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Logical

A CLINICAL APPROACH TO OCCLUSION

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Introduction

We were very pleased to accept the invitation to write the introduction of the book Logical: A clinical approach to occlusion, under the coordination of Dr. Henrique José Piccin, Dr. Pedro Paulo Feltrin and Dr. Weber Adad Ricci. Undoubtedly, this book will contribute greatly to Brazilian Dentistry in an area of extreme importance to Rehabilitative Dentistry: Occlusion as a factor for diagnosis, planning, and execution of restorative work.

We have been pleased to follow the development of Bio-Art over the last 40 years, a company chaired by Mr. Germano José Piccin, an enthusiast who sought to offer quality products in the field of biosafety, clinical practice and laboratory, having as the chief product the Bio-Art Semi-Adjustable Articulator. Today, together with the Piccin family, we are proud to see the company expand and export its products to over 70 countries.

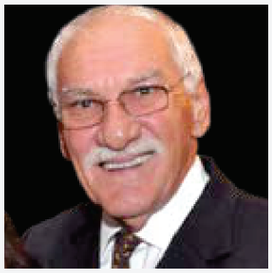
In the spirit of seeking innovation along with quality, we are very pleased to follow the company's commercial director, Dr. Henrique José Piccin, in preparing and coordinating the edition of the book Logical. Dr. Henrique was not satisfied only with manufacturing articulators. To establish a definitive connection between the company and the academic world, as the company actively participates in scientific work in various educational institutions, he decided to offer the dental class a compendium aimed at the clinician in the fields of occlusion and prosthodontics. Congratulations for the initiative!

The book is presented in 10 chapters, very well distributed and written by renowned professionals of Brazilian Dentistry. Chapters 01, 02, 03 and 04 approach the principles of Occlusion, Centric Relation, Posterior Support, Anterior Guidance, and Vertical Dimension and their importance in the context of Oral Rehabilitation. Chapter 05 reviews the semi-adjustable articulators and their day-to-day use by clinicians in performing prosthetic work. In chapter 06, the concept and techniques of occlusal adjustment by addition and/or selective wear are very well presented by the authors. The importance of Planning and Occlusion in the various specialities is addressed by the authors in Chapters 07 and 08. Occlusal Splints or Orthopedic Interocclusal Devices (OIDs) are discussed in chapter 09 as a diagnostic and treatment option for Temporomandibular Disorders (TMD). Finally, Chapter 10 presents an approach to Digital Dentistry addressing the latest generation tools available in the market for diagnosis and planning associated with CAD/CAM technologies.

Thus, we are honored to present this work that will greatly enrich the Brazilian and worldwide dental literature.

Milton Edson Miranda
Marco Antonio Bottino

Preface



Importing was expensive and difficult! There were six prototype articulators. I distributed it to some universities to check if that idea, motivated by a dentist in my city, would work. The process of approving and ordering 80 units by the Araraquara School of Dentistry took approximately four years.

I was the creator, the buyer, the manufacturer, and the seller. But I really liked to produce and so I asked for help with the distribution of the product. I always liked to do things that were useful. I am self-taught and often joke that when the subject is to fabricate thing: I was born ready

From an early age, I had a passion for fixing and creating objects that would suit someone. As a teenager, we did not have a wardrobe, so I built one using old materials we had at home. It became useful and so I realized that this should motivate the producer: ie, to serve someone or a certain purpose. This became the motto of my life as an entrepreneur: TO SERVE!

It was not meant to make money. I didnt worry about running, selling or numbers! I was-concerned about attending to the professionals. And so, for many years, I was the companys technical support. One of my personal advertisements was that the product we made was so meticulously fabricated that it would need no maintenance.

And when the few requests to correct some operation arose, I was the one who came to our clients to serve them. Most of the time it was a false alarm, as in an episode that one of our equipment was not working because it was plugged into an outlet without power.

Our products have been very well accepted and our mission has always been valued by customers and so we sell a lot! I wasnt realizing it but we needed to grow! We expanded and new employees were hired. I always had them by my side. My employees strictly followed my ideas in an orchestrated and straightforward manner.

