerical mandibular skeletal base at the muco-gingival junction (MGJ-MGJ) measurements, and maxillary skeletal base at the level of Mx point (Mx-Mx) dimensions are variable. However, in all cases the differential




[8]Ricketts RM, Grummons D. Frontal Cephalometrics: Practical Applications, Part 1. World J Orthod 2003;4:297– 316.

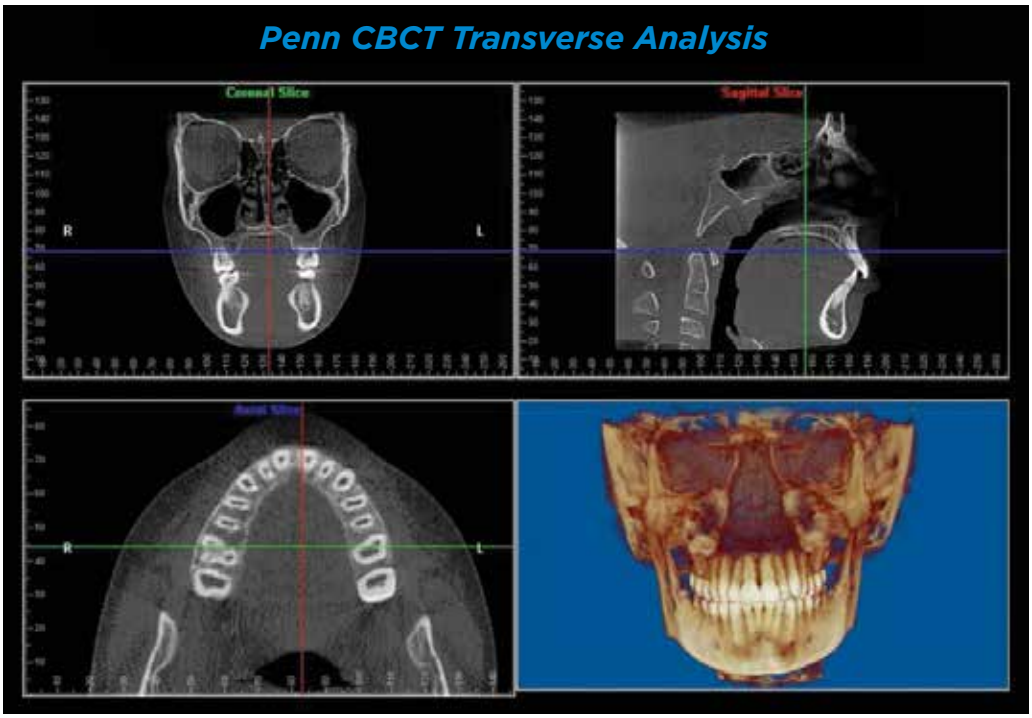
[9]McNamara JA. Maxillary transverse deficiency. Am J Orthod Dentofacial Orthop 2000;117:567-70

transverse relationship between the maxilla and mandible are exactly the same (maxilla = 5 mm wider than mandible). Therefore, achieving this differential relationship becomes the critical goal, regardless of the independent measurement numbers of the jaws.

Two easy methods for determining if a skeletal transverse discrepancy exists will be presented. Both have an equivalent diagnostic meaning. One method (Penn CBCT Analysis) uses cone-beam CT derived measurements. The second (Hayes CAC Analysis) uses measurements obtained via dental casts or with an intraoral scan. If a practitioner has the ability to use both methods, a double-check confirmation of the skeletal transverse deficiency (or lack of) can be realized. However, in the absence of having a CBCT machine or in a model-less/scanner-less office, there will always be one technique easily applicable to whatever technology is available at hand.

***The University of Pennsylvania (Penn) CBCT Transverse Analysis[10,11]***

The Penn CBCT Transverse Analysis uses capabilities of the multi-planar view (MPV) screen available with nearly every DICOM viewing software.

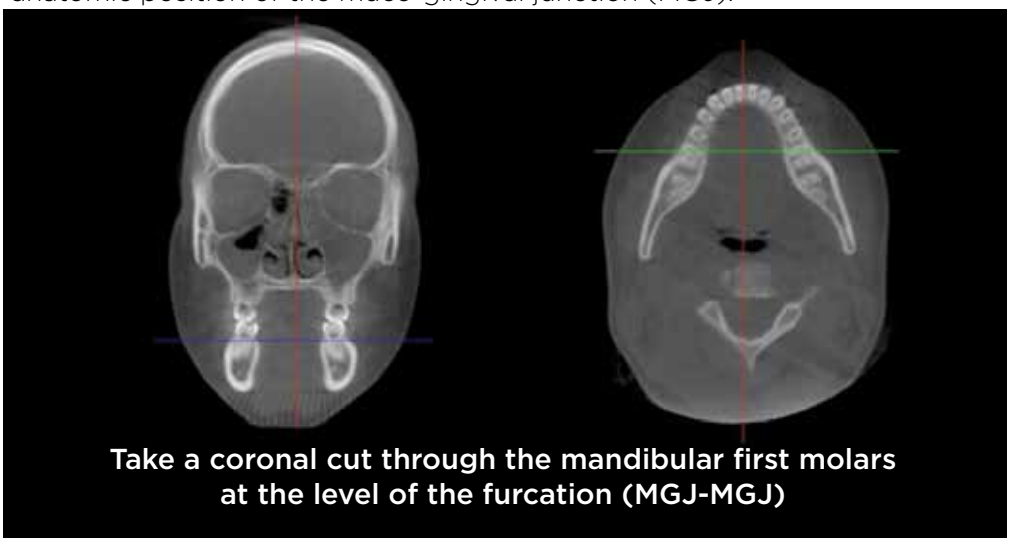



[10]Tamburrino RK, Boucher NS, Vanarsdall RL, Secchi AG. The Transverse Dimension: Diagnosis and Relevance to Functional Occlusion. RWISO Journal, September 2010.

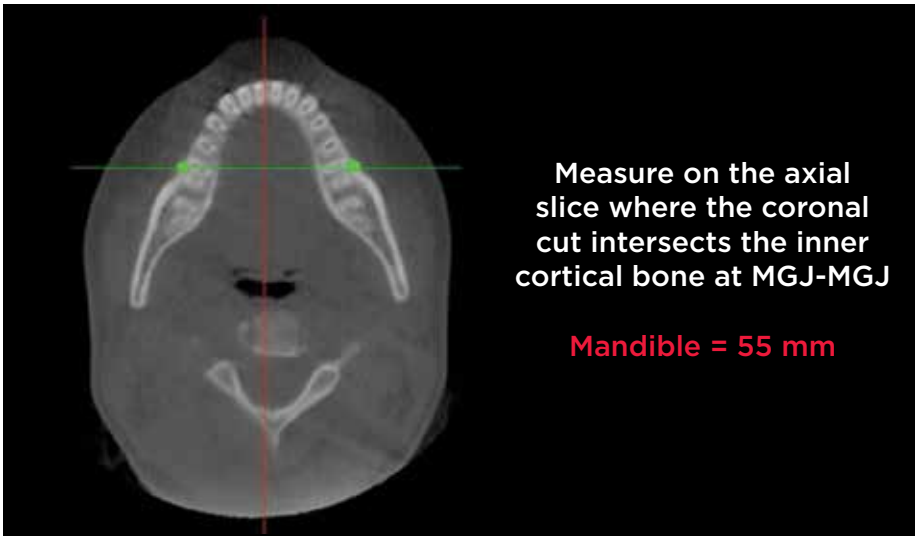
[11]Simontacchi-Gbologah MS, Tamburrino RK, Boucher NS, Vanarsdall RL, Secchi, AG. Comparison of Three Methods to Analyze the Skeletal Transverse Dimension in Orthodontic Diagnosis. Unpublished Thesis. University of Pennsylvania; 2010.

On this screen, the practitioner can independently measure the skeletal transverse dimensions of the maxilla and mandible basal bone at the level of the first molar using the sequence below.

1. Take a coronal cut through the mandibular first molar at the level of the furcation. This represents the approximate anatomic position of the muco-gingival junction (MGJ).



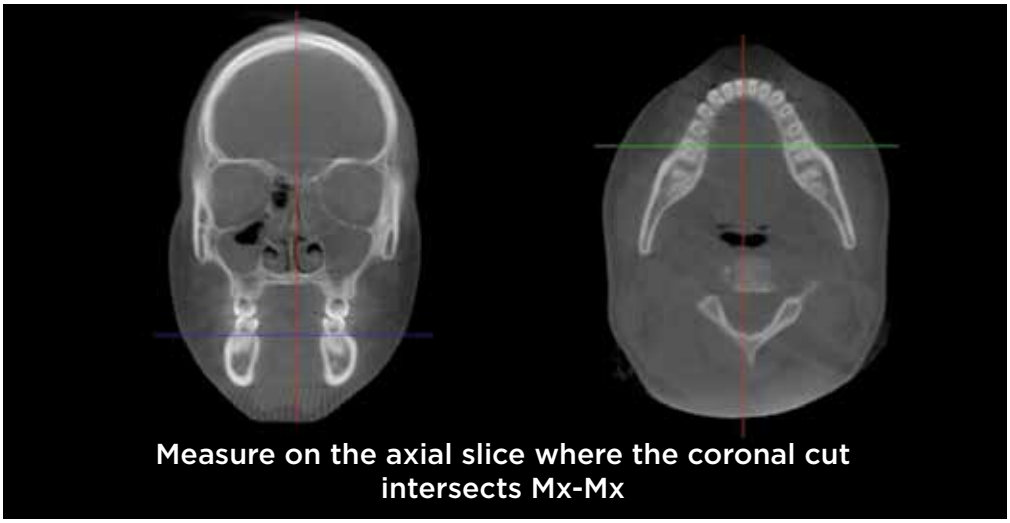

2. On the corresponding axial slice measure the MGJ-MGJ distance from the inner cortical plate of one side to the inner cortical plate of the opposite side of the midpoint of the 1st molar. Record this measurement on the CCO Diagnostic Sheet in the box marked “mandible”.



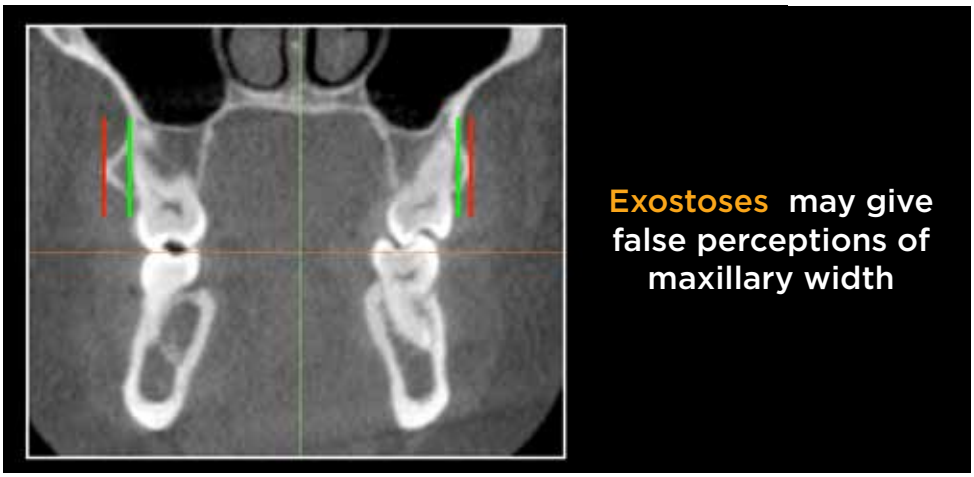

**Transverse Diagnosis**

| *Skeletal* | *CBCT* | *CAC* | *Dental* | *Measured* | *Ideal* |
|---|---|---|---|---|---|
| Maxilla | | | MGJ-MGJ | | |
| Mandible | **55** | | ↓ FA-FA | | |
| Difference | | | ↓ C-C | | |
| Ideal | **5** | **5** | ↑ P-P | | |
| | | | ↑ FA-FA | | |
| Required | | | | | |

3. Take a coronal cut through the maxillary first molar at the level of the deepest concavity of the maxillary process (Mx point).



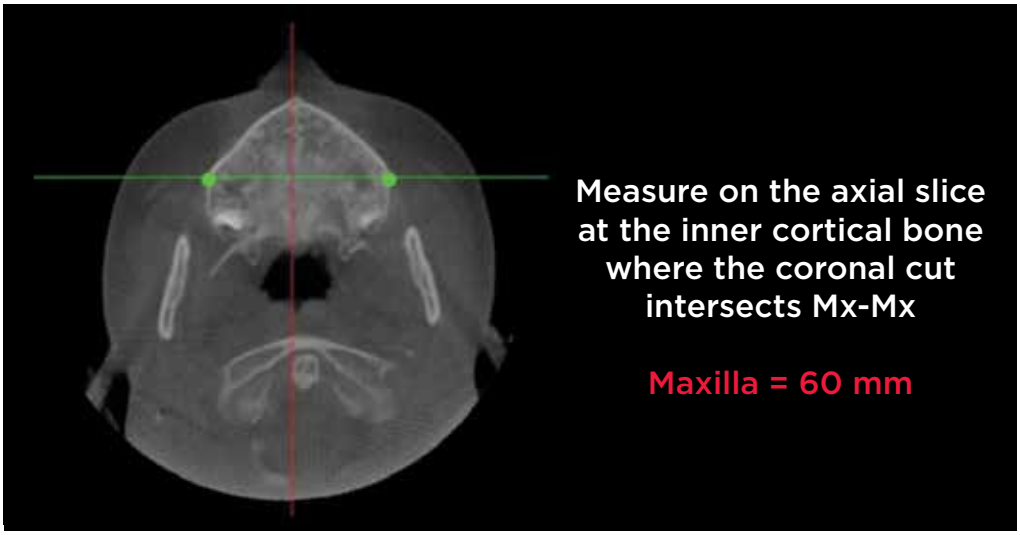

Anatomically, the ideal location would be at the level of the furcation, just like with the mandible. However, there are occasionally exostoses present on the buccal surface of the maxillary teeth and this will produce erroneous maxillary diagnostics if the measurement is taken at the level of the furcation. Using the Mx point will not change the transverse measurement due to the anatomy of the maxillary process but will be above the level where an exostosis could skew the actual basal bone measurement. If the measurement is obtained at the width of the exotosis, the result could produce a false positive that the maxilla is wide enough to accommodate the dentition without inducing root fenestrations, when in reality the root apex could be moved out of the bone.




4. On the corresponding axial slice measure the Mx-Mx distance from the inner cortical plate of one side to the inner cortical plate of the opposite side of the mesiobuccal root. Record this measurement on the CCO Diagnostic Sheet in the box marked “maxilla”.

   Note: This assumes that the patient with finish orthodontic treatment in a “Class 1” molar relationship with the mesiobuccal cusp of the maxillary first molar placed within the buccal groove of the mandibular 1st molar. In cases where the proposed case finish is either “Class 2” or “Class 3” molar, the measurement location needs to change in order to keep corresponding measurements accurate.

   For a “Class 2” molar finish, the pre-treatment maxillary transverse dimension should be measured at the midpoint of the disto-buccal root. For a “Class 3” molar finish, the maxillary transverse dimension should be measured at the midpoint of the 2nd premolar.



