Dedication

I dedicate this book to my family—especially to Susu for your understanding, love, support, and everything you have done for me—and to my daughter, Nur, and my son, Samir, who have always been my focus, my love, and my happiness.

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PASSIVE SELF-LIGATION from A to Z

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Contents

Foreword

The orthodontic profession was first exposed to the extraordinary cases of Dr Dwight Damon in the Ormco publication *Clinical Impressions* in November 1999. In this article, Dwight related a novel concept of applying orthodontic forces with low force and light friction, which allowed him to achieve results rarely seen previously in our profession. His concept hinged on a ligation theory described as "passive self-ligation" (PSL).

His article posited that teeth treated with PSL moved faster than teeth treated with traditionally ligated brackets, so I decided to try it out. Much to my surprise, his theories were confirmed by simple clinical observations. When I related my findings to him, Dwight unexpectedly invited me to come to his clinical facility in Spokane, Washington, suggesting that I "stay as long as you feel you need to stay in order to understand my technique." So I went, and after working with him daily, we struck up a friendship that has lasted more than 20 years now. We have written books together, discussed concepts together, shared family moments together, traveled and lectured together, and watched his amazing technique become the worldwide gold standard for orthodontic treatment results.

Through it all, Dwight has never changed in his focus. His efforts have always been and continue to be directed at improving the lives of our patients as well as the lives of the orthodontists who embrace his theories. Unlike many previous orthodontic innovators, he has never stopped upgrading his system, and in doing so, he has improved our ability to care for our patients. This book is an accumulation of chapters written by those of us fortunate enough to be a part of the development and introduction of Dwight Damon's system of PSL. It is meant as an educational tool, as a reinforcement of what Dwight envisioned, and hopefully as an inspiration to embrace the gift Dwight has given to our profession.

As Dwight would say, "Read and react to what you see." This book is meant to serve that purpose.

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Preface

During the past two decades, considerable energy has been devoted to the concept of passive self-ligation for the correction of different types of malocclusions, including continuous and critical evaluations of our treatment methods and results. This cumulative experience has resulted in significant improvements in the quality of treatments.

This book is a practical guide to the Damon System of passive self-ligation, which allows more efficient treatment with lower levels of force and friction. The objective is to achieve nice arch development while improving smile esthetics, all with a system that is easy to use. All the cases presented in this book were treated according to the principles of the Damon System, and the goal is to empower students and clinicians to apply these principles into their own work to improve patient outcomes and solve various problems encountered in clinical orthodontic practice.

Acknowledgments

My sincere thanks to all the contributors for agreeing to be part of this book. I owe each one a debt of gratitude. I also want to express my respect and gratitude to Dr Dwight Damon for his teachings. Thanks to him, I have become a better orthodontist. Finally, Dr Enrique Gonzalez deserves special recognition for his support and collaboration in making this book a reality. Thanks for your friendship.

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Diagnosis Using the BEST Philosophy

Nasib Balut/Enrique Gonzalez/
Juan Carlos Solorio

"To know how to cure an illness, you must first have to know it exists."
—Peter E. Dawson

Diagnosis is the cornerstone of success in the medical field, including dentistry. A diagnostic analysis allows us to know each patient's therapeutic boundaries and clinical needs and understand if we have a real possibility to provide an integral solution by establishing short-, medium-, and long-term goals within our treatment. Above all, diagnosis allows us to define a solution prognosis.

Since the 1950s, cephalometry has been the main diagnostic method in orthodontics. Historically, diagnosis in orthodontics has mainly consisted of analyzing clinical findings and data gathered from a lateral cephalometric radiograph, a periapical series, and a panoramic radiograph; intraoral and extraoral photographs; and plaster study models.[1] While study models allow the orthodontist to analyze all the aspects of occlusion, precise skeletal relationships based on these models are a matter of conjecture. Therefore, in the second half of the 20th century, routine application of the cephalometric analyses developed by Bolton, Broadbent, Jarabak, Ricketts, Steiner, and others allowed orthodontists to study facial growth, make superimpositions, and observe treatment results in more detail.[1] This led to significant advancements in the fundamental science and daily practice of orthodontics and dentofacial orthopedics.[2]

The greatest defect of cephalometric analysis is the inability to project 3D structures in bidimensional representations.[3,4] Instead we have always had to divide the difference between bilateral anatomical landmarks such as gonion and orbitale, leaving us to wonder whether the variations between sides were due to radiographic projections or real asymmetries.[5]

But things have changed. The adaptation of cone beam computed tomography (CBCT) to orthodontics in the last decade has given way to more precise diagnoses of anatomical issues, showing in detail the characteristics of the temporomandibular joint (TMJ), the state and amount of cortical bone surrounding the tooth, any impacted teeth, and facial asymmetries, among other things. It also allows for volumetric assessment of the patient's airways. CBCT is not only an exploratory tool but also a unique and complete 3D cephalometric measurement system that allows us to make comparisons with the same patient, so the effects of growth and the treatment can be analyzed and compared quantitatively.[5–7]

IN THIS CHAPTER:

- What is BEST?
- General anatomical assessment using CBCT
- Anatomical assessment of paranasal sinuses and upper airways
- Static and dynamic assessment of the TMJ
- Assessment of teeth and their cortical bone
- 3D cephalometric analysis
- Esthetic assessment
- Assessment of records before removing appliances
- Clinical case
- BEST forms