I listened more and more to teachers to know their needs. I wanted to serve and assist my clients. There were many opinions, and at this moment, I saw that if I was going to meet every request for modifications, accessories and new parts, the projects would not have an identity. Thus, I sought to understand everyones needs to the fullest and finally used my vision as a developer to perfect almost all of the requests.

There were times when I felt resistance from teachers who believed that what we produced was inferior to imported products. I struggled a lot so that our Brazilian product could be valued up to what it really was because I knew we were always doing something cutting edge and with high quality. This was another motto that I always defended: Quality Reserve. This means that we must always strive to create and innovate. So when the competition is trying to match your product, you already have the reserve to leap forward once again.

Today I feel proud and fulfilled every time I go to the company and see this legacy is now directed by my children. They keep serving our customers. With this, the company is prepared for the future facing an increasingly globalized economy, but without losing our values.

I am grateful to God for my life trajectory. With Him, I learned to serve. I also thank my wife Maria Jose for always supporting me. Today, I see the initiative of this book as another attempt to follow my motto. However, I believe that just reading the book will not do much on its own. You have to read, interact, be present, discuss, reason and create and if necessary, start over again! Only then one can truly SERVE!

Germano José Piccin

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Summary

01
History of the Evolution of Occlusion

Eurípedes Vedovato | Luiz Antônio S. Zeppini

Occlusion is part of a highly complex operating system. Thirty million years of evolution lead us to the thinking beings we are today.

The book Little Medical Book of All Kinds of Diseases and Infirmities if Teeth, published in Germany in 1530, marks the start of dental literature. However, the interest of medicine only came in the 18th century, with the book Le Chirurgien Dentiste(The Dental Surgeon) by Pierre-Fauchard, written in 1723 but published in 1728.

First Wave

The first wave is characterized by empiricism and a lot of individuals and team dedication that deepened the study of occlusion. We must keep in mind that the studies of occlusion approached complete dentures, focusing on the reestablishment of function and the stabilization of complete removable dentures. Some people became famous for dedicating themselves to studies of occlusion through clinical experiences and experiments or even through observations of the clinical practice. This was also a wave characterized by the application of the geometric analysis of the Occlusion. Lets look at the studies of some and the philosophy of others within their methods of thinking. It was the period of occlusal theories.

1756. Philip Pfaff (Berlin) acknowledged the importance of bite registrations.

1805. In France, Gariot introduced a method of articulating models with plaster, thus being considered the first mechanical articulator.

1864, Bonwill created the theory of the equilateral triangle formed by imaginary lines going from the inter-incisor point to the center of the condyles. Thus, he built the first anatomical articulator presented at the Meeting of the American Dental Association (ADA).

1866. Balkwill described the characteristics of mandibular movements in the horizontal plane. He traced a line in the occlusal plane associated with the Bonwill triangle, discovering an angle with an average of 26 degrees (until today used to manufacture some semi-adjustable articulators).

1889. Edward Angle first described dental relationships. The gear parameters between the arcades became a topic of interest and much controversy in the following years.

1890. Von Spee described the curve related to the occlusal plane, which was ascending in the anteroposterior direction, starting at the tip of the lower canine to the tip of the distal-buccal cusp of the last lower mandibular molar, also touching the tips of the remaining buccal cusps in the same quadrant as the dental arch.

1895. W.E. Walker studied condylar guides and built an articulator that could accommodate them.

1899. George B. Snow built a device that became a cinematic facebow, improved in 1906.

1905. Christensen introduced the registration in protrusion. The phenomenon of opening of the posteriors when protrusion is performed was named after him (Christensen Phenomenon).

1908. Bennett studied the effects of lateral excursive movements, and then, in 1924, he described the movement and angle that bear his name.

1910. Gysi introduced an articulator with fixed values and a the first device for adjusting the incisal guidance.

1920. Monson described his Spheroidal Theory based on the Von Spee Curve. Later, this knowledge would give Broadrick the opportunity to create his pennant, still used today by many to determine the personalized occlusal plane.