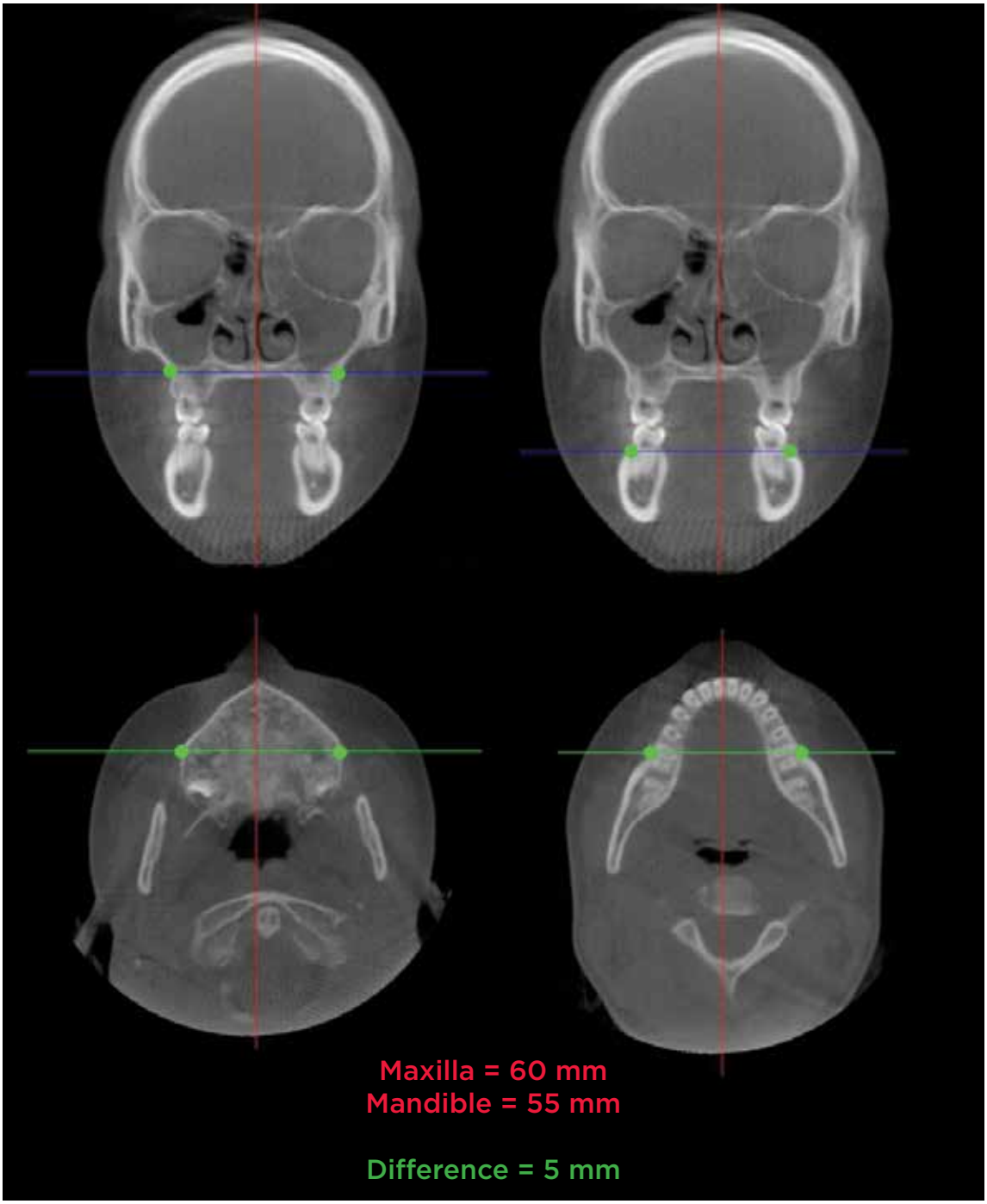

| Transverse Diagnosis | | | | | |
|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | ***Ideal*** |
| Maxilla | **60** | | MGJ-MGJ | | |
| Mandible | **55** | | ↓ FA-FA | | |
| Difference | | | ↓ C-C | | |
| Ideal | **5** | **5** | ↑ P-P | | |
| | | | ↑ FA-FA | | |
| Required | | | | | |

5. On the CCO Diagnostic Sheet, subtract the MGJ-MGJ measurement from the Mx-Mx measurement to get the difference.

| Transverse Diagnosis | | | | | |
|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | ***Ideal*** |
| Maxilla | **60** | | MGJ-MGJ | | |
| Mandible | **55** | | ↓ FA-FA | | |
| Difference | **5** | | ↓ C-C | | |
| Ideal | **5** | **5** | ↑ P-P | | |
| | | | ↑ FA-FA | | |
| Required | | | | | |

6. Since the ideal difference between the maxilla and mandible is 5 mm, subtract 5 mm from the difference to determine how much maxillary skeletal transverse deficiency is present. This now determines how much skeletal base expansion would be ideally required for the patient.

| Transverse Diagnosis | | | | | |
|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | ***Ideal*** |
| Maxilla | **60** | | MGJ-MGJ | | |
| Mandible | **55** | | ↓ FA-FA | | |
| Difference | **5** | | ↓ C-C | | |
| Ideal | **5** | **5** | ↑ P-P | | |
| | | | ↑ FA-FA | | |
| Required | **0** | | | | |



For the patient example shown here, the amount of expansion needed is 0 mm. This makes sense given the initial presentation of the posterior teeth is already being upright in the alveolus, centered in the alveolus, and well-intercuspated.

In other words, this patient already has an ideal skeletal transverse relationship, and skeletal expansion is not indicated. Doing so when not indicated now creates a reverse skeletal discrepancy where the maxilla is too large for the corresponding mandibular size. By obtaining these measurements objectively, the question of "Would this patient benefit from an expander?" is answered definitively and quickly.

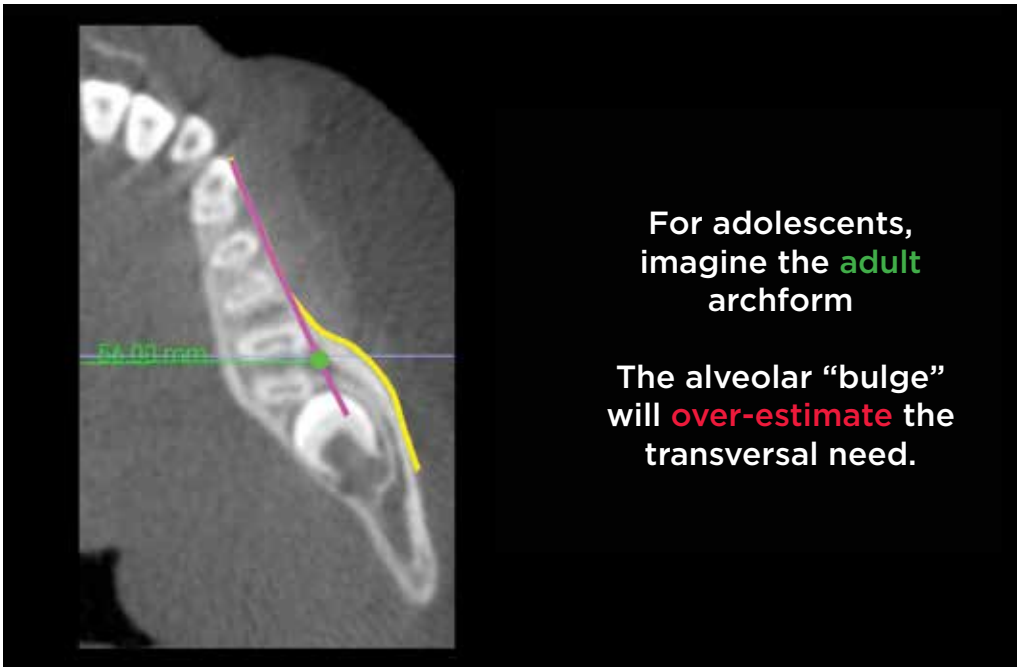
***University of Pennsylvania CBCT Analysis (Adolescent Modification)***

The Penn CBCT Analysis is a powerful tool and can be used on any patient of any age. However, one modification of the mandibular MGJ-MGJ measurement is indicated for young patients in the mixed dentition.

The mandibular body lengthens during growth via resorption of the anterior border of the ramus[12]. For immature patients, the ramus and its processes are very close to the mandibular 1st molar. On an axial CBCT slice, this appears as a "bulge".

If the MGJ-MGJ measurement is taken via the same methods described above on an "adult" patient, this would grossly overstate the true size of the mandibular basal bone in children and produce a corresponding expansion need far greater than required.

To overcome this potential for error, one must imagine the "adult" archform that will result once the skeleton matures and the anterior ramus resorbs posteriorly. The MGJ-MGJ measurement should now be obtained along this line at the level of the 1st molar. This will remove the error and be an accurate representation of the mandibular basal bone dimension.

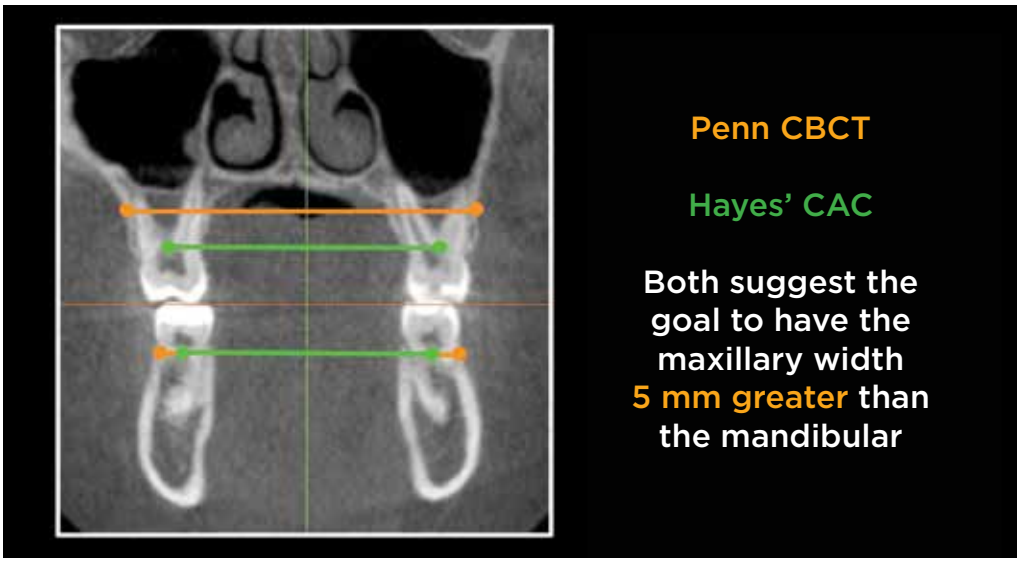



[12]Enlow DH, Hans MG. Essentials of Facial Growth. Saunders. 1996.

[13]Hayes JL. In search of improved skeletal transverse diagnosis. Part 2: A new measurement technique used of 114 consecutive untreated patients. Orthodontic Practice US 1(4); 34-39. 2010.

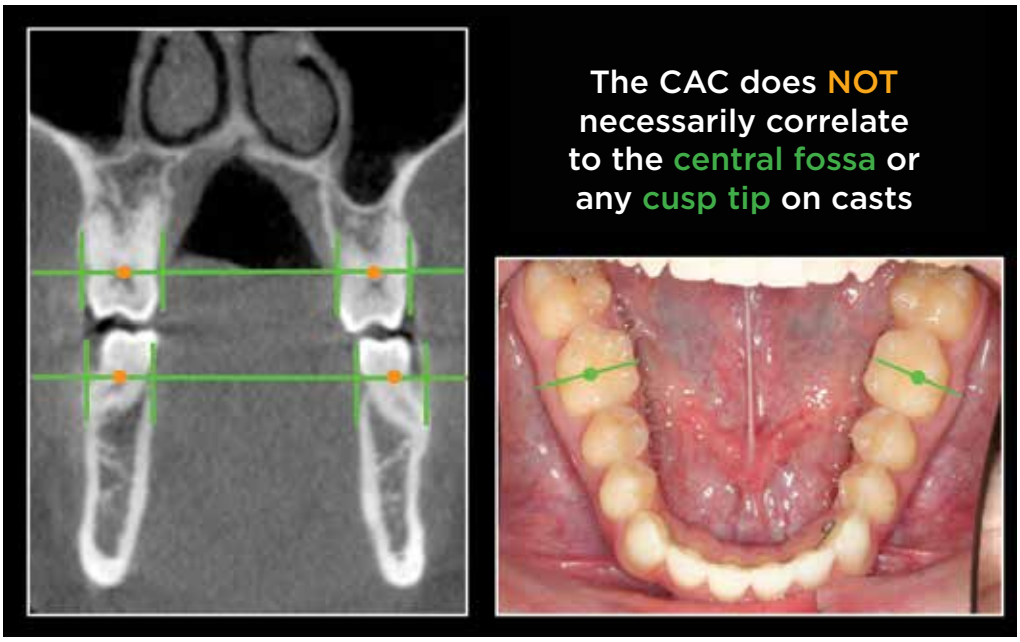
***The Hayes CAC Transverse Analysis***

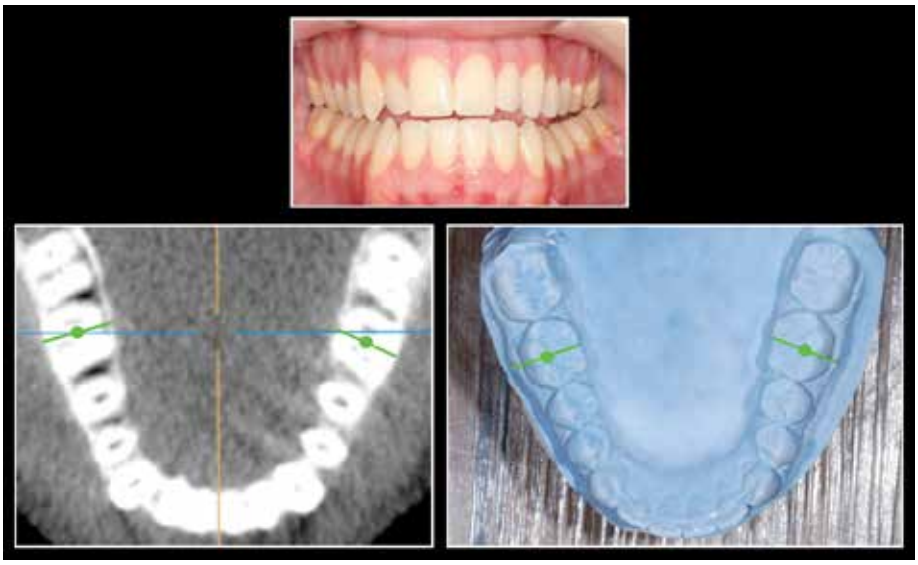
The CAC (Center of the Alveolar Crest) Analysis[13] uses dental casts or an intraoral scan to determine the skeletal transverse dimensions of the maxilla to determine if skeletal expansion will benefit the patient. Similar to the Penn CBCT Analysis, the ideal relationship is for the maxillary basal bone to be 5 mm wider than the mandibular basal bone. However, instead of measuring from the inner cortical plate to the inner cortical plate, the CAC analysis measures the distance between the centers of the alveolar bone at the level of the CEJ.




Similar to the Penn CBCT analysis, the existing dental positions or inclinations are irrelevant. The goal is strictly to match up the skeletal bases to achieve skeletal harmony and set the foundation for positioning the teeth. The sequence for determining the amount of skeletal expansion, if any at all, is as follows:

1. At the level of the MGJ of the mandibular 1st molar on the dental casts/scan, visually determine the midpoint of the buccal and lingual cortices and place a mark. This midpoint can, but will often NOT, correlate to the central fossa or any cusp tip on the molar. This will represent the midpoint of the underlying mandibular basal bone.

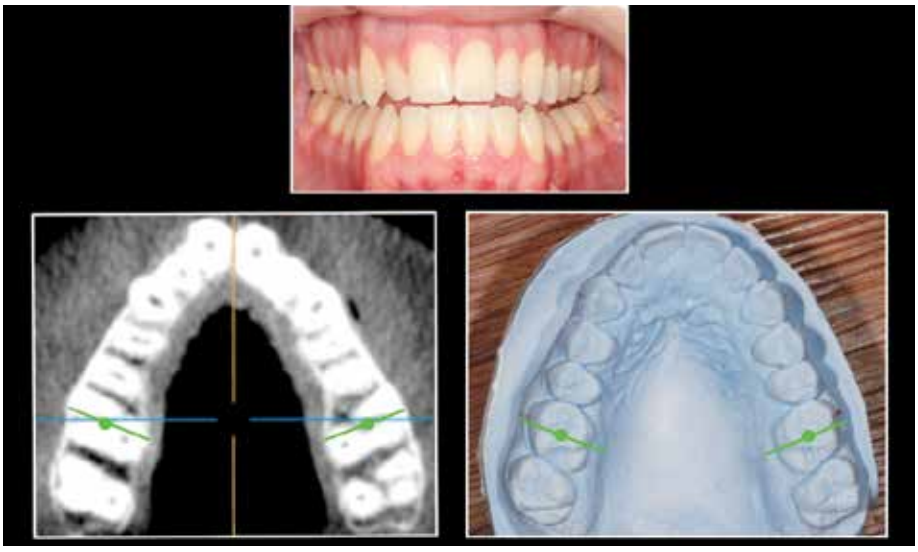




2. Measure the distance between the right and left mandibular markings and record this measurement on the CCO Diagnostic Sheet.

| Transverse Diagnosis | | | | | |
|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | ***Ideal*** |
| Maxilla | | | MGJ-MGJ | | |
| Mandible | | **47** | ↓ FA-FA | | |
| Difference | | | ↓ C-C | | |
| Ideal | **5** | **5** | ↑ P-P | | |
| | | | ↑ FA-FA | | |
| Required | | | | | |

3 At the level of the MGJ at the mesiobuccal cusps of the maxillary 1st molar on the dental casts/scan, visually determine the midpoint of the buccal and lingual cortices and place a mark. This midpoint can, but will often NOT, correlate to the central fossa or any cusp tip on the molar. This will represent the midpoint of the underlying maxillary basal bone.



Note: Similar to the Penn CBCT analysis, this measurement assumes the case will finish in a "Class 1" molar relationship. If the planned finish is "Class 2" or "Class 3" molar, then the measurement position needs to be adjusted accordingly using the rationale described previously.

4. Measure the distance between the right and left maxillary markings and record this measurement on the CCO Diagnostic Sheet.

| Transverse Diagnosis | | | | | |
|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | ***Ideal*** |
| Maxilla | | **45** | MGJ-MGJ | | |
| Mandible | | **47** | ↓ FA-FA | | |
| Difference | | | ↓ C-C | | |
| Ideal | **5** | **5** | ↑ P-P | | |
| | | | ↑ FA-FA | | |
| Required | | | | | |

5. On the CCO Diagnostic Sheet, subtract the mandibular measurement from the maxillary measurement to get the difference. Ideally this difference should be 5 mm.