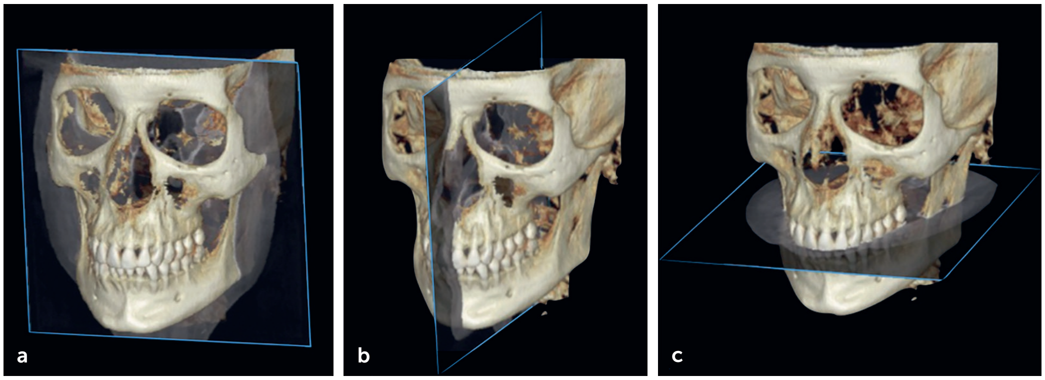


Fig 1-1 Three planes of the face. *(a)* Coronal plane. *(b)* Sagittal plane. *(c)* Axial plane.

In other words, modern-day orthodontists have the opportunity to carry out a more thorough assessment of the patient from a static and dynamic perspective; however, with so much data available, it is essential that the clinician is prepared to generate accurate information without excess or deficiency.[2,3]

What Is BEST?

BEST is the diagnosis and treatment method created by Drs Nasib Balut, Enrique González, and Juan Carlos Solorio. This method uses cutting-edge technology and a defined and practical protocol to allow for customized treatment mechanics for each case. New technologies do not seek to discard traditional concepts; on the contrary, they should be combined with diagnostic data to offer a broader knowledge of our patients and help us generate more comprehensive diagnoses, elevating the quality standards of orthodontic treatments regardless of the philosophy followed by the clinician.

The BEST diagnosis and treatment method involves evaluation of seven areas:

1. General anatomical assessment using CBCT
2. Anatomical assessment of paranasal sinuses and upper airways
3. Static and dynamic assessment of the TMJ
4. Assessment of teeth and their cortical bone
5. 3D cephalometric analysis
6. Esthetic assessment
7. Assessment of records before removing appliances

General Anatomical Assessment Using CBCT

Before carrying out the anatomical assessment, it is necessary to know and identify the three planes: coronal, sagittal, and axial. They must be interpreted separately, but we should also know how these planes interact with each other.

- **Coronal plane:** It faces the anterior portion of the face, parallel to the facial surfaces of the anterior teeth. It divides the skull into an anterior and posterior portion. We can observe the structures from back to front or front to back (Fig 1-1a).
- **Sagittal plane:** It divides the skull into two symmetric portions. It runs transversely and allows for the study of two segments: right and left (Fig 1-1b).
- **Axial plane:** It is parallel to the ground and faces the occlusal plane. It divides the skull into two equal sections—upper and lower—so we can observe the structures from the top down and from the bottom up (Fig 1-1c).

Anatomical assessment in the three planes is an invaluable opportunity provided by CBCT, because we can perform a complete exploration and assessment of the 3D anatomy. Very frequently we are able to observe anatomical variants or very subtle findings that are crucial to treatment planning.

We recommend observing and measuring the patient's enamel thickness during the general anatomical assessment. This information is important because when there is a Bolton discrepancy or a need to gain space, interproximal reduction (IPR) will be required, and you have to know the starting enamel thickness to avoid rubbing away too much. Many patients have had previous orthodontic treatments and will not remember if IPR has already been performed; even if they do remember, they usually do not remember on which teeth this has been performed, so it's best to measure every time.

Enamel thickness is obtained by generating coronal and sagittal slices in each of the teeth and precisely locating the crown's middle third. This is measured directly over the axial plane. Filters that distinguish the boundaries between enamel and dentin based on density are used to aid visualization (Fig 1-2).

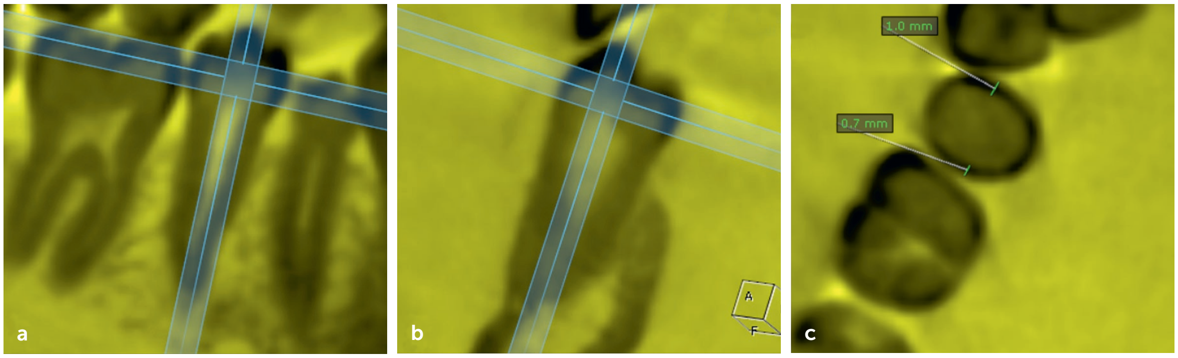


Fig 1-2 *(a)* Location of the middle third in a sagittal slice. *(b)* Location of the middle third in a coronal slice. *(c)* Location of the middle third in an axial slice.