1925. The first significant concept developed to describe ideal functional occlusion was called balanced occlusion, stated by Sears.

Second Wave

The second wave started with the development of innovative, philosophical ideas and treatment rationales. Along with this collection of ideas, each line of thought developed its instruments and equipment that simulated the transfer of the patients occlusal determinants to the articulators. At this stage, the understanding had already ceased to be directed towards the full dentures, moving to the restoration of natural teeth. It is possible that this was the most fertile period in terms of the development of occlusal concepts, as it started in empiricism and evolved to scientific developments. It was the period of modern occlusal concepts.

In 1926, McCollun, Stuart, and Stallard adopted the word gnathology when they founded the California Gnathological Society. The term gnatology was intended to describe the science that approaches the biology of the masticatory system. In other words, it refers to the science dedicated to the study of the mouth as a functional unit, in close relationship with its morphology, histology, physiology, and therapeutics, including its vital relations with the rest of the organism.

They developed a device that, when used correctly, was able to reproduce the particularities of the mandibular movement of an individual. The apparatus under consideration comprised a kinematic facebow to locate the transverse axis, a gnathoscope, and a gnathograph.

A harmonious anterior disocclusion would define occlusal morphologies compatible with the so-called balanced occlusion. This concept of occlusion then stated that the temporomandibular joint rules the shape and function of the teeth. Due to this assertion, occlusion was considered a phenomenon independent of the proprioceptor mechanism, where an anatomical reason directs the functional movements of the mandible due to the shape of the TMJ and not due, to the muscular action.

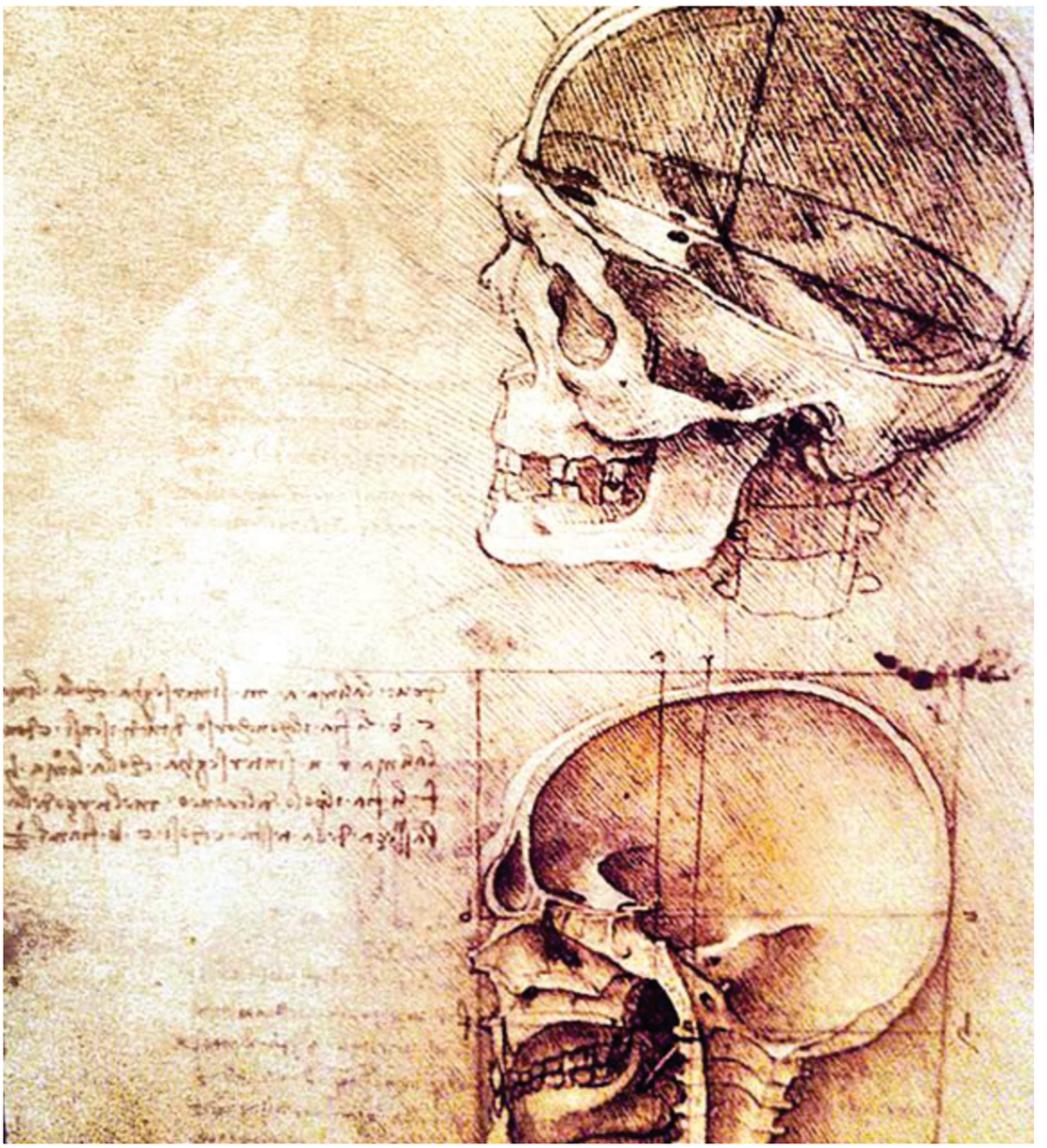
The principle of balanced occlusion was abandoned and Stallard and Stuart presented, in turn, the concept of organized or organic occlusion. Even though they still believed in the original principles of gnatology, they changed old concepts. They denied the principle that functional excursions had a predominant masticatory movement, based on the fact that the masticatory action is more vertical than lateral. Therefore, the grinding of food would be seen as a reciprocal action and, the instant the cusps touch the antagonistic tooth, the action is reversed and another stroke begins. Knowing that the disocclusion is the reverse of the occlusion, they postulated that the teeth should disocclude during functional excursions. A posterior organized disocclusion would avoid the invasion of the free functional space,