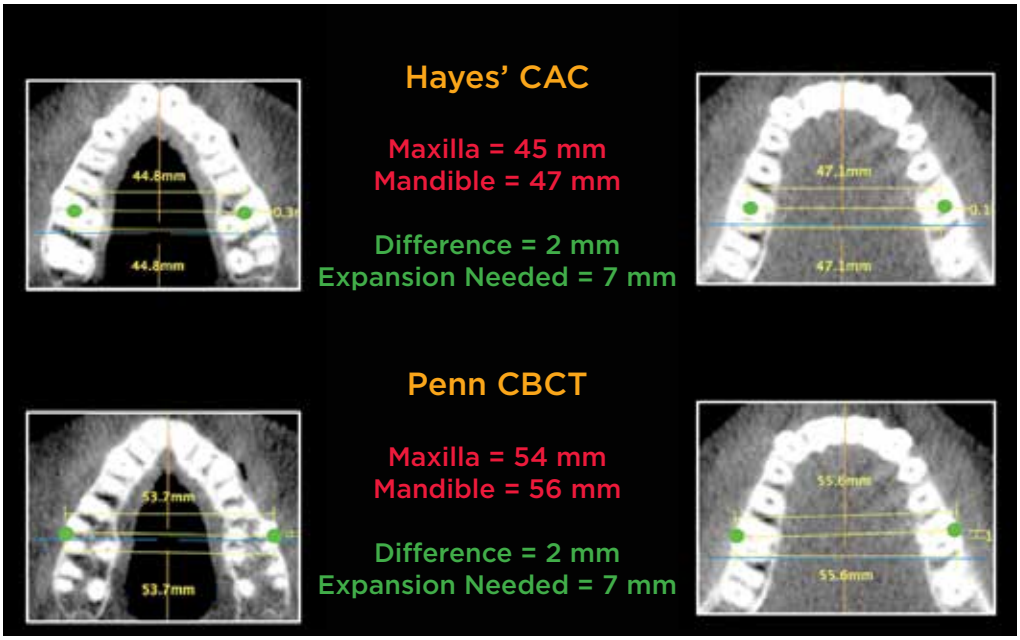
| Transverse Diagnosis | | | | | |
|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | ***Ideal*** |
| Maxilla | | **45** | MGJ-MGJ | | |
| Mandible | | **47** | ↓ FA-FA | | |
| Difference | | **-2** | ↓ C-C | | |
| Ideal | **5** | **5** | ↑ P-P | | |
| | | | ↑ FA-FA | | |
| Required | | | | | |

6. Subtract 5 mm from the difference to determine how much maxillary skeletal transverse deficiency is present and how much maxillary skeletal base expansion, ideally, would be required. In this example the patient is 7 mm deficient in the maxillary width and would benefit from 7 mm of skeletal expansion to achieve ideal transverse harmony.

| Transverse Diagnosis | | | | | |
|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | ***Ideal*** |
| Maxilla | | **45** | MGJ-MGJ | | |
| Mandible | | **47** | ↓ FA-FA | | |
| Difference | | **-2** | ↓ C-C | | |
| Ideal | **5** | **5** | ↑ P-P | | |
| | | | ↑ FA-FA | | |
| Required | | **-7** | | | |

The following case example illustrates the benefit of using both the Penn CBCT and Hayes CAC transverse analyses as a double check as well as the consistency between the methods. In this example, for ease of visualization of the measurements, the patient's CBCT was used instead of the casts/intraoral scan for the Hayes CAC method. The locations of the measurements are the same, however.

Note: While both the locations and actual measurements differ, the relationship between the measurements, and thus the ideal skeletal transverse need, is identical. This is typical. On cases where both analyses are used to confirm the diagnosis, the results will be within 0-1 mm of each other with respect to ideal skeletal transverse need.




**Transverse Diagnosis**

| *Skeletal* | *CBCT* | *CAC* | *Dental* | *Measured* | *Ideal* |
|---|---|---|---|---|---|
| Maxilla | **54** | **45** | MGJ-MGJ | | |
| Mandible | **56** | **47** | ↓ FA-FA | | |
| Difference | **-2** | **-2** | ↓ C-C | | |
| Ideal | **5** | **5** | ↑ P-P | | |
| | | | ↑ FA-FA | | |
| Required | **7** | **7** | | | |

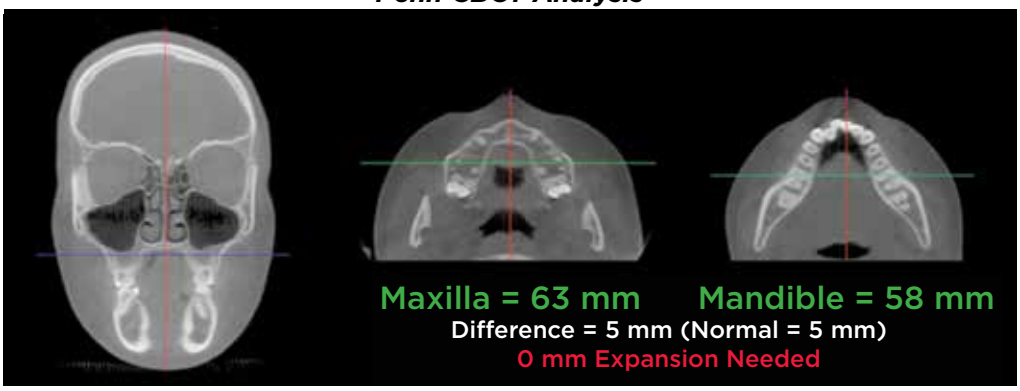
***Maxillary Expansion and the Diagnostic Sheet***

Sutural changes of the maxilla via palatal expansion will also increase the amount of space available for dental alignment. If a deficiency is measured and corrected, according to Andrews', 1 mm of maxillary sutural expansion will correlate to essentially 1 mm of space gain for the arch.

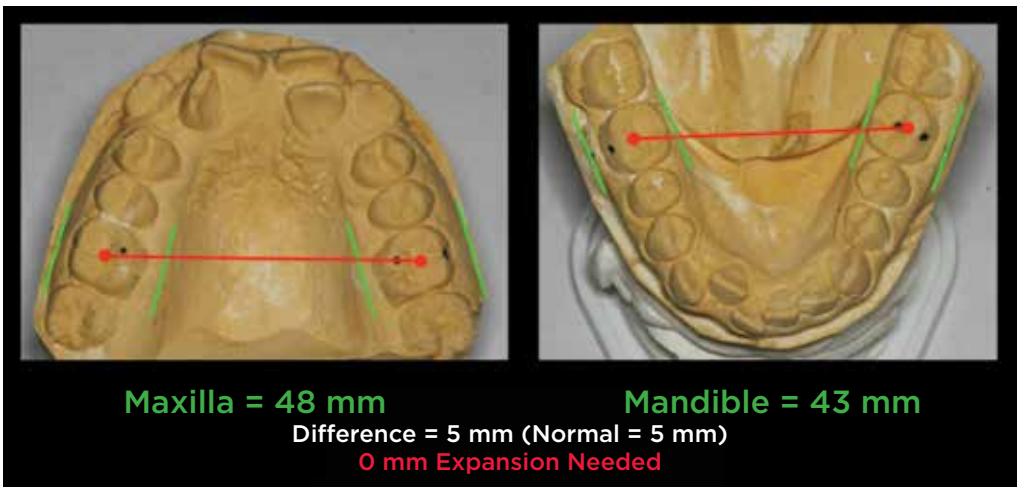
1 mm of expansion = ~1 mm of space gain

For our case example, the existing transverse difference between the maxilla and mandible according to both the Penn and Hayes' analyses is ideal at 5 mm. Therefore, no skeletal expansion is needed and this value of 0 can be recorded in the maxillary expansion portion of the diagnostic sheet.

***Penn CBCT Analysis***




***Hayes' CAC Analysis***




As with incisor inclination, some cases may require a compromise of the transverse dimension, such as adults who decline surgically-assisted expansion or children who have very severe discrepancies, such as 10+ mm. In these instances, the ideal space gain from the transverse change cannot be included in the space analysis because it does not represent what will actually be happening for the patient. Therefore, this box on the space analysis portion of the diagnostic sheet also has a place for an "ideal" and a "compromise/realistic" value.

Also, the goal for maxillary expansion is to minimize the discrepancy to <3 mm. So, in cases where, for example, 7 mm of expansion is indicated, but potentially only 4 mm of skeletal change will be achieved, then only 4 mm can be used for the space calculation.

Mandibular non-surgical skeletal expansion is not possible due to the mandible being one solid bone, and surgical mandibular expansion is contraindicated in nearly all instances of routine care. Therefore, this value will almost always be zero.

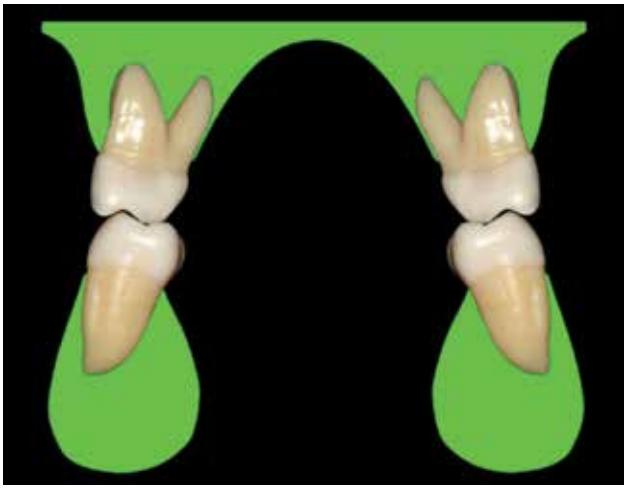
### *Space Requirement*

| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Incisor Inclination (X2) | 4 | | -1 | |
| Crowding/Spacing | -17 | | -4 | |
| Maxillary Expansion | 0 | | | |
| Dental Expansion | | | | |
| Curve of Spee | | | | |
| Tooth/Size Discrepancy | | | | |
| Unresolved Space Requirement | | | | |
| Extraction | | | | |
| Distalization/Mesialization (X2) | | | | |
| IPR | | | | |
| Final Space Requirement | 0 | | 0 | |

***Dental Expansion***

When describing "expansion" there is a significant difference between skeletal and dental expansion. Skeletal expansion involves a skeletal diagnosis to normalize the skeletal transverse dimension. Dental expansion involves inclining the posterior teeth ideally and centering them within the alveolus in order to harmonize the occlusion. The two concepts are inter-related, meaning that the posterior teeth cannot be positioned and inclined ideally on skeletal bases that do not transversely relate to each other.


Looking at an example of optimal posterior dental intercuspation, one can appreciate that the mesio-palatal cusp of the maxillary first molar and the mesio-buccal cusp of the mandibular first molar are centered in the central fossae of the molars in the opposing arch. In this ideal dental relationship, the distance between the cusp tips will be approximately 2.5 mm. Therefore, in order to have the teeth upright and centered within the alveolus, the maxilla must be 2.5 mm/side wider than the mandible (for a total amount of 5 mm).



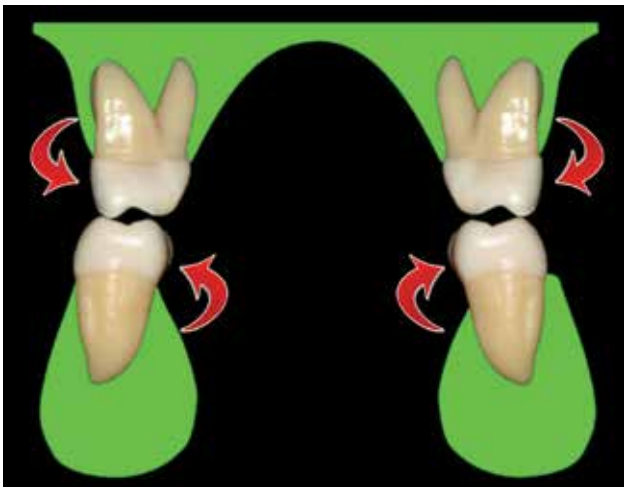
If one aims to set the dentition properly in the arches, dental compensations for skeletal mismatches must be accounted for in the pre-orthodontic diagnosis, and the treatment plan should address their correction. Therefore, in a case that has a maxillary transverse deficiency, correction will usually involve buccal uprighting of the mandibular posterior teeth and lingualization of the maxillary posterior teeth, as shown in the following example:

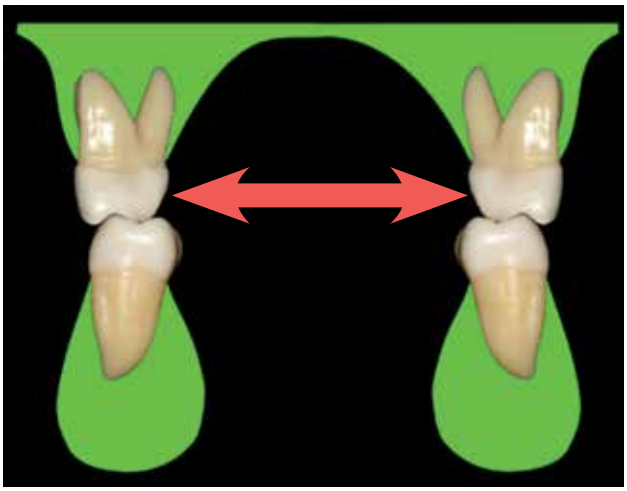
A theoretical patient presents with a skeletal transverse

discrepancy. No dental crossbite is present, but note the buccally inclined maxillary molars and lingually inclined mandibular molars.

Dental "decompensation" to optimally incline the molars and center them in bone would unmask the underlying skeletal discrepancy and show that the teeth are now in crossbite or an edge-edge relationship.

Maxillary expansion to first normalize the skeletal discrepancy will allow for proper intercuspation of the posterior teeth at the ideal inclination once the brackets are placed. In order for this scenario to happen, the maxilla must, ideally, be ~5 mm wider than the mandible. However, the goal is to achieve a skeletal transverse discrepancy of 3 mm or less from ideal.





Similar to changing the inclination of the incisors, decompensating the posterior teeth and/or dentally expanding the archform will also have a net effect on the intra-arch spacing. However, limits and targets have to be established for the ideal positioning of these teeth. For this, the focus will be on the mandibular mucogingival junction (MGJ) as the frame of reference. Based on the work of Andrews[14] and reinforced by Katona[15], the MGJ represents the level of the center of resistance of the mandibular first molars and is highlighted below.

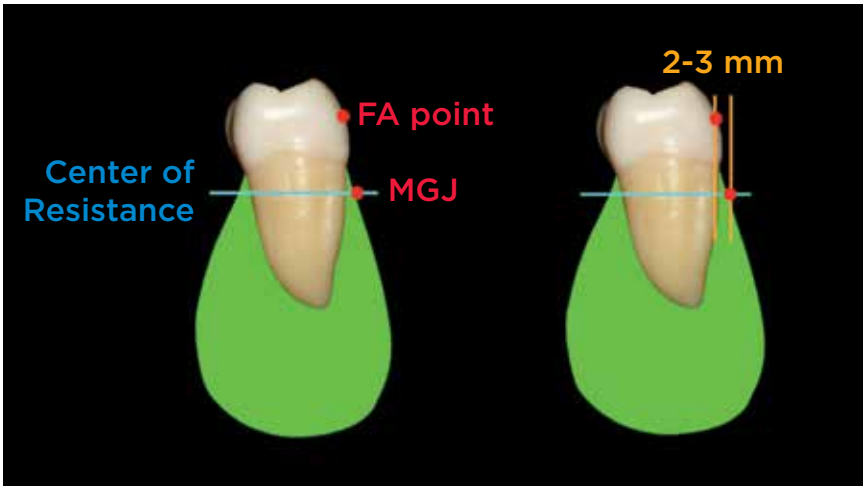
The importance of this concept is that, during uprighting of the mandibular posterior teeth, rotation will occur at approximately this level. Also, this point identifies the location where coronally, is alveolar bone, which is known to change and adapt to tooth position. However, apical to the MGJ, the minimal width of the skeletal base is relatively immutable with conventional orthodontic treatment. Thus, it is a stable location to use for a width reference of the mandibular skeletal base as well the position of the dentition.

[14]Andrews LF, Andrews WA. Andrews analysis. In: Syllabus of the Andrews Orthodontic Philosophy. 9th ed. Six Elements Course Manual; 2001

[15]Katona TR. An engineering analysis of dental occlusion principles. Am J Orthod Dentofac Orthop. 2009; 135(6): 696.

According to Andrews[16] and verified by Ronay[16], et al, the ideal position of the mandibular first molar is one where the FA point of the molar is approximately 2-3 mm lingual to the MGJ when viewed occlusally. This will center the tooth in the alveolus and place it at the ideal inclination.

**The FA point of the mandibular 1st molar is ideally ~2-3 mm lingual to the MGJ**



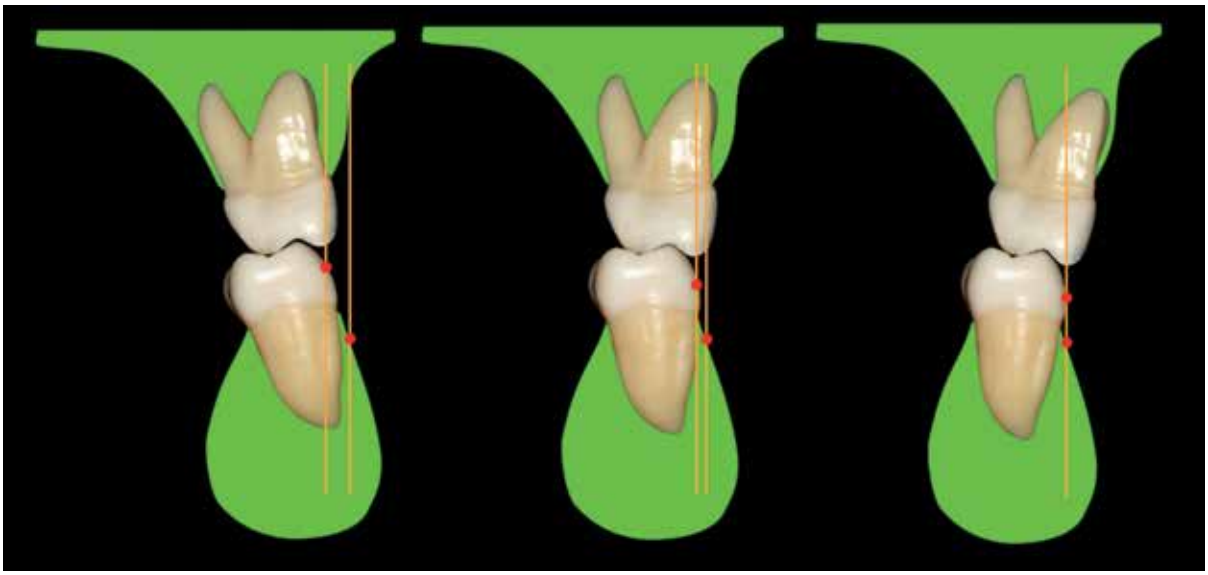

In situations where the mandibular FA point is greater than 2-3 mm from the MGJ and the teeth are not in crossbite, the dentition is often camouflaging a significant deficiency in the width of the maxilla.