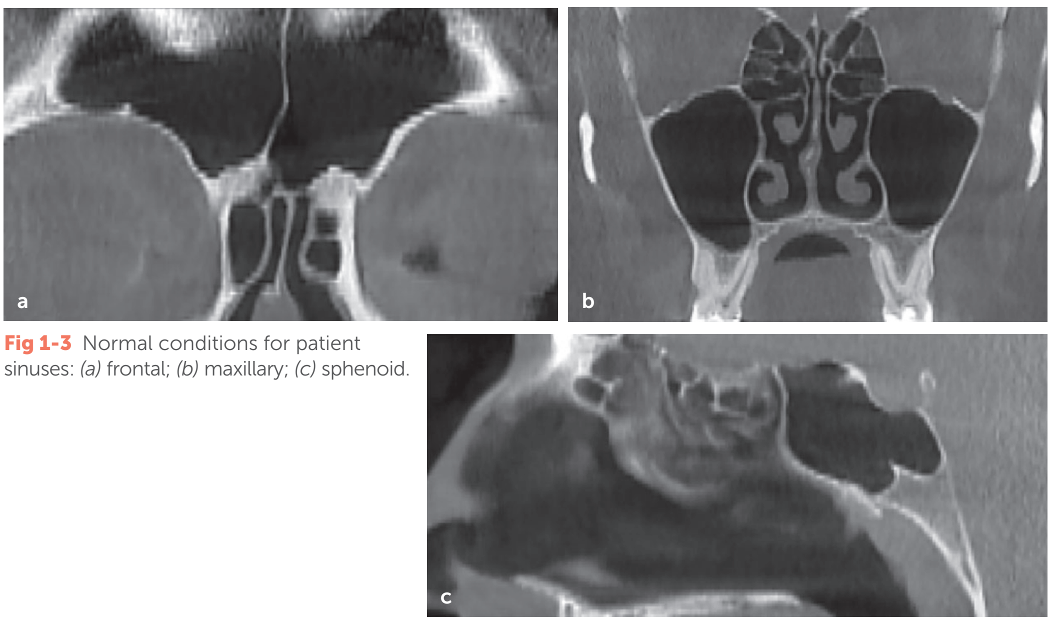


Fig 1-3 Normal conditions for patient sinuses: *(a)* frontal; *(b)* maxillary; *(c)* sphenoid.

Anatomical Assessment of Paranasal Sinuses and Upper Airways

Breathing is a fundamental process in human development. It influences the growth and development of the craniofacial structures and contributes to important physiologic, cognitive, and esthetic processes as well as oral and general health. A 3D assessment of the airway completely changes the specialist's perception and, most importantly, potentially the life of the patient.

Once again, we recommend performing the assessment methodically and systematically, in the following order:

1. **Paranasal sinuses:**
   - Frontal sinuses
   - Maxillary sinuses
   - Sphenoid sinuses
2. **Upper airway:**
   - Nasopharynx
   - Oropharynx
   - Laryngopharynx

We recommend performing 3D reconstructions to evaluate the anatomy from a volumetric perspective and observing the upper airways internally through virtual endoscopy. Figures 1-3 and 1-4 show normal conditions for the sinuses and airway, and Fig 1-5 shows the significant clinical findings in an airway assessment in adolescent patients.

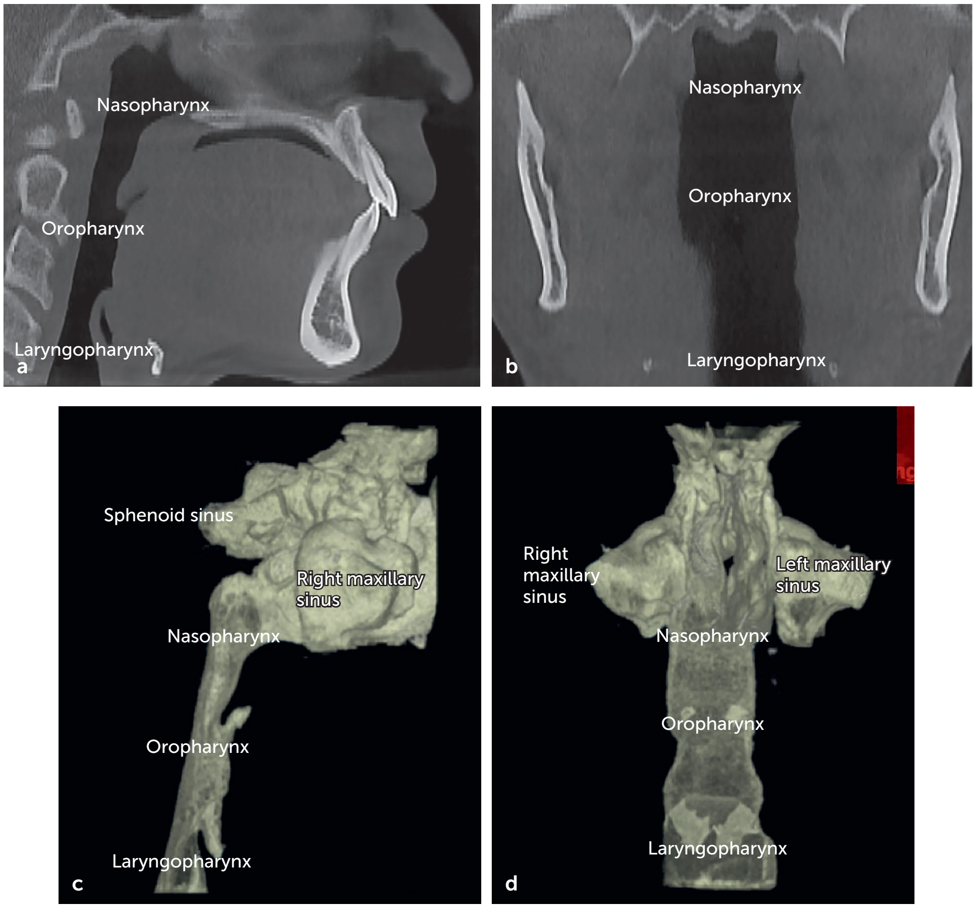


Fig 1-4 Normal conditions for patient airway: *(a)* sagittal slice, *(b)* coronal slice; *(c)* sagittal 3D reconstruction; *(d)* coronal 3D reconstruction.