02
Anatomy
Physiology of the stomatognathic system

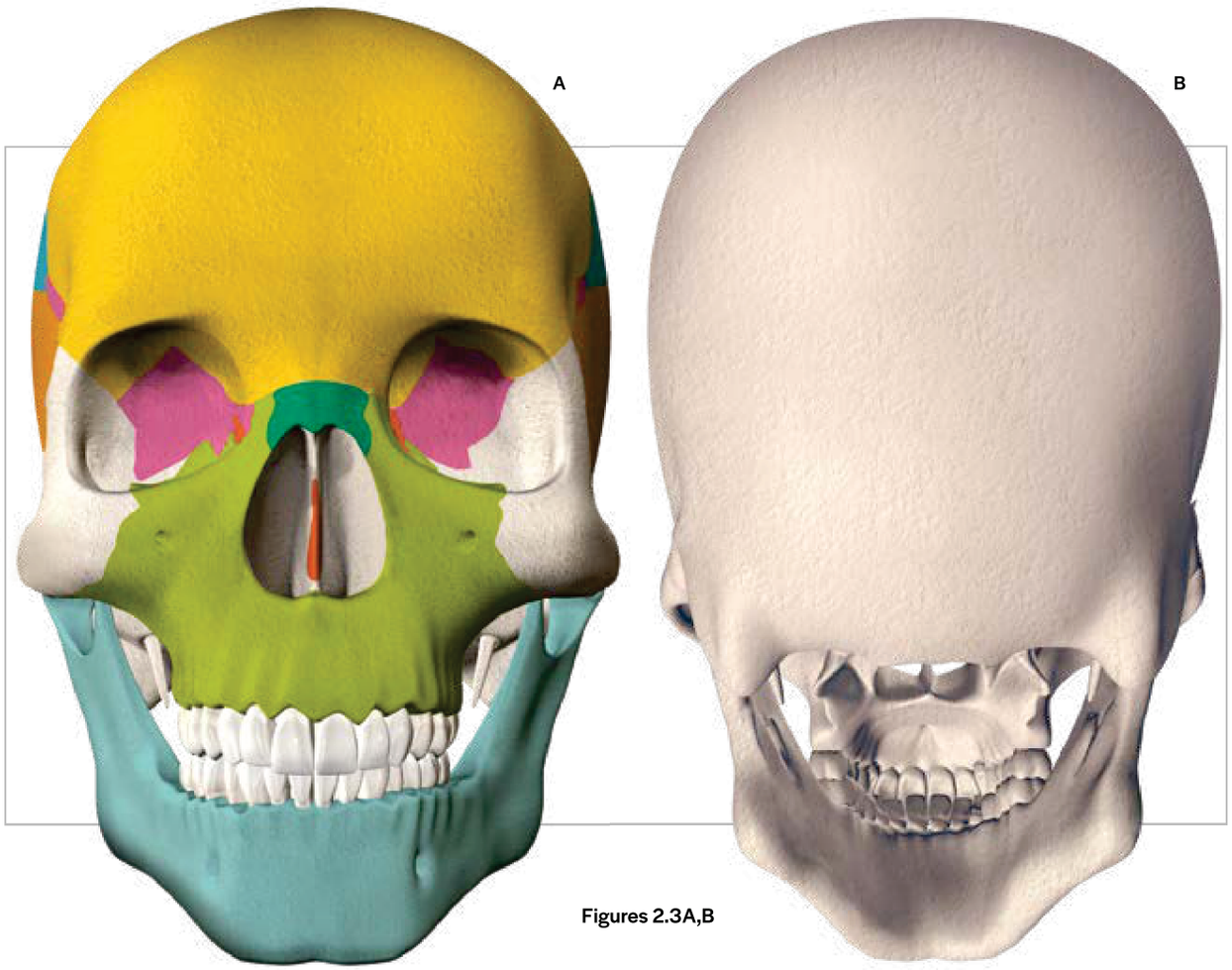
Laerte Balduino Schenkel | Rita Schmitt Caccia

Introduction

Modern physiology emerged at the time of the Renaissance when trying to understand the functioning of the human body, Leonardo da Vinci is one of the greatest scholars on the subject. He left for posterity numerous studies and sketches about the anatomy of the human being **(Figures 2.1 and 2.2)** It was noticed, however, that this study of anatomy would not be enough to explain how the body works. It was necessary to associate the knowledge of the components of the body with the observation of these living structures during their functioning and to understand how the physical, chemical and mechanical factors act, in addition to the nerve transmissions that enable the development and maintenance of their integrated function. All of this ended up forming the basis of current physiology.



Figures 2.1



Figures 2.3A,B

Dynamic Structures of the Stomatognathic System

They are represented by the neuromuscular unit that mobilizes the static parts, which are susceptible to be mobilized by these structures, such as the mandible and the hyoid bone.

They can be classified in:

Muscles of Facial Expression

Although they are designated under this name of the functional character, their most important functions are actually related to food and phonation. They are the buccinator, orbicularis oris, zygomaticus, Levator and Depressor anguli oris, Levator labii superioris, levator labii superioris alaeque nasi, platysma, orbicularis oculi, occiptofrontalis, procerus, corrugator supercilii, nSAAlis, risorius and mentalis **(Figure 2.4).**

03
Occlusal References for Oral Rehabilitation

Weber Adad Ricci | Pedro Paulo Feltrin | Henrique José Piccin

Occlusal Principles and Terminologies

For the study and management of occlusion, it is extremely important that the clinician knows the anatomical and morphological aspects of a healthy functional occlusion. This implies (a) adequate morphology of the components of the system, (b) well-organized and correctly geared arches and (c) well-defined biomechanical rules. Respect for these three aspects will result in a system with adequate functionality, less destructive, with structural sustainability and capable of adequately performing the functions of the stomatognathic system. .

In this chapter we will cover the concepts and understanding for the management of the following occlusal references:

(1) Centric Relation (CR).

(2) Posterior Support (PS).

(3) Anterior Guidance (AG).