Therefore, the only way for the dentition to compensate for the discrepancy is for the mandibular molars to incline lingually and, often, for the maxillary molars to incline buccally. Thus, the MGJ-FA distance will be larger.

The reverse situation, although less likely, is possible in cases of maxillary transverse excess. In this scenario, the mandibular molars are inclined buccally, and the maxillary dentition must compensate by inclining lingually. Therefore, the MGJ-FA distance will be <2 mm.

The illustrations below show the dental relationships when the MGJ-FA distance is ideal, too large (suggesting a maxillary deficiency with good intercuspation), and too small (suggesting a maxillary excess with good intercuspation).

[16]Ronay V, Miner RM, Will LA, Arai K. Mandibular Arch Form: The Relationship Between Dental and Basal Anatomy. Am J Orthod Dentofacial Orthop 2008; 134:430-8.



***Excessive MGJ-FA (>3 mm)*** ***Ideal MGJ-FA (2-3 mm)*** ***Reduced MGJ-FA (<2 mm)***

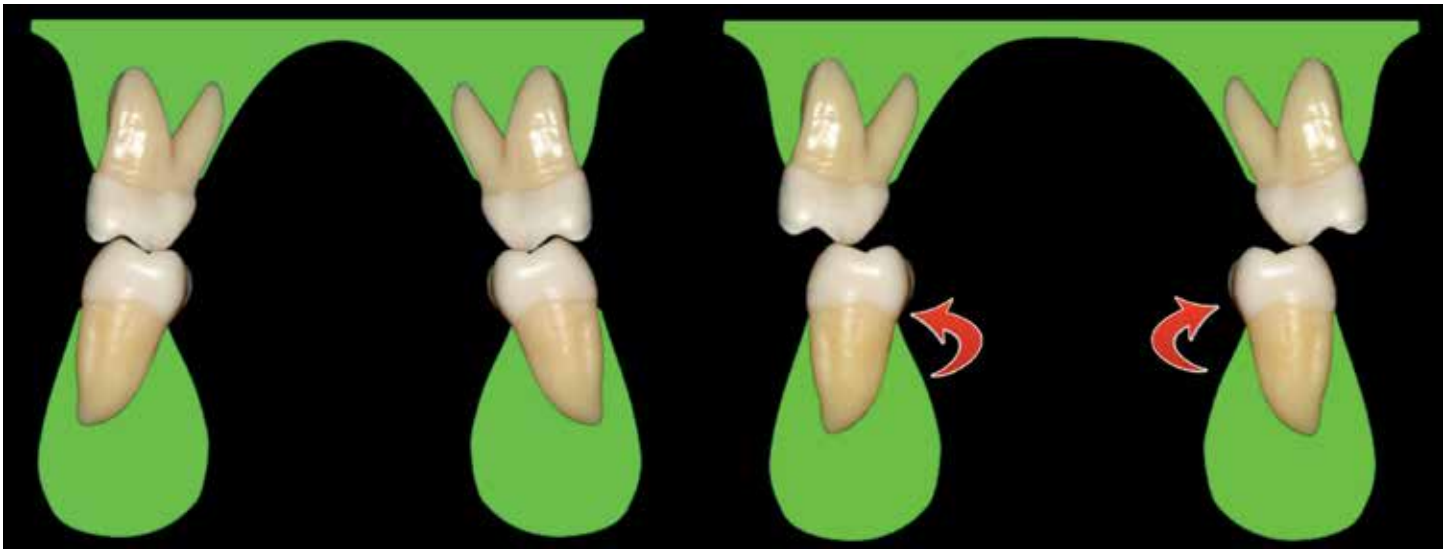
The dental and periodontal consequences of non-ideal tooth inclinations are beyond the scope of this manual and will be covered in detail separately. For the purposes of Treatment Design, the goal is to understand where ideal tooth positions are located, how inclinations of the posterior teeth can affect the space available, and how the methods described in this manual are aimed at idealizing the dentition for function and stability.

The data and calculations for this portion are can be recorded on the "dental" component of the transverse diagnosis on the CCO diagnostic sheet.

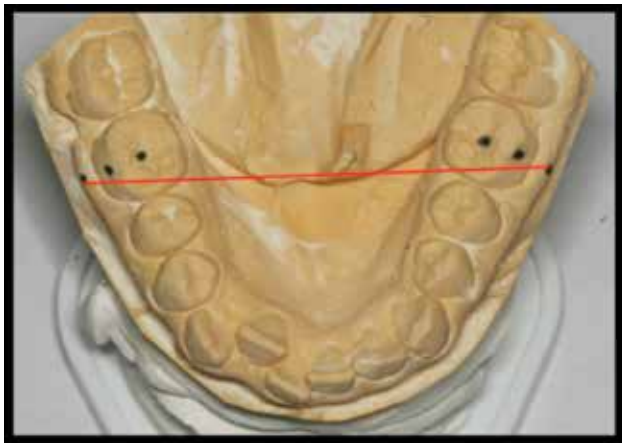
| ***Dental*** | ***Measured*** | ***Ideal*** |
|---|---|---|
| MGJ-MGJ | | |
| ↓ FA-FA | | |
| ↓ C-C | | |
| ↑ P-P | | |
| ↑ FA-FA | | |
| | | |

***Mandibular Dental Expansion***

By knowing that the goal for the mandibular dentition is for the FA point to be 2-3 mm lingual to the MGJ, theoretical decompensation and ideal positioning of the molars is straightforward. For this portion, we will use casts of our case example and follow a series of measurements to objectively determine the amount of mandibular dental expansion/decompensation.

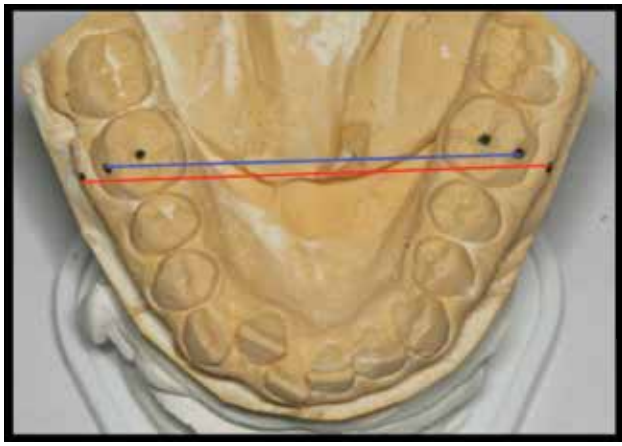


1. Measure the distance across MGJ-MGJ of the mandibular first molars. As this distance will not change with treatment, this is the "ideal" measurement and a stable reference position.



| | Initial | Ideal |
|---|---|---|
| MGJ-MGJ | 58 | 58 |
| Mandibular FA-FA | | |
| Mandibular C-C | | |

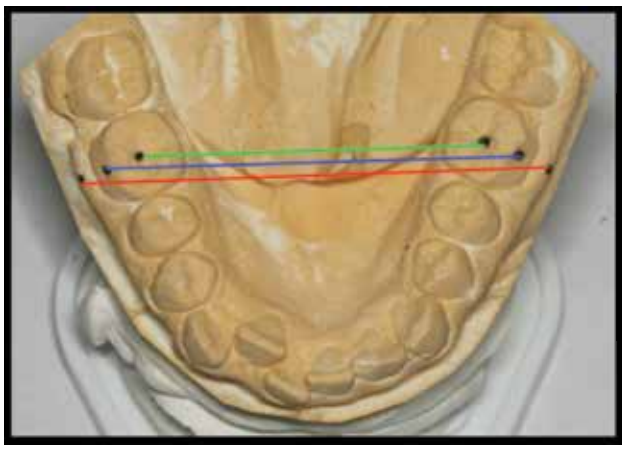
2. Measure the distance from the FA point-FA point of the mandibular first molar. As was determined previously, the ideal FA-FA distance is 2 mm less/side than the MGJ-MGJ distance, for a total of 4 mm. Since the initial FA-FA distance for this patient measures 50 mm, the ideal FA-FA distance is 54 mm (with the MGJ-MGJ = 58 mm). The actual number is unique to each patient, but the goal for the mandibular FA-FA being 4 mm less than the MGJ-MGJ is universal.



| | Initial | Ideal |
|---|---|---|
| MGJ-MGJ | 58 | 58 |
| Mandibular FA-FA | 50 | 54 |
| Mandibular C-C | | |

3. Measure the distance between the central fossae of the molars. This distance will change the same amount with uprighting the dentition as the FA-FA distance. It represents the amount of space gain/loss that will also occur with optimizing the position of the mandibular dentition.

   This value can now be entered on the space analysis table for mandibular dental expansion.



| | Initial | Ideal |
|---|---|---|
| MGJ-MGJ | 58 | 58 |
| Mandibular FA-FA | 50 | 54 |
| Mandibular C-C | 40 | |

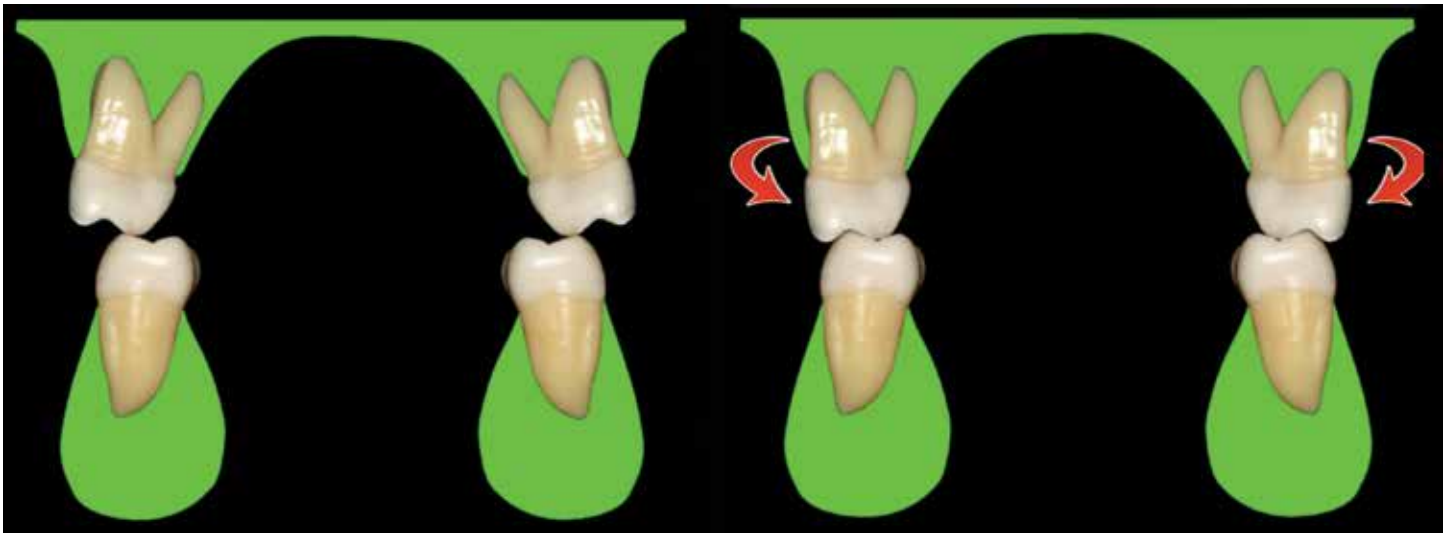
**4 mm of space gained**

### *Space Requirement*

| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Incisor Inclination (X2) | 4 | | -1 | |
| Crowding/Spacing | -17 | | -4 | |
| Maxillary Expansion | 0 | | | |
| Dental Expansion | | | 4 | |
| Curve of Spee | | | | |
| Tooth/Size Discrepancy | | | | |
| Unresolved Space Requirement | | | | |
| Extraction | | | | |
| Distalization/Mesialization (X2) | | | | |
| IPR | | | | |
| Final Space Requirement | 0 | | 0 | |

***Maxillary Dental Expansion***

Once the mandibular teeth are ideally positioned, the amount of maxillary dental expansion or constriction can be determined. The purpose of this measurement is to theoretically decompensate the maxillary dentition to upright the molars, center them in the alveolus, and have the mesio-palatal cusp positioned optimally into the central fossa of the mandibular molar following any required skeletal expansion.



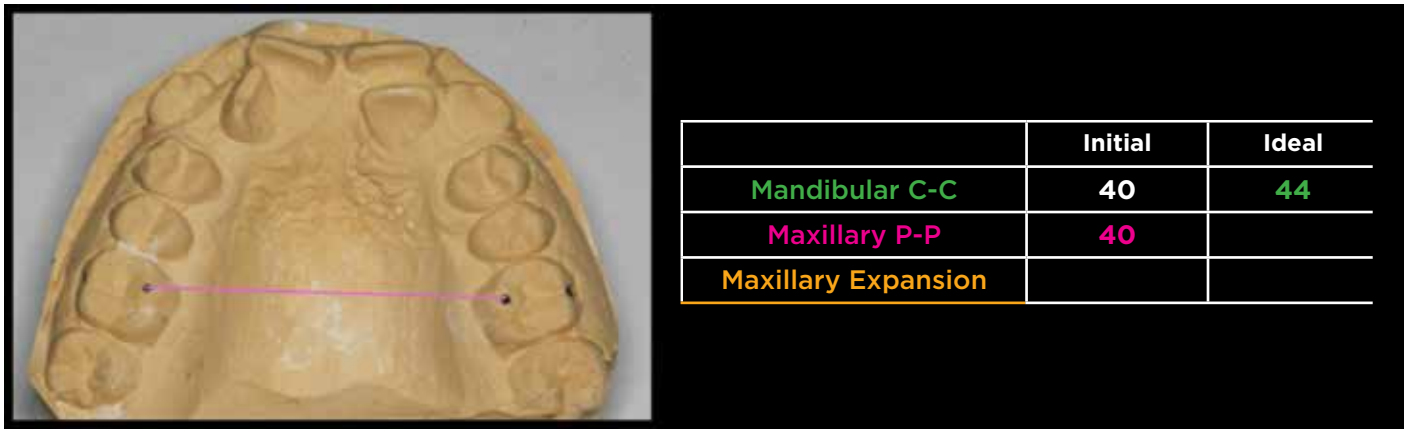
There are two methods to determine the amount of dental expansion, one is objective and uses a previously determined amount of palatal expansion, and the other is subjective, which can be used in the absence of having a CBCT machine. Both methods will result in a similar determination of dental expansion needs,[17] and the CCO Diagnostic Sheet has the capability for recording this data under the "dental" portion of the transverse diagnosis.

The first technique described will assume the practitioner has already determined the needed amount of skeletal maxillary expansion via the CBCT or CAC methods.

[17]Simontacchi-Gbologah MS, Tamburrino RK, Boucher NS, Vanarsall RL, Secchi AG. Comparison of Three Methods to Analyze the Skeletal Transverse Dimension in Orthodontic Diagnosis [thesis]. University of Pennsylvania; 2010.

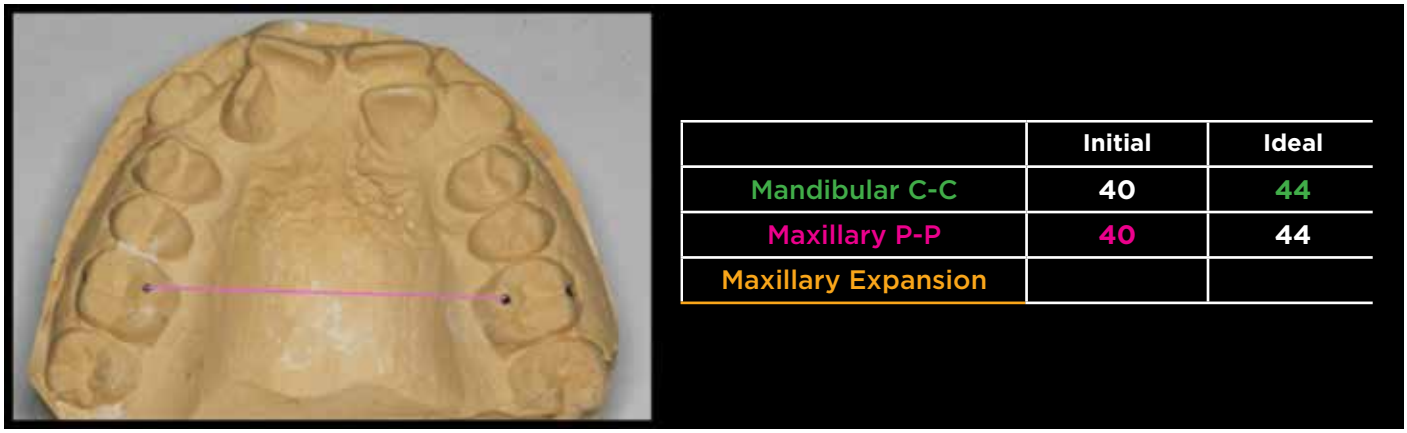
*Method 1*

1. Record the measurements for the mandibular CF-CF distance (previously determined) and measure the palatal cusp-cusp (P-P) distance between the maxillary first molars.