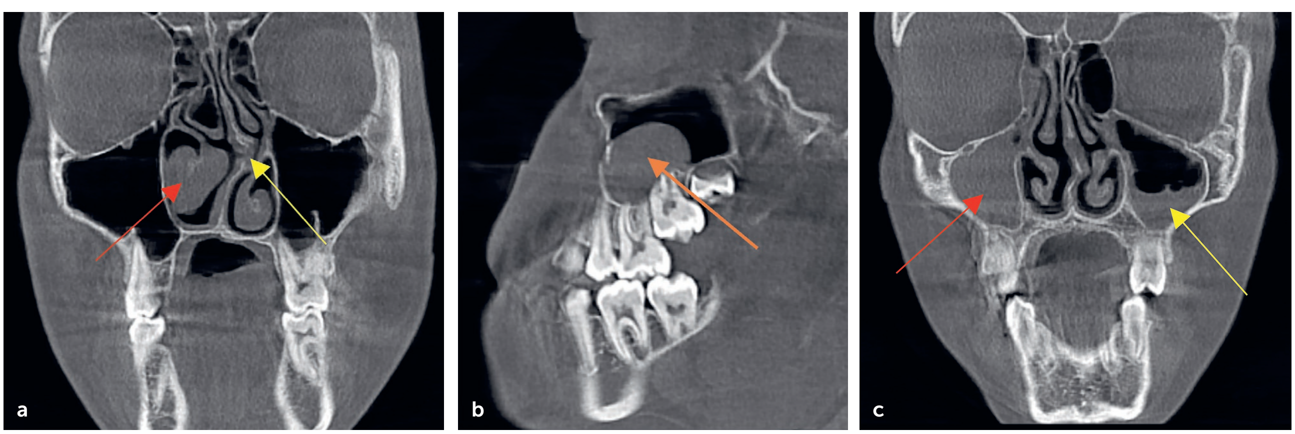


Fig 1-5 Clinical findings in airway assessment in adolescent patients. *(a)* Coronal 3D reconstruction: hypertrophy of lower right turbinate *(red arrow)*; nasal septum deviation *(yellow arrow)*. *(b)* Sagittal 3D reconstruction: polyp on right maxillary sinus *(orange arrow)*. *(c)* Coronal 3D reconstruction: total opacification of right maxillary sinus *(red arrow)* and partial opacification of left maxillary sinus *(yellow arrow)*.

Static and Dynamic Assessment of the TMJ

The diagnosis of the TMJ is complex, and so is its exploration. To make it simpler and avoid omitting information,[8] the clinician must perform the following.

Comprehensive history taking

Based on previous knowledge of the disorders that affect the TMJ, the clinician must gather as much information as possible by asking clear, direct, and precise questions, emphasizing what exactly the patient experiences, be it

Fig 1-6 *(a to c)* Dynamic assessment of the muscular structures and joints.

pain, tension, joint noises, deviations, excessive or limited joint movement, vertigo, etc.

It is worth mentioning that many patients who have emotional stress report chronic craniofacial pain and tend to depend on medication or other treatments; they also often experience low self-esteem or apathy and may engage in hostile behaviors. Patients who suffer from chronic pain could also show signs of depression.[8,9]

Meticulous clinical examination

Observation of mandibular movements

This must include all the eccentric mandibular movements, including lateral, protrusive, opening, and closing.

Exploration of the TMJ

This must include external palpation of the TMJ and its surrounding structures, internal palpation through the external auditory canal, and auscultation.

Exploration of the masticatory muscles

Muscle parafunction may produce damage to the TMJ, periodontal damage, and dental wear. Therefore, it is necessary to evaluate the muscles.[10] Palpation can be used to evaluate the neuromuscular system and determine the volume (hypertrophy, atrophy) and tone of the muscles involved. A systematic and bimanual analysis is recommended, which will allow for a comparative exploration between the right and left sides. We suggest doing this at rest and during muscular contraction activity[8,9,11–13] (Fig 1-6).

As previously mentioned, before evaluating the bony structures of the TMJ, the specialist must locate the anatomy of the glenoid fossa and condyle in all three planes of space. This can be performed with a 3D reconstruction of a CBCT or any diagnostic software that allows for evaluation of the joint spaces in the sagittal, coronal, and axial planes. We suggest utilizing the method proposed by Ikeda and Kawamura.[14,15] This method consists of making linear measurements in the reconstruction of sagittal images obtained from CBCT. The assessment must be performed in both condyles and the three planes in the following order: sagittal, coronal, axial.

Sagittal assessment

A horizontal line is traced on the glenoid fossa's uppermost point to be used as a plane of reference. Tangent lines are drawn from the same point to the most prominent part of the anterior and posterior condylar surfaces.

The distances from the anterior and posterior tangent points to the glenoid fossa correspond to the anterior joint space (AS) and posterior joint space (PS), respectively. The distance from the uppermost point of the mandibular condyle to the uppermost point of the glenoid fossa corresponds to the superior joint space (SS; Fig 1-7).

Ikeda and Kawamura evaluated the joint spaces of healthy TMJs and found the following values for sagittal assessment:

AS: 1.3 mm ± 0.2 mm
SS: 2.5 mm ± 0.5 mm
PS: 2.1 mm ± 0.3 mm

Coronal assessment

This corresponds to the measurement of points selected using the Ikeda and Kawamura method to locate the position of the medial, lateral, and upper part of the condyle concerning the glenoid fossa in a coronal view (Fig 1-8).