(4) Vertical Dimension (VD).

Thorough knowledge of these concepts by clinicians will respect the three questions mentioned earlier in this chapter as the factors which determine an Healthy Functional Occlusion. This will also make it possible to control the oral restructuring process in low, medium or high complexity rehabilitations. The correct handling of the four references, following a structured protocol within the concepts validated by scientific evidence, maintaining the consistency and the rationale of a conscious clinical practice, will make the rehabilitator able to succeed in their rehabilitation **(Figure 3.1).**

Initially, we will address the three principles of a Healthy Functional Occlusion and, finally, we will discuss the references and management of these four concepts.

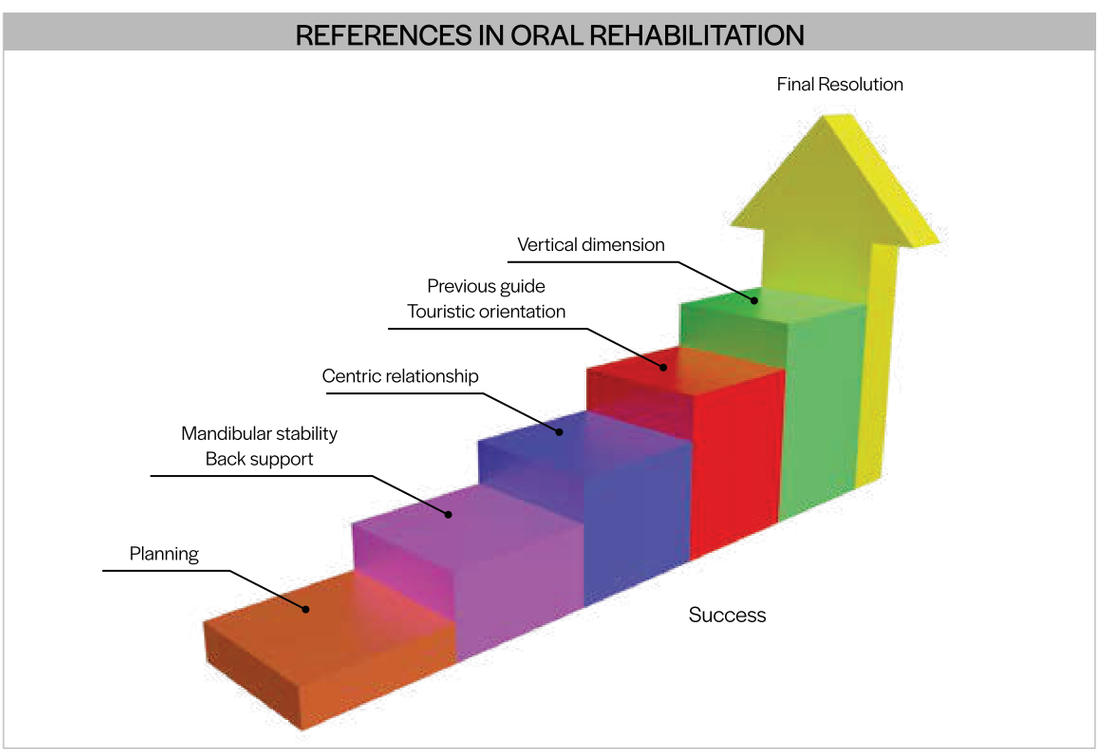


Figure 3.1 - Respect for appropriate references in an oral rehabilitation allows the clinician to consciously plan for Healthy Functional Occlusion, thus achieving success in the final resolution.