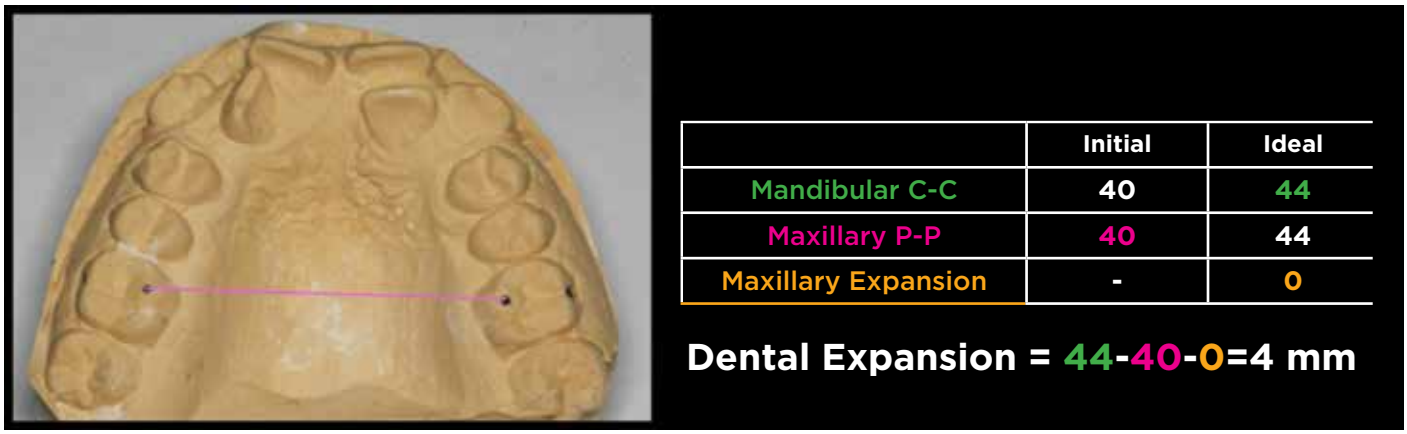
| | Initial | Ideal |
|---|---|---|
| Mandibular C-C | 40 | 44 |
| Maxillary P-P | 40 | |
| Maxillary Expansion | | |

2. The goal is to have the maxillary molar palatal cusps fit into the mandibular central fossae for an ideal occlusion. Therefore, the "ideal" measurements for the CF-CF distance and P-P distance must be identical.



| | Initial | Ideal |
|---|---|---|
| Mandibular C-C | 40 | 44 |
| Maxillary P-P | 40 | 44 |
| Maxillary Expansion | | |

3. By knowing the ideal amount of skeletal maxillary expansion, the amount of maxillary dental decompensation required is then calculated as the difference between the ideal measurement of the mandibular central fossae, initial measurement of the maxillary palatal cusps, and the required skeletal expansion.



| | Initial | Ideal |
|---|---|---|
| Mandibular C-C | 40 | 44 |
| Maxillary P-P | 40 | 44 |
| Maxillary Expansion | - | 0 |

**Dental Expansion = 44-40-0=4 mm**

Record this value in the maxillary dental expansion box of the space analysis chart.

## *Space Requirement*

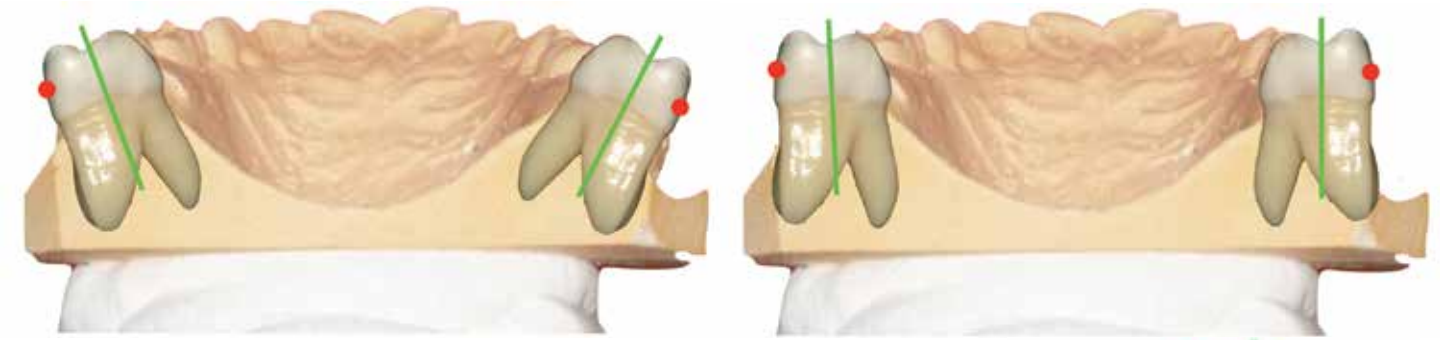
| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Incisor Inclination (X2) | 4 | | -1 | |
| Crowding/Spacing | -17 | | -4 | |
| Maxillary Expansion | 0 | | | |
| Dental Expansion | 4 | | 4 | |
| Curve of Spee | | | | |
| Tooth/Size Discrepancy | | | | |
| Unresolved Space Requirement | | | | |
| Extraction | | | | |
| Distalization/Mesialization (X2) | | | | |
| IPR | | | | |
| Final Space Requirement | 0 | | 0 | |

*Method 2*

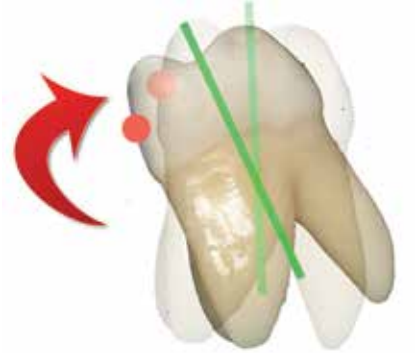
| *Dental* | *Measured* | *Ideal* |
|---|---|---|
| MGJ-MGJ | | |
| ↓ FA-FA | | |
| ↓ C-C | | |
| ↑ P-P | | |
| ↑ FA-FA | | |
| | | |

The second method involves looking at maxillary cast and the existing inclinations of the first molar from the posterior. The CCO Diagnostic Sheet has the capability for recording values for this technique already built in via the split boxes for the P-P and FA-FA measurements.

Andrews' research established a guideline of 1 mm space change per 5° of molar inclination change. For this method, one must estimate the amount of dental decompensation needed for both the right and left molars to level the cusp tips (level the Curve of Wilson). These two values are then added together to determine the total space needed to do this (which will be a negative value).



An additional way to think about this methodology is to envision the amount of change of each FA point as the tooth is decompensated. For this, 1 mm of horizontal FA point change is 1 mm of space needed. The superimposition below illustrates how the FA point changes horizontally as the tooth uprights around the center of resistance.



While this method may seem somewhat difficult to envision at first, experience and looking at many casts will lead to the conclusion that most cases will call for 0 mm, 0.5 mm, 1 mm, or 1.5 mm of change/side.

Do not try to be more precise than the nearest 0.5 mm, as it is very difficult to do and will not be clinically significant enough to alter the diagnosis.

For our case example, these values on the diagnostic sheet below are previously determined from measuring both the skeletal transverse need and the dental casts:

| Transverse Diagnosis | | | | | |
|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | ***Ideal*** |
| Maxilla | **63** | **48** | MGJ-MGJ | | **43** |
| Mandible | **58** | **43** | ↓ FA-FA | **50** | **54** |
| Difference | **5** | **5** | ↓ C-C | **40** | **44** |
| Ideal | **5** | **5** | ↑ P-P | **40** | |
| | | | ↑ FA-FA | **60** | |
| Required | **0** | **0** | | | |

Looking at the maxillary casts from the posterior, the first molars are buccally inclined by 1 mm/side. Therefore, it will take 2 mm of space to upright these teeth. The "actual" P-P and FA-FA measurements are then adjusted to represent the P-P and FA-FA measurements of decompensated teeth with a level Curve of Wilson.

| Transverse Diagnosis | | | | | |
|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | ***Ideal*** |
| Maxilla | **63** | **48** | MGJ-MGJ | | **43** |
| Mandible | **58** | **43** | ↓ FA-FA | **50** | **54** |
| Difference | **5** | **5** | ↓ C-C | **40** | **44** |
| Ideal | **5** | **5** | ↑ P-P | **40** | **38** |
| | | | ↑ FA-FA | **60** | **58** |
| Required | **0** | **0** | | | |

The palatal cusp of the maxillary first molar needs to fit in the central fossa of the mandibular first molar, assuming a Class I molar relationship on debond. Therefore, the ideal maxillary P-P distance is the same as the ideal mandibular CF-CF distance. Note: If the case is considered for a Cl. II or Cl. III molar finish, then these measurements must be altered to reflect this change to ensure a transverse discrepancy is not inadvertently missed.

| Transverse Diagnosis | | | | | |
|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | ***Ideal*** |
| Maxilla | **63** | **48** | MGJ-MGJ | | **43** |
| Mandible | **58** | **43** | FA-FA | **50** | **54** |
| Difference | **5** | **5** | C-C | **40** | **44** |
| Ideal | **5** | **5** | P-P | **40** | **38** |
| | | | FA-FA | **60** | **58** |
| Required | **0** | **0** | | | |

In an ideal jaw relationship, the ideal maxillary FA-FA measurement is 5 mm greater than the mandibular FA-FA measurement, which is the same target ideal as the CBCT and CAC methods. This value is then calculated and recorded.

| Transverse Diagnosis | | | | | | |
|---|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | | ***Ideal*** |
| Maxilla | **63** | **48** | MGJ-MGJ | | | **43** |
| Mandible | **58** | **43** | FA-FA | **50** | | **54** |
| Difference | **5** | **5** | C-C | **40** | | **44** |
| Ideal | **5** | **5** | P-P | **40** | **38** | **44** |
| | | | FA-FA | **60** | **58** | **59** |
| Required | **0** | **0** | | | | |

This method also provides a triple check for the skeletal expansion need via the difference between the ideal maxillary FA-FA and the adjusted FA-FA. There may and often will be a 1-2 mm variation among the three method,s and this is clinically acceptable. However, if a gross discrepancy is revealed, this would necessitate reconfirming the skeletal measurements to ensure they are correct. Additionally, the goal for including skeletal expansion as a part of the treatment plan is for skeletal discrepancies greater than 3 mm. A discrepancy of 3 mm or less allows the practitioner to record "0 mm" as the maxillary expansion (since skeletal expansion will not be performed) that will actually be performed, regardless of the measurement.

| Transverse Diagnosis | | | | | | |
|---|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | | ***Ideal*** |
| Maxilla | **63** | **48** | MGJ-MGJ | | | **43** |
| Mandible | **58** | **43** | FA-FA | **50** | | **54** |
| Difference | **5** | **5** | C-C | **40** | | **44** |
| Ideal | **5** | **5** | P-P | **40** | **38** | **44** |
| | | | FA-FA | **60** | **58** | **59** |
| Required | **0** | **0** | | | | **-1** |

The amount of dental expansion is the difference between the ideal P-P and the measured P-P, minus the planned amount of skeletal expansion being performed. For this case example, the maxillary dental expansion is 44-40-(-1)= 5 mm. However, since no maxillary skeletal expansion is being performed, the actual calculation is 44-40-0 = 4 mm, which is identical to the previous method.

| Transverse Diagnosis | | | | | | |
|---|---|---|---|---|---|---|
| ***Skeletal*** | ***CBCT*** | ***CAC*** | ***Dental*** | ***Measured*** | | ***Ideal*** |
| Maxilla | **63** | **48** | MGJ-MGJ | | | **43** |
| Mandible | **58** | **43** | FA-FA | **50** | | **54** |
| Difference | **5** | **5** | C-C | **40** | | **44** |
| Ideal | **5** | **5** | P-P | **40** | **38** | **44** |
| | | | FA-FA | **60** | **58** | **59** |
| Required | **0** | **0** | | | | **-1** |

Record this value in the maxillary dental expansion box of the space analysis chart.

***Space Requirement***

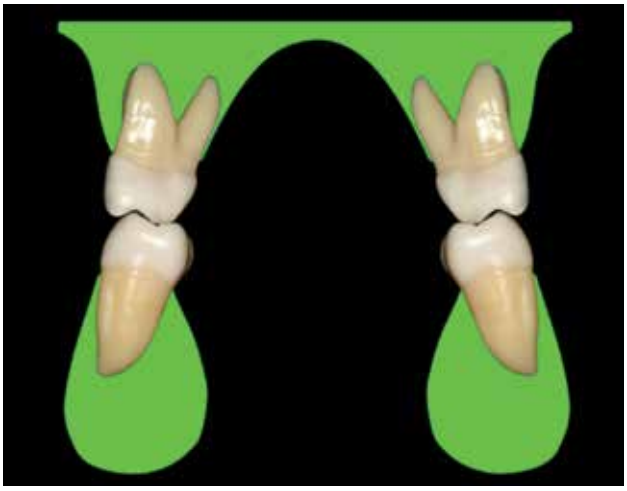
| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Incisor Inclination (X2) | 4 | | -1 | |
| Crowding/Spacing | -17 | | -4 | |
| Maxillary Expansion | 0 | | | |
| Dental Expansion | 4 | | 4 | |
| Curve of Spee | | | | |
| Tooth/Size Discrepancy | | | | |
| Unresolved Space Requirement | | | | |
| Extraction | | | | |
| Distalization/Mesialization (X2) | | | | |
| IPR | | | | |
| Final Space Requirement | 0 | | 0 | |

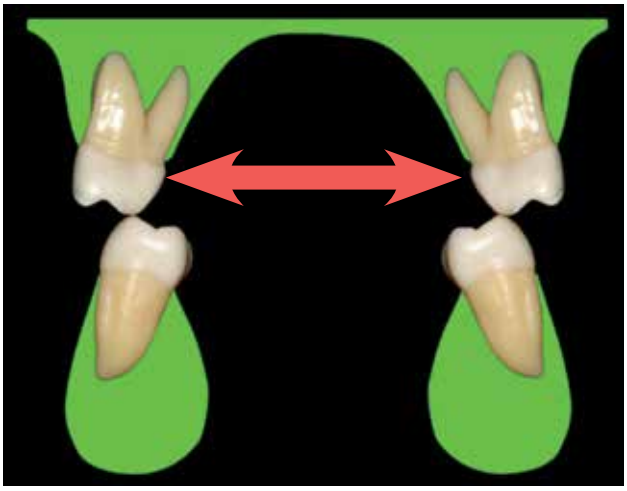
***Maxillary/Dental Expansion Review***

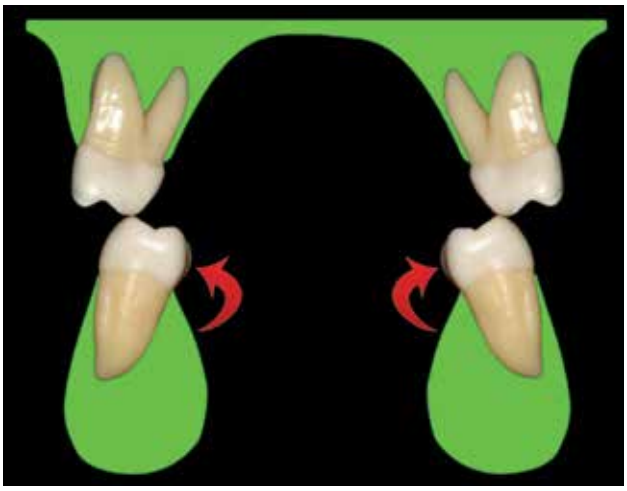
The previous explanation of dental expansion involved theoretical transverse optimization of both the jaws and the dentition. If the patient is planned for segmental surgical expansion of the maxilla, then decompensation before expansion is appropriate to more precisely target jaw movements and improve long-term stability. However, when performing expansion on adolescents and children, as well as surgically assisted expansion of adults, it is prudent to make expansion the first procedure. The rationale for adolescents is to employ expansion early to ensure easier separation of the palatal suture. However, the diagnosis is identical. The following graphics are meant to aid visualization of the procedure from initial presentation to ideal result.

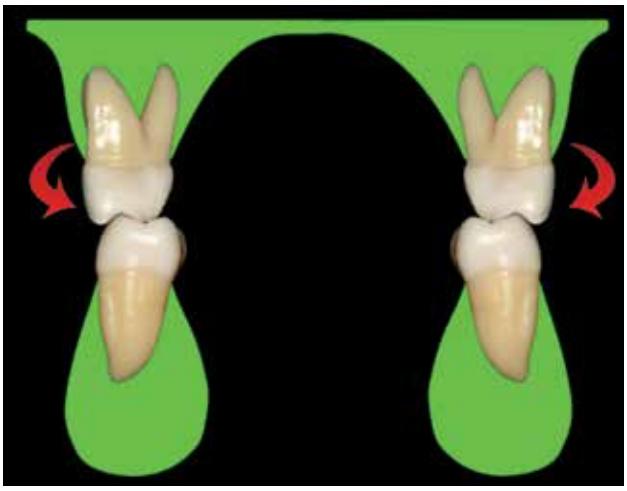
The initial presentation: Note lingual inclination of mandibular molars and buccal inclination of maxillary molars without dental crossbite. This is a common dental compensation for an underlying skeletal maxillary transverse deficiency.