Coronal lateral space: 1.8 mm ± 0.4 mm
Coronal central space: 2.7 mm ± 0.5 mm
Coronal medial space: 2.4 mm ± 0.5 mm

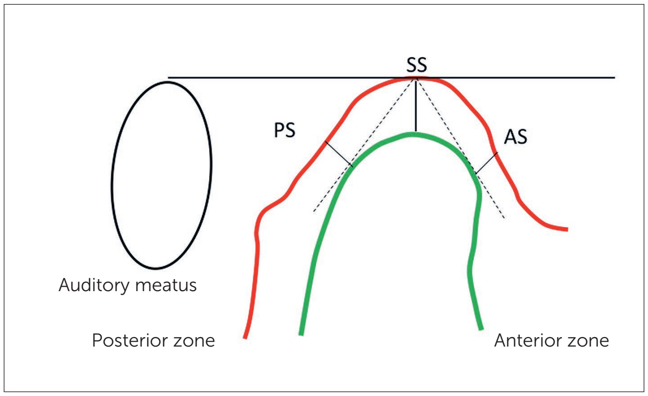


Fig 1-7 Sagittal view of the mandibular condyle and its glenoid fossa. SS, superior joint space; PS, posterior joint space; AS, anterior joint space.

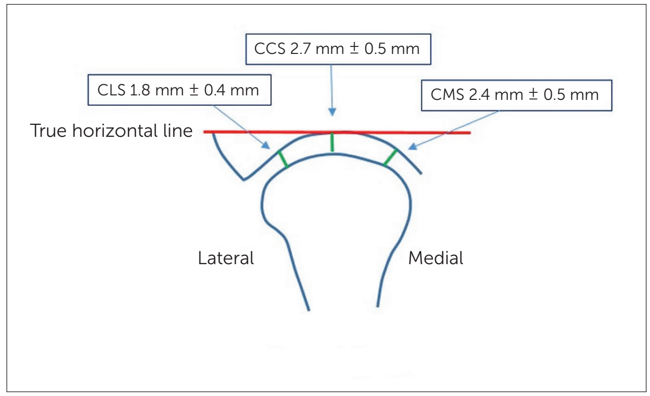


Fig 1-8 Coronal view of the mandibular condyle and its glenoid fossa. CLS, coronal lateral space; CCS, coronal central space; CMS, coronal medial space.

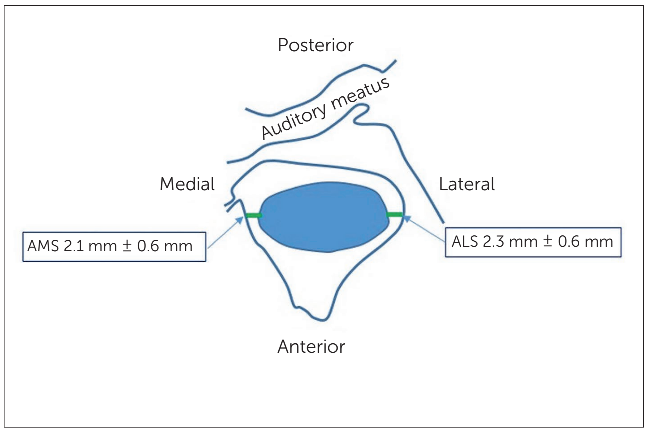


Fig 1-9 Axial view of the mandibular condyle and its glenoid fossa. AMS, axial medial space; ALS, axial lateral space.

Axial assessment

Ikeda and Kawamura establish two measurements for this axial view of the condyle in relation to its glenoid fossa (Fig 1-9):

Axial medial space: 2.1 mm ± 0.6 mm
Axial lateral space: 2.3 mm ± 0.6 mm

The BEST philosophy utilizes the Avantis 3D system, a software that integrates CBCT and intraoral scanning to allow identification of all structures in all three planes of space as well as their whole surface (Fig 1-10). This precision is important because no patient is perfectly symmetric, and their anatomy may vary from right side to left side (Fig 1-11).

Other advantages include automatic analysis of the joint space between the mandibular condyle and its glenoid fossa as well as the ability to obtain measurements for the height and inclination of the articular tubercle and the dimensions of the mandibular condyle. We can also perform dynamic assessments by modifying the mandibular position automatically or manually and observing the simulation and calculation of mandibular movement parameters, the position of the condyles, and the occlusal contact points during functional movements (Fig 1-12).

In the BEST diagnosis concept, we suggest utilizing these values as a reference; however, the reader must consider that there could be anatomical variations according to the brachyfacial, dolichofacial, and mesofacial pattern of the patient as well as racial or ethnic variations. The values expressed here are intended to guide the clinician to determine the location of the space between the glenoid fossa and the mandibular condyle.

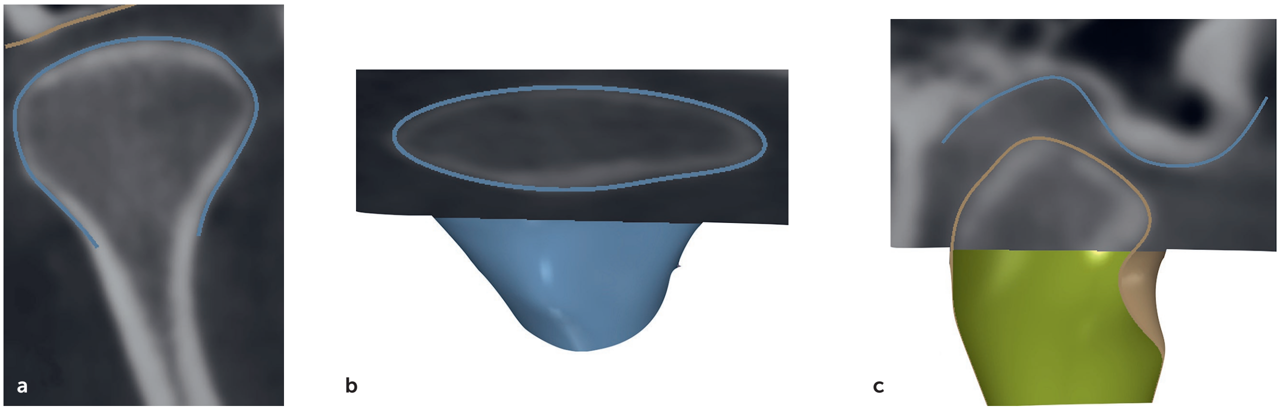


Fig 1-10 Assessment of the precision of the volumetric reconstruction. *(a)* Condyle and glenoid fossa in coronal slice. *(b)* Condyle in axial slice. *(c)* Condyle and glenoid fossa in sagittal slice.

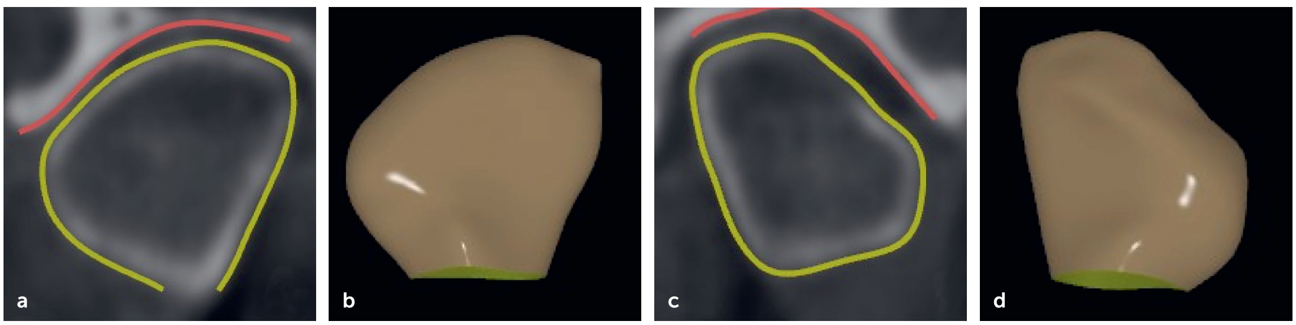


Fig 1-11 *(a)* Right condyle in coronal slice. *(b)* 3D reconstruction of right condyle. *(c)* Left condyle in coronal slice. *(d)* 3D reconstruction of left condyle.

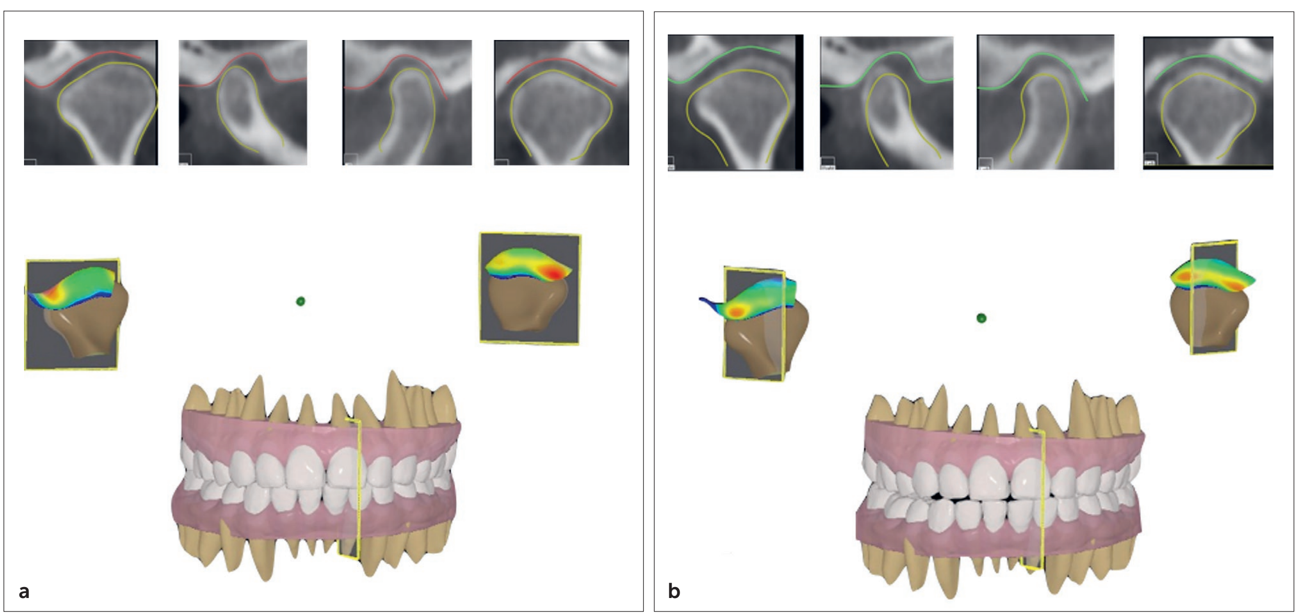


Fig 1-12 *(a)* Habitual occlusion, where we can observe the posterior condylar position. *(b)* Ideal anatomical location of the mandibular condyle within its glenoid fossa and the change in occlusion.

Fig 1-13 *(a)* Patient at the beginning of treatment with a gingival recession on the mandibular left central incisor. *(b)* Final photograph after orthodontic treatment where the recession worsened due to poor hygiene, orthodontic movement, and frenum traction.