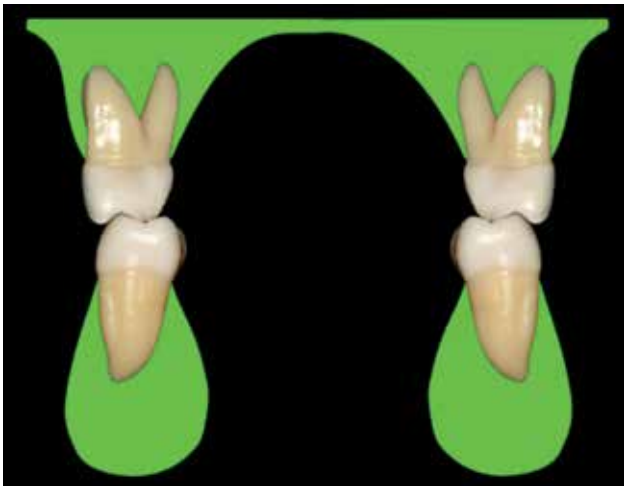
The dentition immediately following maxillary expansion: The maxillary skeletal width is normalized, but the dental compensation is still present.











Placement of bonded appliances on the mandibular teeth while the expansion is stabilized will allow for the mandibular dentition to upright in the alveolus to the proper inclination.

After removal of the expander, the maxillary appliances are placed. With arch coordination and the expression of proper torque in the molar brackets, the maxillary posterior teeth will upright to their ideal inclination.

The final ideal result: Note the upright position of the molars, centralization of the teeth in the alveolus, and optimal intercuspation. This dental relationship is possible only when the skeletal transverse dimension is normal.

***Curve of Spee***

A functional goal of CCO treatment is to level the Curve of Spee. To do so requires space. When evaluating the patient, the maxillary and mandibular casts should be viewed from the buccal, and a flat object should be placed from the incisor to the second molar. The greatest vertical distance from the flat object to the dentition should be recorded. Only the side with the greatest depth needs to be recorded.

Once again, research from Dr. Andrews[18] has produced a relationship between the depth of the Curve of Spee and the needed space to level the curve. This table applies for both the maxillary and mandibular dentition.

| ***Curve Depth*** | ***Space Needed*** |
|---|---|
| 2 mm | 1 mm |
| 3 mm | 2 mm |
| 4 mm | 3 mm |
| 5 mm | 5 mm |
| 6 mm | 7 mm |

[18]Andrews LF, Andrews WA. Andrews analysis. In: Syllabus of the Andrews Orthodontic Philosophy. 9th ed. Six Elements Course Manual; 2001

For the case example, the following space requirements to level the Curves of Spee are noted and recorded.

***Depth of Curve = 0 mm***

***Depth of Curve = 2 mm (Space Needed = 1 mm)***

***Space Requirement***

| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Incisor Inclination (X2) | 4 | | -1 | |
| Crowding/Spacing | -17 | | -4 | |
| Maxillary Expansion | 0 | | | |
| Dental Expansion | 4 | | 4 | |
| Curve of Spee | 0 | | -1 | |
| Tooth/Size Discrepancy | | | | |
| Unresolved Space Requirement | | | | |
| Extraction | | | | |
| Distalization/Mesialization (X2) | | | | |
| IPR | | | | |
| Final Space Requirement | 0 | | 0 | |

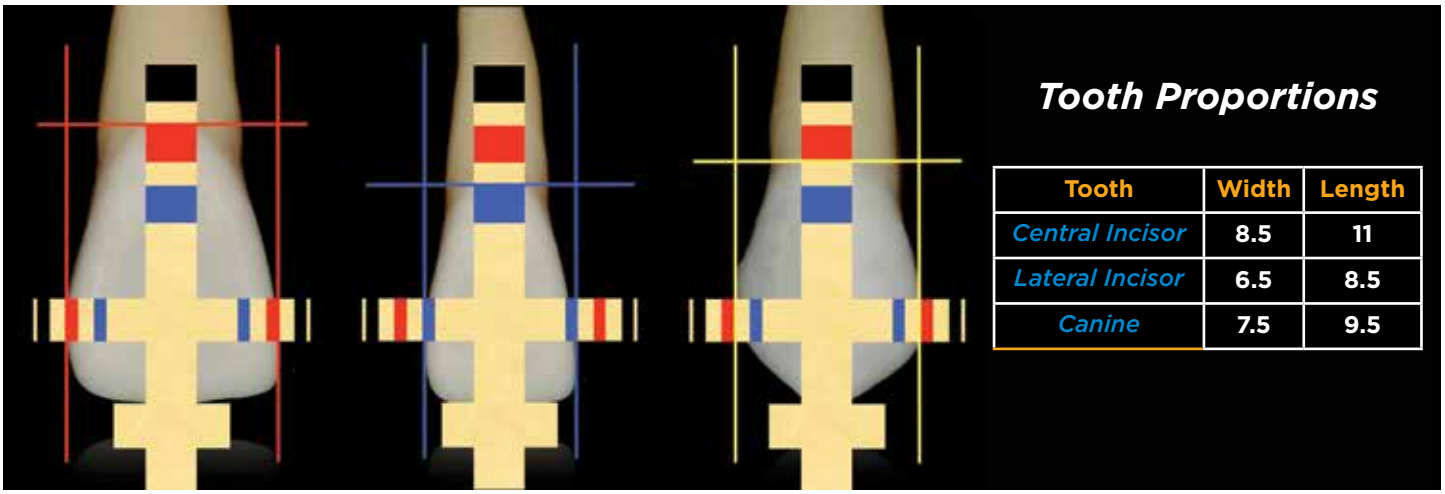
***Tooth/Size Discrepancy***

For patients that are in the mixed dentition or present with under/oversized teeth, the space analysis needs to be performed with respect to the permanent dentition. Therefore, if primary teeth remain, the leeway, or E-space should be placed in this category as space available (usually 3-4 mm in the mandible and 2-3 mm in the maxilla).

Additionally, many patients present with a Bolton discrepancy of the anterior or posterior teeth. For the teeth to fit ideally at their ideal inclination with no spacing and crowding, the mesial-distal dimension of the six anterior teeth must coincide, as shown in the treated case below.

Patients will commonly present with undersized or missing maxillary lateral incisors. A decision that needs to be accounted for in the treatment planning phase is whether or not to restore these teeth to their ideal proportions. If they are to be restored, the orthodontist must allow for a proper amount of space to have an ideal restoration. While there are many methods to determine tooth-size discrepancies, a quick method is through the use of the Chu Gauge (Hu-Friedy).

Use of this gauge allows for planning proper dimensions of the maxillary central incisor, maxillary lateral incisor, and maxillary canine based on an optimal width/height proportion of 78%[19]. Optimal proportions and use of the gauge is illustrated below. Note the position of the stripes for optimal proportions.



***Tooth Proportions***

| Tooth | Width | Length |
|---|---|---|
| *Central Incisor* | 8.5 | 11 |
| *Lateral Incisor* | 6.5 | 8.5 |
| *Canine* | 7.5 | 9.5 |

***Initial***

| | Width | Length |
|---|---|---|
| *Central* | 8.5 | 10.5 |
| *Lateral* | 4 | 6 |

***Required***

| | Width | Length |
|---|---|---|
| *Central* | 8.5 | 11 |
| *Lateral* | 6.5 | 8.5 |

[19]Chu SJ. A biometric approach to predictable treatment of clinical crown discrepancies. Pract Proced Aesthet Dent. 2007;19(7):401-409

As an example, this patient presents with a width of #7 of 4 mm. Using the gauge to place the tooth in proportion with the central incisor requires 2.5 mm of space to be created to optimize the restoration. Therefore, in the space analysis sheet, this would be placed as -2.5 mm since space is required.

For our case example, the teeth are in optimal proportion, and no E-space remains. Therefore, values of 0 mm are entered for both the maxillary and mandibular arches.

***Space Requirement***

| | Maxilla | Mandible |
|---|---|---|
| Incisor Inclination (X2) | 4 | -1 |
| Crowding/Spacing | -17 | -4 |
| Maxillary Expansion | 0 | |
| Dental Expansion | 4 | 4 |
| Curve of Spee | 0 | -1 |
| Tooth/Size Discrepancy | 0 | 0 |
| Unresolved Space Requirement | | |
| Extraction | | |
| Distalization/Mesialization (X2) | | |
| IPR | | |
| Final Space Requirement | 0 | 0 |

***Unresolved Space Requirement***

***Space Requirement***

| | Maxilla | Mandible |
|---|---|---|
| Incisor Inclination (X2) | 4 | -1 |
| Crowding/Spacing | -17 | -4 |
| Maxillary Expansion | 0 | |
| Dental Expansion | 4 | 4 |
| Curve of Spee | 0 | -1 |
| Tooth/Size Discrepancy | 0 | 0 |
| Unresolved Space Requirement | -9 | -2 |
| Extraction | | |
| Distalization/Mesialization (X2) | | |
| IPR | | |
| Final Space Requirement | 0 | 0 |

Once the components of the space analysis are analyzed, the unresolved space requirement to idealize the dentition is determined by adding all of the values for the maxilla and the mandible. For the case example, this calculation results in a net space requirement of 9 mm in the maxilla and 2 mm in the mandible.

The goal is to resolve the crowding and have the final space requirement be zero for both arches. Therefore, two treatment plans are possible according to the space requirement. For the maxilla, the most efficient and

practical way to create 9 mm of space is to remove maxillary premolars. However, for the mandible,the 2 mm of crowding could be resolved in two ways, either by extraction of the mandibular 2nd premolars (if a Cl. I molar relationship upon finishing is desired) or by interproximal reduction (with anticipation of a Cl. II molar finish).

## Treatment Possibilities

| | Plan 1 | Plan 2 |
|---|---|---|
| Maxilla | Extract 1st bicuspids | Extract 1st bicuspids |
| Mandible | Extract 2nd bicuspids | Non-extraction |

***Space Requirement***

***Treatment Option 1***

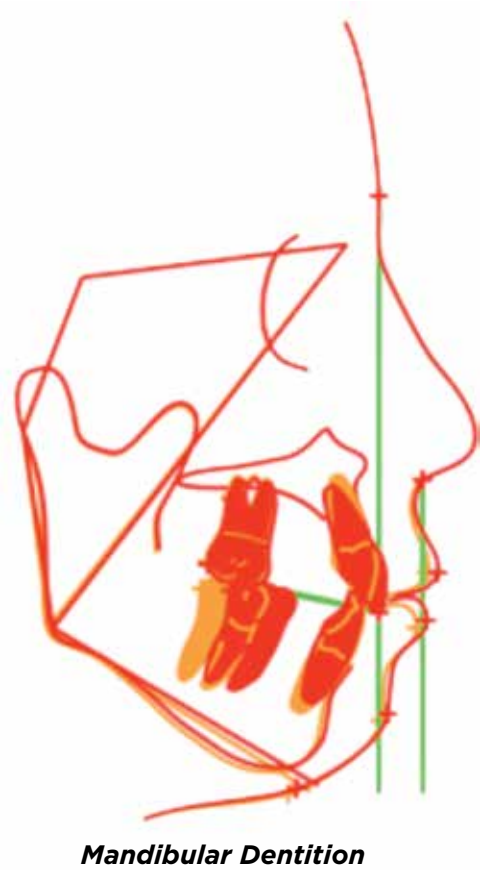
| | Maxilla | Mandible |
|---|---|---|
| Incisor Inclination (X2) | 4 | -1 |
| Crowding/Spacing | -17 | -4 |
| Maxillary Expansion | 0 | |
| Dental Expansion | 4 | 4 |
| Curve of Spee | 0 | -1 |
| Tooth/Size Discrepancy | 0 | 0 |
| Unresolved Space Requirement | -9 | -2 |
| Extraction | 14 | 14 |
| Distalization/Mesialization (X2) | -5 | -12 |
| IPR | 0 | 0 |
| Final Space Requirement | 0 | 0 |

***Space Requirement***

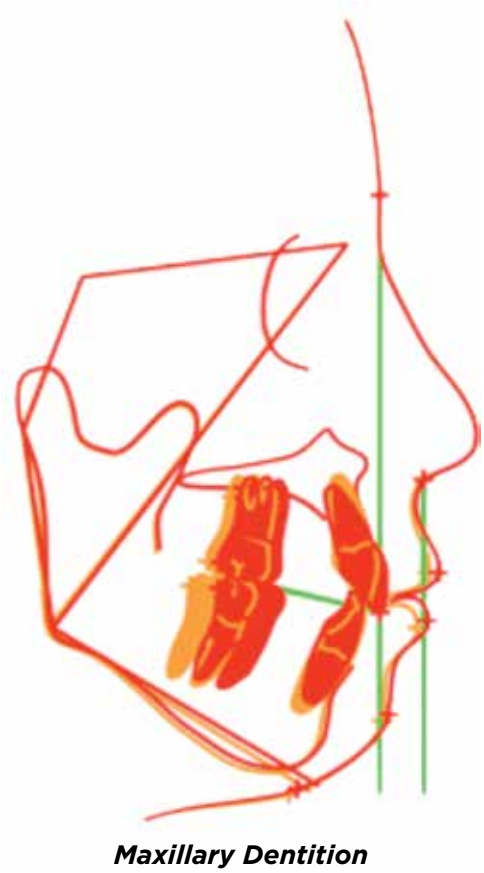
***Treatment Option 2***

| | Maxilla | Mandible |
|---|---|---|
| Incisor Inclination (X2) | 4 | -1 |
| Crowding/Spacing | -17 | -4 |
| Maxillary Expansion | 0 | |
| Dental Expansion | 4 | 4 |
| Curve of Spee | 0 | -1 |
| Tooth/Size Discrepancy | 0 | 0 |
| Unresolved Space Requirement | -9 | -2 |
| Extraction | 14 | 0 |
| Distalization/Mesialization (X2) | -5 | 0 |
| IPR | 0 | 2 |
| Final Space Requirement | 0 | 0 |

In order to compare the feasibility of both plans and to determine the mechanics for achieving them, the posterior teeth have to be moved into position. To calculate the movement needed with extraction of the mandibular second premolars, the assumption used is that both premolars are 7 mm in width, thus giving 14 mm of space. Because the Treatment Design only shows one side of the dentition, the resultant space is divided by 2 and the molar is mesialized this amount along the occlusal plane. The same is done for the maxillary molars.



***Mandibular Dentition***
***14-2 = 12/2 = 6 mm/side***

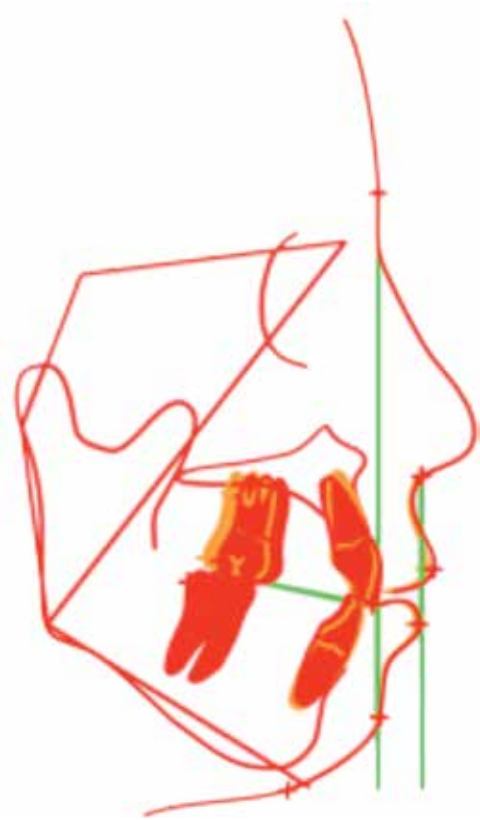


***Maxillary Dentition***
***14-9 = 2/2 = 2.5 mm/side***

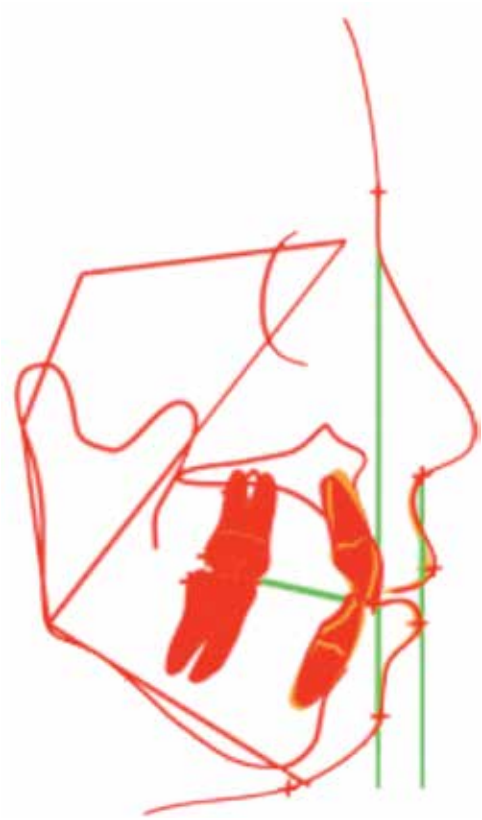
Superimposition of the maxilla on the ANS-PNS line and the mandible on the Corpus Axis allows for evaluation of the required movements and the anchorage requirements.

| ***Arch*** | ***Anchorage*** | ***Feasibility*** |
|---|---|---|
| Maxilla | Minimum | Yes |
| Mandible | Minimum | Difficult |

Simulate of the second option with extraction of only the maxillary premolars.