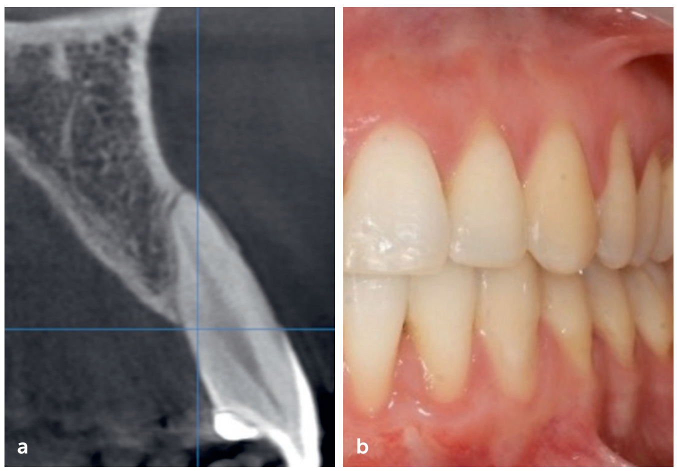


Fig 1-14 *(a)* Final CBCT of the maxillary left lateral incisor shows that the root is considerably devoid of cortical bone. *(b)* Final clinical photograph of the same tooth after orthodontic treatment. Clinically, the missing bone plate is not visible.

Assessment of Teeth and Their Cortical Bone

The possibility of alveolar bone damage during orthodontic movement depends on several factors, including the magnitude and direction of the applied forces, the gingival phenotype, and the volume and anatomy of the cortical bone. The risk becomes exceptionally high if the teeth move to positions outside of the cortical bone. These risky movements include inadequate torque, tooth proclination, and arch expansion.[16,17]

When orthodontic appliances are involved, inadequate oral hygiene could negatively affect the periodontium by transforming gingivitis into periodontitis with extensive alveolar bone loss.[18]

One of the consequences of risky movements without prior assessment of the amount of cortical bone of the patient is a gingival recession, which can be localized or generalized, but it always affects at least one dental surface.[1] It happens more often in the mandibular arch than in the maxillary arch.[17] Gingival displacement can become a critical complication that could cause esthetic discomfort, root sensitivity, periodontal insertion loss, difficulty in performing oral hygiene, and a greater risk of root cavities.[19] Exposed root surfaces are also more prone to dental abrasion due to brushing.[20]

Other causes for gingival recession as primary underlying factors include traumatic brushing, localized periodontal inflammation due to plaque, and generalized destructive periodontal disease.[17,21] Among the possible secondary factors are anatomical causes (such as frenum traction), smoking and other stimulants, as well as orthodontic treatments without previous assessment of cortical bone dimensions.[19,22]

There are cases where we apply negative torques to avoid the proclination of teeth with cortical bone plates that are too thin, especially in patients with thin phenotypes. In these cases, we are at risk of leaving the root of a tooth

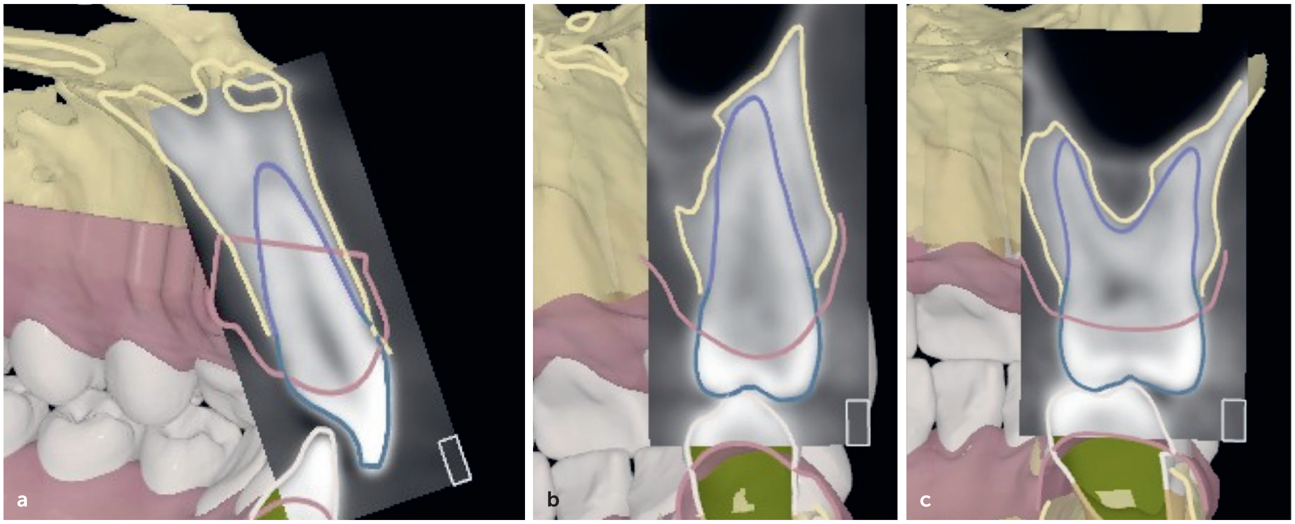


Fig 1-15 Assessment of tooth relationships. *(a)* Maxillary right central incisor. *(b)* Maxillary right first premolar. *(c)* Maxillary right first molar with its cortical bone.

over the cortical bone or even outside of it. Clinically, it is difficult to see a root that is slightly outside of the cortical bone, as can be seen in Figs 1-13 and 1-14.

Palatal expanders generate heavy intermittent forces to cause hyalinization of the periodontal ligament of the anchorage teeth where the expander is fixed. During the hyalinization phase, all the forces exerted by the expander must be released onto the median palatine suture[23] to obtain a more orthopedic and less orthodontic effect[24]; however, we always observe a buccal movement of the anchorage teeth.[25]

The dislocation of the teeth outside of the alveolar process could damage the periodontal support or reduce the thickness and height of the cortical bone, causing a gingival recession, fenestration, and reabsorption, as shown by many recent studies with the use of CBCT.[26,27]

It is crucial to evaluate the cortical bones before starting orthodontic treatment in order to know the amount of cortical bone surrounding each tooth in the facial, palatal, and lingual areas, especially for the mandibular incisors. This will help us determine the amount of torque we can use. We recommend doing a CBCT to carry out this assessment in the final treatment stages to ensure there is enough cortical bone before removing the appliances.

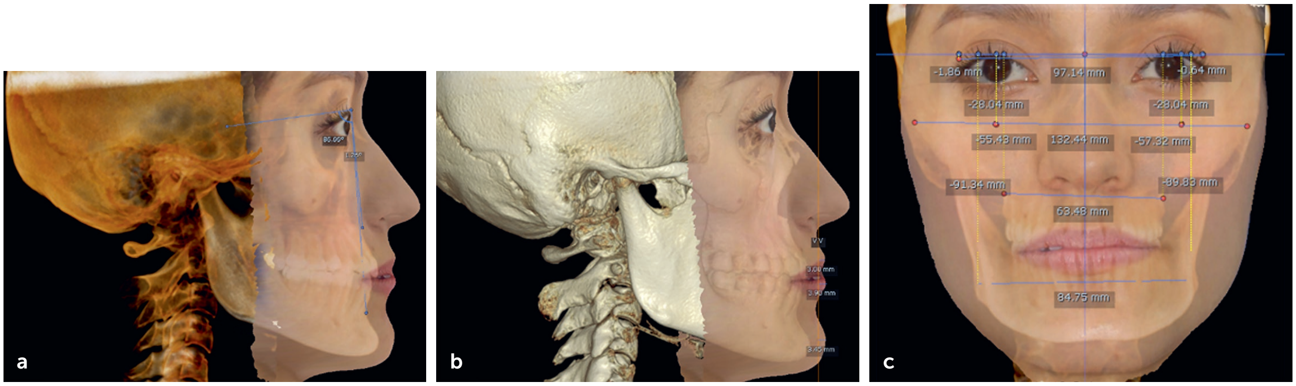
To assess the position of the roots and the cortical boundaries, one must do a superimposition of the CBCT's DICOM format and the STL format of the intraoral scan. This method allows us to evaluate in one dynamic scene, slice to slice, the relationship between these structures, and we can simulate with more precision the exact intrusion, extrusion, sagittal or transversal movements, and the degrees of torque to be used. This way, we can know the anatomical and physiologic boundaries we must consider during our treatment mechanics (Fig 1-15).

3D Cephalometric Analysis

With the BEST protocol, pretreatment and progress CBCT scans are taken so that we can assess a 3D point of view. We suggest that the clinician performs the measurements they deem necessary for each case and utilize the software they prefer. We use 3D CITEG cephalometry.

This 3D cephalometry proposed by Dr Enrique González is based on Jarabak and Steiner's cephalometries, with some added measurements, that provide information from the frontal, sagittal, and vertical perspectives that are not possible to evaluate with a 2D radiograph. Additionally, we can observe the spatial positions of the maxilla and mandible and see, among other things, the degree of symmetry of our patients (Fig 1-16).

It is worth mentioning that before tracing, each point must be evaluated in the axial, sagittal, and coronal planes, and a volumetric reconstruction should be performed in the needed density for each case. However, 3D anatomical location is much simpler than bidimensional location, as shown in Fig 1-17.



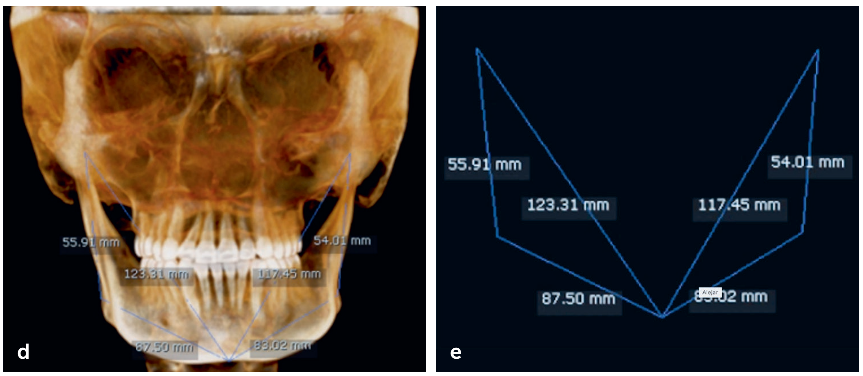


Fig 1-16 *(a)* Steiner analysis. *(b)* Spradley line for profile esthetics assessment. *(c)* Frontal symmetry assessment. *(d and e)* Assessment of mandibular symmetry: location of measurements on a 3D volume and representation of the left and right mandibular dimensions.

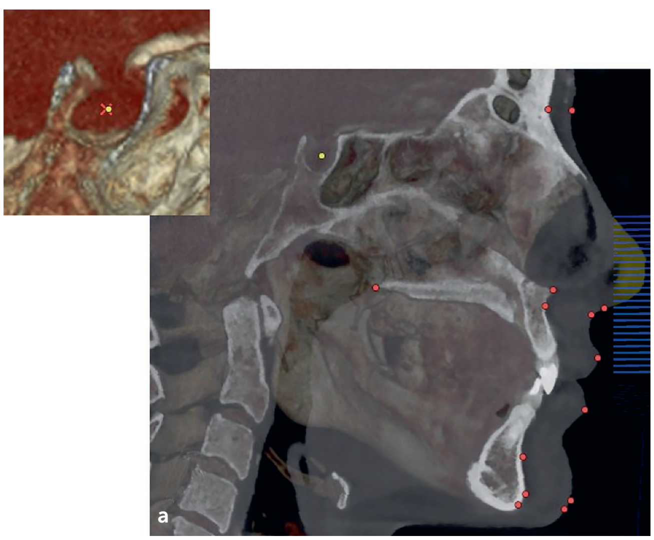


Fig 1-17 Correct 3D location of point S. *(a)* 3D reconstruction and sagittal superimposition. *(b)* Axial plane. *(c)* Sagittal plane. *(d)* Coronal plane.