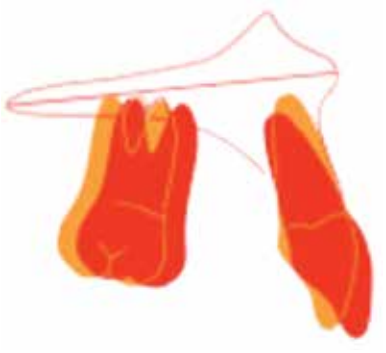


***Mandibular Dentition***
***14-2 = 12/2 = 6 mm/side***



***Maxillary Dentition***
***14-9 = 5/2 = 2.5 mm/side***

Again, superimpose on the ANS-PNS line and the Corpus Axis to evaluate the tooth movement and anchorage requirements.



| ***Arch*** | ***Anchorage*** | ***Feasibility*** |
|---|---|---|
| Maxilla | Minimum | Yes |
| Mandible | Minimum | Yes |

When evaluating the superimpositions and different treatment options, the goals of treatment as well as treatment feasibility and efficiency need to be considered. For this case example, the breakdown is as follows. The first two options will allow for normalization of the jaws at the correct OB/OJ, with a compromise having a mildly retrusive chin. The third option will normalize the teeth, efficiency, as well as esthetics, but of course, a genioplasty is elective and does not have a bearing on the orthodontic movements. Additionally, for this example, extraction of the lower second premolars would result in a large amount of posterior space to close and necessitate precise anchorage control. While possible, this would require careful mechanics and take a significant amount of time. By extracting the upper premolars only and finishing in a Class II molar relationship, the treatment efficiency is increased with no compromise to the treatment goals.

| ***Goal*** | ***Exo U4/L5*** | ***Exo U4*** | ***Exo U4 + Genio*** |
|---|---|---|---|
| Function | ✓ | Yes | ✓ |
| Esthetics | Compromise | Compromise | ✓ |
| Stability | ✓ | ✓ | ✓ |
| Feasibility | Possibly | ✓ | ✓ |
| Efficiency | No | ✓ | ✓ |

This is the power of Treatment Design. By simulating potential treatment options before ever placing a bracket on the patient, the orthodontist has the capability to determine the most effective treatment plan to achieve the treatment goals. Following is the completed Diagnostic Sheet for the patient example, which consolidates all of this information.

# CCO Patient Diagnostic Sheet

Date: _____

Chart: _____

Patient: Case Example Age: Adult Referring Doctor: Self

CC: Crooked Front Teeth

Goals for Treatment: Improve Smile, Correct Bite

Obstacles to Ideal Treatment: None

History of Concerns: None Relevant

## Dental Data

| | |
|---|---|
| Lower Archform | **Normal** Constricted |
| Spacing/Crowding | None **Mild** Moderate Severe |
| Upper Archform | **Normal** Constricted |
| Spacing/Crowding | None Mild Moderate **Severe** |
| Overbite | Ideal **Shallow** Open Deep |
| Overjet | Ideal **Mild** Moderate Severe Negative |
| Crossbite | **None** Unilateral Bilateral Anterior Skeletal |
| Molar Class | I II div.I **II div.II** II sub R II sub L III |
| Wear Facets | None **Anterior** Posterior |
| Excursion Right | Canine **Posterior GF** Anterior GF NW Interferences |
| Excurstion Left | Canine **Posterior GF** Anterior GF NW Interferences |
| Protrusive | Anterior Guidance **Balancing Interferences** |

## Muscular TMJ Data

| *Palpation (1-10)* | Right | Left |
|---|---|---|
| Temporalis | | |
| Masseter | | |
| Submandibular | | |
| Pterygoid | | |
| Occipital | | |
| SCM | | |
| Trapezius | | |
| Intracapsular | | |
| Resistance | Yes | **No** |

## Periodontal Data

| | |
|---|---|
| Frenum | **Max Labial** Mand Labial Lingual Buccal |
| Biotype | Normal Thin **Thick** |
| Recession | **None** Localized: _____ Generalized |
| Inflammation | Absent **Present** |
| Visible Plaque | Absent **Present** |
| Fremitus | **Absent** Present |
| Occlusal Trauma | None **Anterior** Posterior |

## Clinical TMJ Data

| | Right | Left |
|---|---|---|
| Opening Click | X | |
| Closing Click | | |
| Crepitation | | |
| Deviation | mm | mm |
| Max Opening | 40 mm | |
| Functional Shift | mm | R L A |

## Airway Data

| | |
|---|---|
| Snoring | |
| Brux / Clench | x |
| Reflux | |
| AM Headache | |
| Tires Easily | |
| Asthma/Allergies | x |
| Tonsils | |
| Apnea | |
| Cross Section | 132 $mm^2$ |

## Radiographic TMJ Data

| | Right | Left |
|---|---|---|
| Past Remodeling | | |
| Altered Joint Space | x | |
| Subcortical Cyst | | |
| Erosion | | |
| Edema | | |

## Transverse Diagnosis

| *Skeletal* | CBCT | CAC | *Dental* | Measured | | Ideal |
|---|---|---|---|---|---|---|
| Maxilla | 63 | 48 | MGJ-MGJ | | | 58 |
| Mandible | 58 | 43 | ▽ FA-FA | 50 | | 54 |
| Difference | 5 | 5 | ▽ CF-CF | 40 | | 44 |
| Ideal | 5 | 5 | △ P-P | 40 | 38 | 44 |
| | | | △ FA-FA | 60 | 58 | 59 |
| Required | 0 | 0 | | | | -1 |

## Space Requirement

| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Incisor Inclination (X2) | 4 | | -1 | |
| Crowding/Spacing | -17 | | -4 | |
| Maxillary Expansion | 0 | | | |
| Dental Expansion | 4 | | 4 | |
| Curve of Spee | 0 | | -1 | |
| Tooth/Size Discrepancy | 0 | | 0 | |
| Unresolved Space Requirement | -9 | | -2 | |
| Extraction | 14 | | 0 | |
| Distalization/Mesialization (X2) | -5 | | 0 | |
| IPR | 0 | | 2 | |
| Final Space Requirement | 0 | | 0 | |

## Sagittal Diagnosis (CR)

| | |
|---|---|
| Skeletal | I / II / III |
| Dental | I / II / III |
| Maxilla | Deficiency / Excess |
| Mandible | Deficiency / Excess |
| Overjet | mm |

## Vertical Diagnosis (CR)

| | |
|---|---|
| Skeletal | Open Normal Deep |
| Dental | Open Normal Deep |
| Maxilla | Deficiency / Excess |
| Mandible | Deficiency / Excess |
| Overbite | mm |

## Archform

| | |
|---|---|
| Template | |
| Mandible | S M L Custom |
| Maxilla | S M L Custom |

| Orthodontic Plan | Retention Strategy | Restorative Plan |
|---|---|---|
| △ Anchorage: Min Mod Max | Maxilla: Hawley bite plate with acrylic on labial bow | Restore wear facets PRN |
| ▽ Anchorage: Min Mod Max | Mandible Hawley retainer with acrylic on labial bow | |
| Bond U/L 7-7 | | |
| Extract maxillary 1st premolars | **Treatment Alerts** | **Surgical Plan** |
| IPR L 3-3 (2mm) | | |
| | | |
| | | |
| | **Periodontal Plan** | **Other Disciplines** |
| | Gingevectomy/Osseous Reduction U anterior | |
| | | |

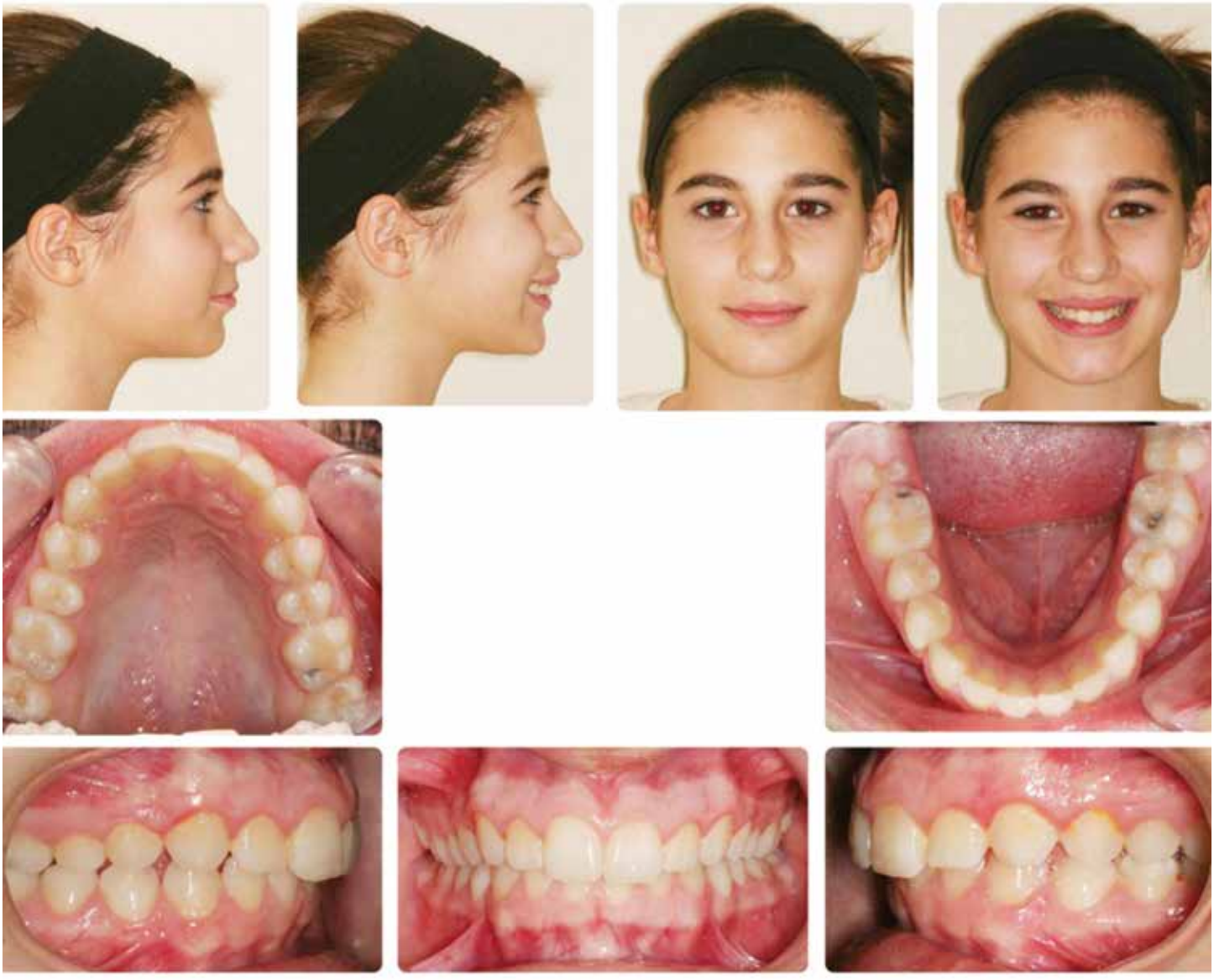
Patient: _____ Chart: _____ Page 2

The following pictures are the initial bonding, 6 months, and 11 months into treatment, immediately prior to space closure on the maxilla. Note the ~2.5 mm of space remaining distal to each maxillary canines with the maxillary anterior teeth at the optimal inclination, which illustrates the accuracy of the space analysis methodology presented earlier.

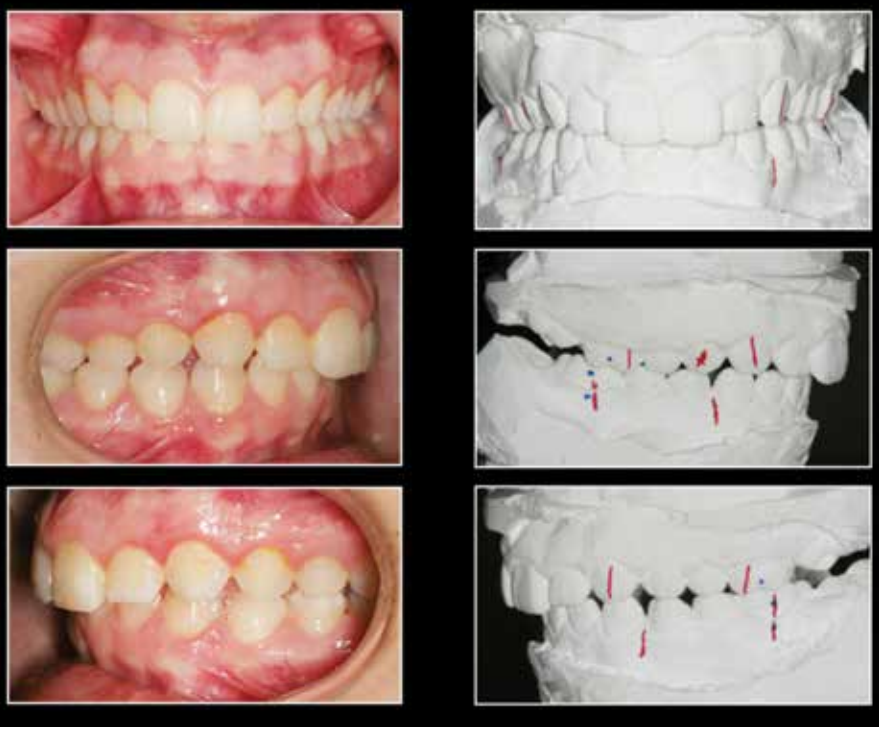
***Initial Bonding*** ***6 Months*** ***11 Months***

# 7. Case Example - Gianna D.

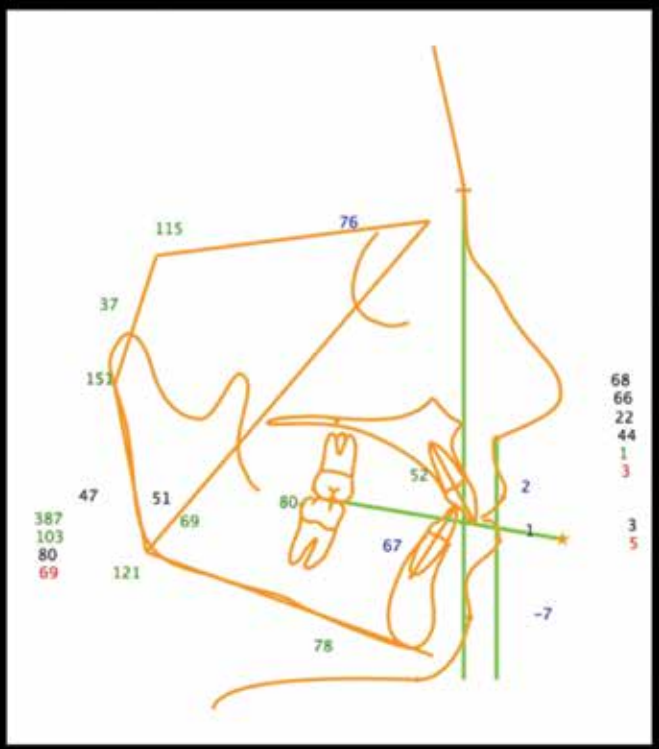
The following example is a 12 year old female, and illustrates the CCO treatment planning process from start to finish. A CBCT was not available for this patient, so the data reflects the technology used – mounted casts, lateral headfilm, panoramic film, and photographs.



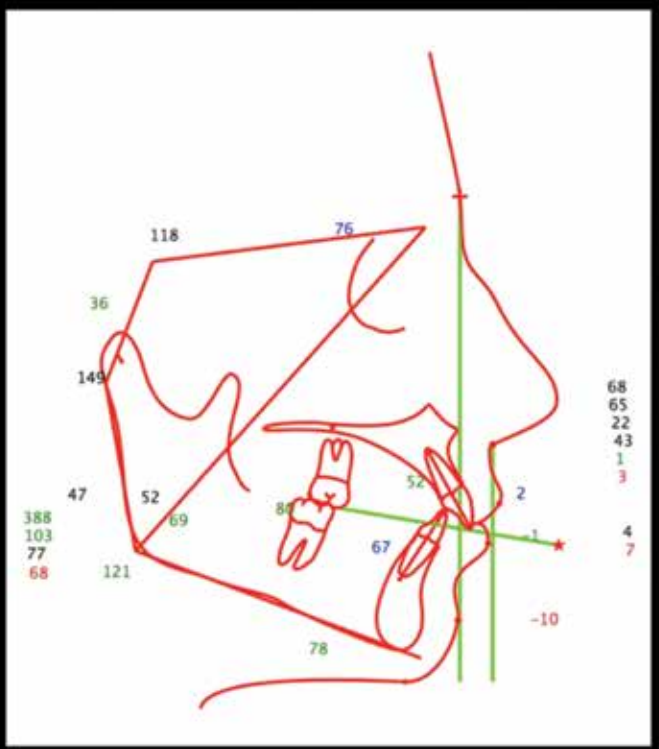
## *Initial Models*



## *Converted Lateral Ceph Tracing*




MIC Ceph




SCP Ceph

# CCO Patient Diagnostic Sheet

Date: _____

Chart: _____

Patient: Gianna D. Age: 12 Referring Doctor: Self

CC: I was told I needed to see an orthodontist for my bite.

Goals for Treatment: Maintain esthetics, correct bite

Obstacles to Ideal Treatment: None

History of Concerns: None

## Dental Data

| | |
|---|---|
| Lower Archform | **Normal** Constricted |
| Spacing/Crowding | None **Mild** Moderate Severe |
| Upper Archform | **Normal** Constricted |
| Spacing/Crowding | None **Mild** Moderate Severe |
| Overbite | Ideal Shallow Open **Deep** |
| Overjet | Ideal Mild **Moderate** Severe Negative |
| Crossbite | **None** Unilateral Bilateral Anterior Skeletal |
| Molar Class | I **II div. I** II div. II II sub R II sub L III |
| Wear Facets | None **Anterior** Posterior |
| Excursion Right | Canine **Posterior GF** Anterior GF NW Interferences |
| Excurstion Left | Canine **Posterior GF** Anterior GF NW Interferences |
| Protrusive | **Anterior Guidance** Balancing Interferences |

## Muscular TMJ Data

| *Palpation (1-10)* | Right | Left |
|---|---|---|
| Temporalis | | |
| Masseter | | |
| Submandibular | | |
| Pterygoid | | |
| Occipital | | |
| SCM | | |
| Trapezius | | |
| Intracapsular | | |
| Resistance | Yes | **No** |

## Periodontal Data

| | |
|---|---|
| Frenum | Max Labial Mand Labial Lingual Buccal |
| Biotype | **Normal** Thin Thick |
| Recession | **None** Localized: _____ Generalized |
| Inflammation | **Absent** Present |
| Visible Plaque | **Absent** Present |
| Fremitus | **Absent** Present |
| Occlusal Trauma | **None** Anterior Posterior |

## Clinical TMJ Data

| | Right | Left |
|---|---|---|
| Opening Click | | |
| Closing Click | | |
| Crepitation | | |
| Deviation | mm | mm |
| Max Opening | mm | |
| Functional Shift | mm | R L **A** |

## Airway Data

| | |
|---|---|
| Snoring | |
| Brux / Clench | |
| Reflux | |
| AM Headache | |
| Tires Easily | |
| Asthma/Allergies | |
| Tonsils | |
| Apnea | |
| Cross Section | $mm^2$ |

## Transverse Diagnosis

| *Skeletal* | CBCT | CAC | *Dental* | Measured | | Ideal |
|---|---|---|---|---|---|---|
| Maxilla | | 43 | MGJ-MGJ | | | 55 |
| Mandible | | 42 | ▽ FA-FA | 50 | | 51 |
| Difference | | 1 | ▽ CF-CF | 40 | | 41 |
| Ideal | 5 | 5 | △ P-P | 37 | 37 | 41 |
| | | | △ FA-FA | 52 | 52 | 56 |
| Required | | -4 | | | | -4 |

## Radiographic TMJ Data

| | Right | Left |
|---|---|---|
| Past Remodeling | | |
| Altered Joint Space | | |
| Subcortical Cyst | | |
| Erosion | | |
| Edema | | |

## Space Requirement

| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Incisor Inclination (X2) | -3 | | -1 | |
| Crowding/Spacing | 0 | | -2 | |
| Maxillary Expansion | 4 | | | |
| Dental Expansion | 0 | | 1 | |
| Curve of Spee | -1 | | -1 | |
| Tooth/Size Discrepancy | -1 | | 0 | |
| Unresolved Space Requirement | -1 | | -3 | |
| Extraction | 0 | | 0 | |
| Distalization/Mesialization (X2) | 1 | | 0 | |
| IPR | 0 | | 3 | |
| Final Space Requirement | 0 | | 0 | |

## Sagittal Diagnosis (CR)

| | |
|---|---|
| Skeletal | I / II / III |
| Dental | I / II / III |
| Maxilla | Deficiency / Excess |
| Mandible | Deficiency / Excess |
| Overjet | mm |

## Vertical Diagnosis (CR)

| | |
|---|---|
| Skeletal | Open Normal Deep |
| Dental | Open Normal Deep |
| Maxilla | Deficiency / Excess |
| Mandible | Deficiency / Excess |
| Overbite | mm |

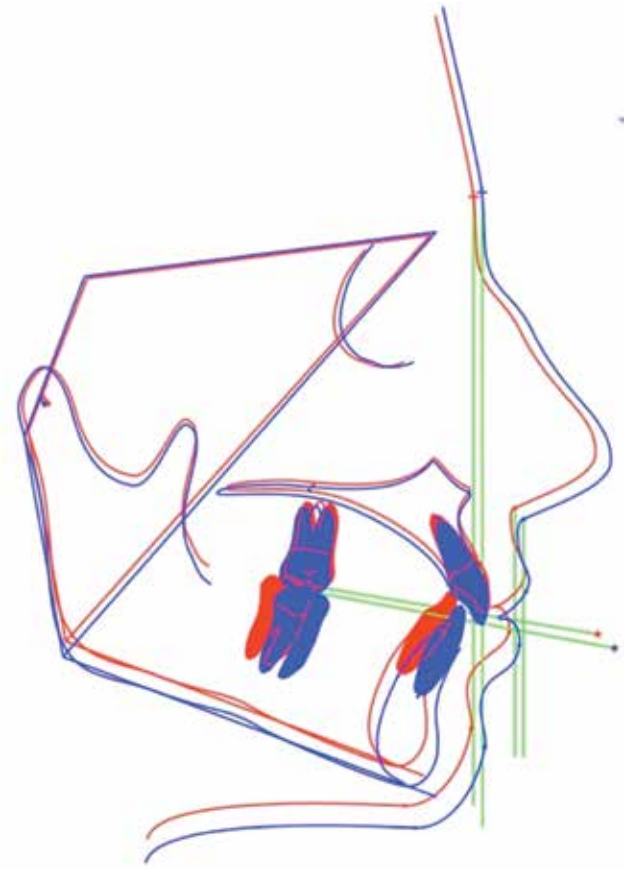
## Archform

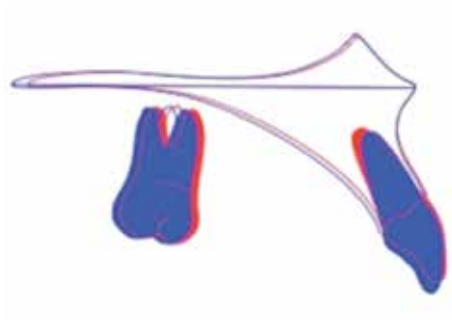
| | |
|---|---|
| Template | |
| Mandible | S M L Custom |
| Maxilla | S M L Custom |

| Orthodontic Plan | Retention Strategy | Restorative Plan |
|---|---|---|
| △ Anchorage: Min Mod Max | Maxilla: Hawley Bite Plate | |
| ▽ Anchorage: Min Mod Max | Mandible: Hawley Spring Aligner or L 3-3 | |
| Bonded RPE (8 mm screw) | | |
| Bond U/L 7-7, Band U6s | **Treatment Alerts** | **Surgical Plan** |
| High-pull HG | | |
| Distalize U posterior teeth with OCS/elastics | | |
| IPR L 3-3 (3 mm) | | |
| Occlusal adjustment as needed | **Periodontal Plan** | **Other Disciplines** |
| | | |
| | | |

Patient: _____ Chart: _____

The Treatment Design for Gianna calls for the Cl. II correction to be resolved with growth, and the dental positioning will be optimized with good bracket placement and predictable mechanics, as described on the diagnostic sheet.





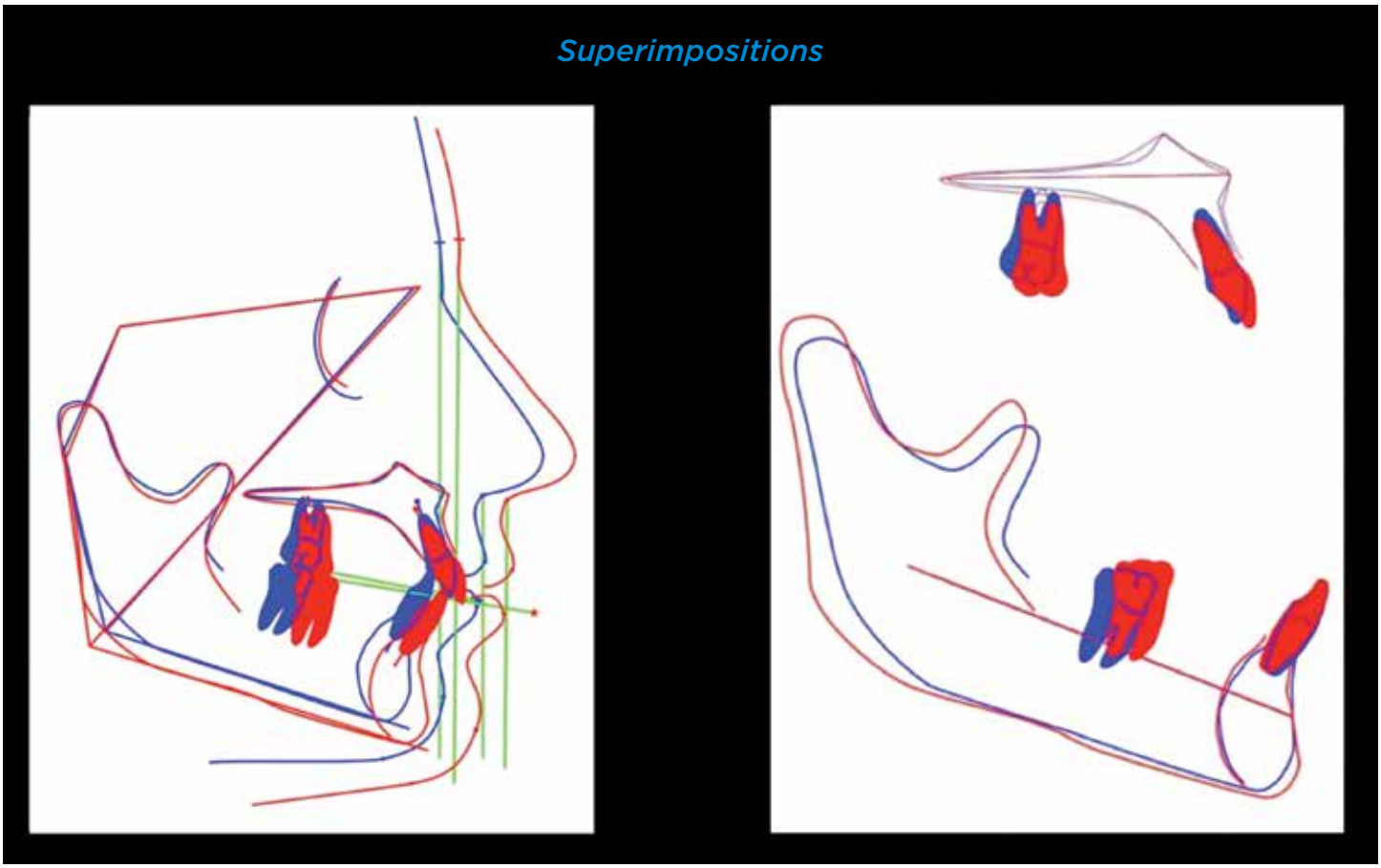
| ***Goal*** | ***RPE + HPHG + B/B U/L*** |
|---|---|
| Function | ✓ |
| Esthetics | ✓ |
| Stability | ✓ |
| Feasibility | ✓ |
| Efficiency | ✓ |

Execution of the plan is as follows:

Gianna's final photographs depict good dental intercuspation, good function in all excursions, good periodontal health, and good facial/smile esthetics.

While this result would satisfy most practitioner's desires to provide good orthodontic care, the true measure of the Treatment Design process is proving that the movements and mechanics that were planned at the beginning actually occurred. If they did, then the practitioner was successful and the assumptions and diagnostic criteria that were used can be applied for future patients. If they did not, this provides a critical learning experience. The practitioner can then learn truly what they "think" is happening vs. what "actually" happens to be able to effectively use that information for the future.

Looking at Gianna's case, the following superimpositions show what actually occurred:

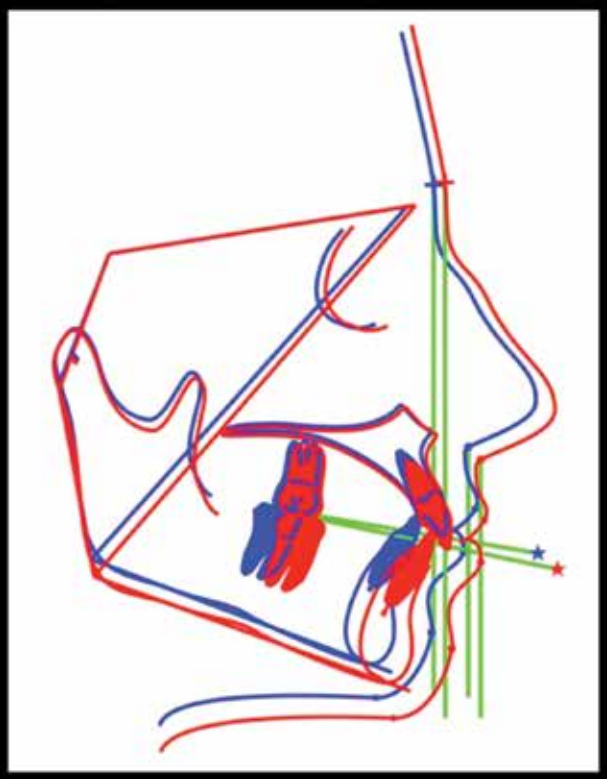


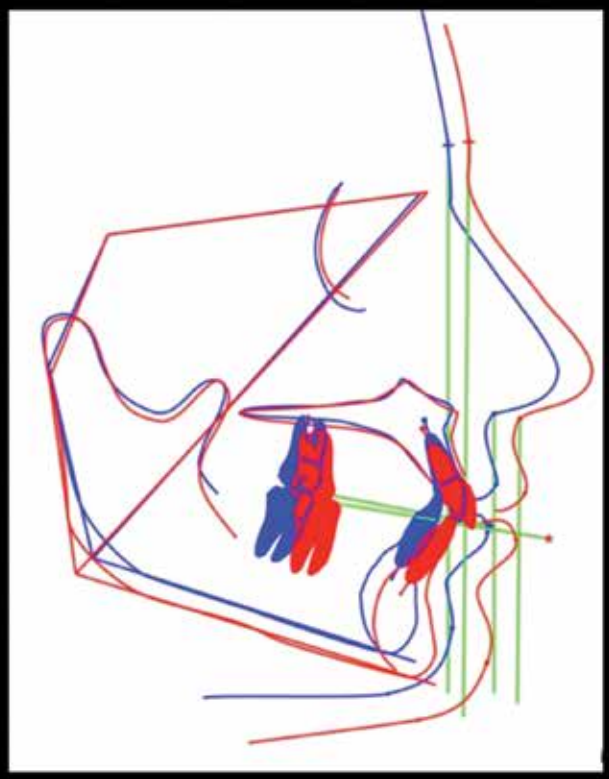

Her plan called for the incisors to be optimally inclined, the HPHG to restrict the forward movement of the maxilla while the mandible grew to correct the Cl. II relationship, and for the vertical dimension to remain unchanged.

The true power of the Treatment Design exercise is to provide a realistic simulation of what will happen with orthodontic treatment, so expectations of both the practitioner and the patient can be set at the beginning. The simulation should provide a virtual realization of the outcome, along with any potential compromises that could be made while maintaining good esthetics, good periodontal health, and good dental function.

Gianna's comparison of her Treatment Design to the actual outcome shows a nearly identical result to what was planned pre-treatment, thus highlighting the viability of the plan and the realistic assumptions that were objectively determined using the Diagnostic Sheet.

## *Comparisons*





# 7. Conclusion

Treatment Design is an essential tool for any orthodontist who wishes to provide the highest quality of care with confidence for themselves and for their patients. This manual focused on the importance of head positioning, target lines, and space analysis along with the roles they play in successfully constructing a treatment simulation. Additionally, the methodology presented was one where having a logical progression for analysis, while keeping treatment goals in mind, will naturally lead to a proper diagnosis. Further usage and practice with Treatment Design will afford the practitioner a diagnostic tool that is much quicker, easier, and more comprehensive than other previously established techniques. Ultimately, this will lead to improved treatment outcomes for the patient.

As long as the practitioner understands the core concepts presented in this manual, the foundation for predictable, advanced treatment planning is in place. Additional sessions will build on this material, and upon completion, the orthodontist will have a comprehensive and complete strategy for building a clinically sound and efficient practice.

## Ryan K. Tamburrino, DMD

Dr. Tamburrino grew up in Pittsburgh and his tinkering and technical interests during his early years led him to Duke University where he received degrees in Biomedical Engineering/Materials Science. Wanting to also be involved in healthcare, he enrolled at the University of Pennsylvania where he received his Doctorate of Dental Medicine and specialty Certificate in Orthodontics.

In addition to maintaining several locations of the Center for Orthodontic Excellence with his practice partner, Dr. Shalin Shah, Dr. Tamburrino is on the faculty at the University of Pennsylvania in the Department of Orthodontics. Dr. Tamburrino also lectures locally with various study groups as well as internationally/nationally with the Complete Clinical Orthodontics Course. He strongly believes that it is important to teach and to help raise the standard of dental care for local communities as well as for the entire profession, and he thoroughly enjoys any opportunity to do so, either written or through speaking.

Outside of his professional practice he enjoys spending time with his wife, two sons, and two crazy cats, Tomato and Basil. He is also an avid golfer and model railroader.

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