Principles of Physiological Occlusion Morphology

Posterior Dental

The posterior teeth are responsible for supporting the occlusion, being the main elements of dissipation of the occlusal loads in the vertical axis. The positioning of these teeth in the force line of the main jaw elevation muscles, associated with the large area of root insertion which forms an anchorage base, especially in the molars, are the most important factors in this process. Similarly, it is possible to compare these elements with large diameter screws, which, even though they often have shorter intraosseous root lengths than the anterior teeth, this amplitude of the radicular diametrical area allows them to be more mechanically favorable to receiving forces on the vertical axis, unlike the anterior teeth, which have longer roots and better resist lateral forces **(Figure 3.2).**

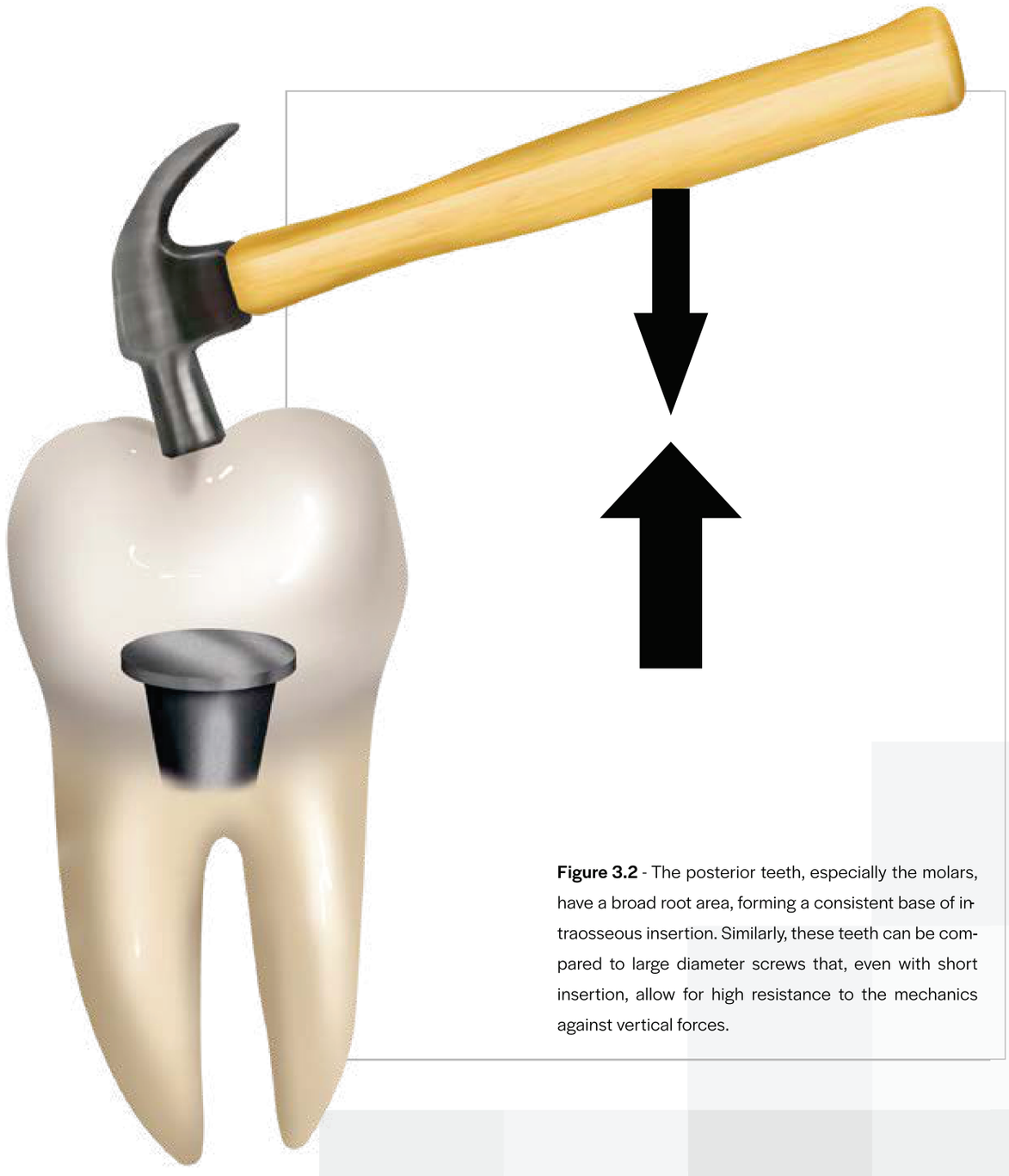
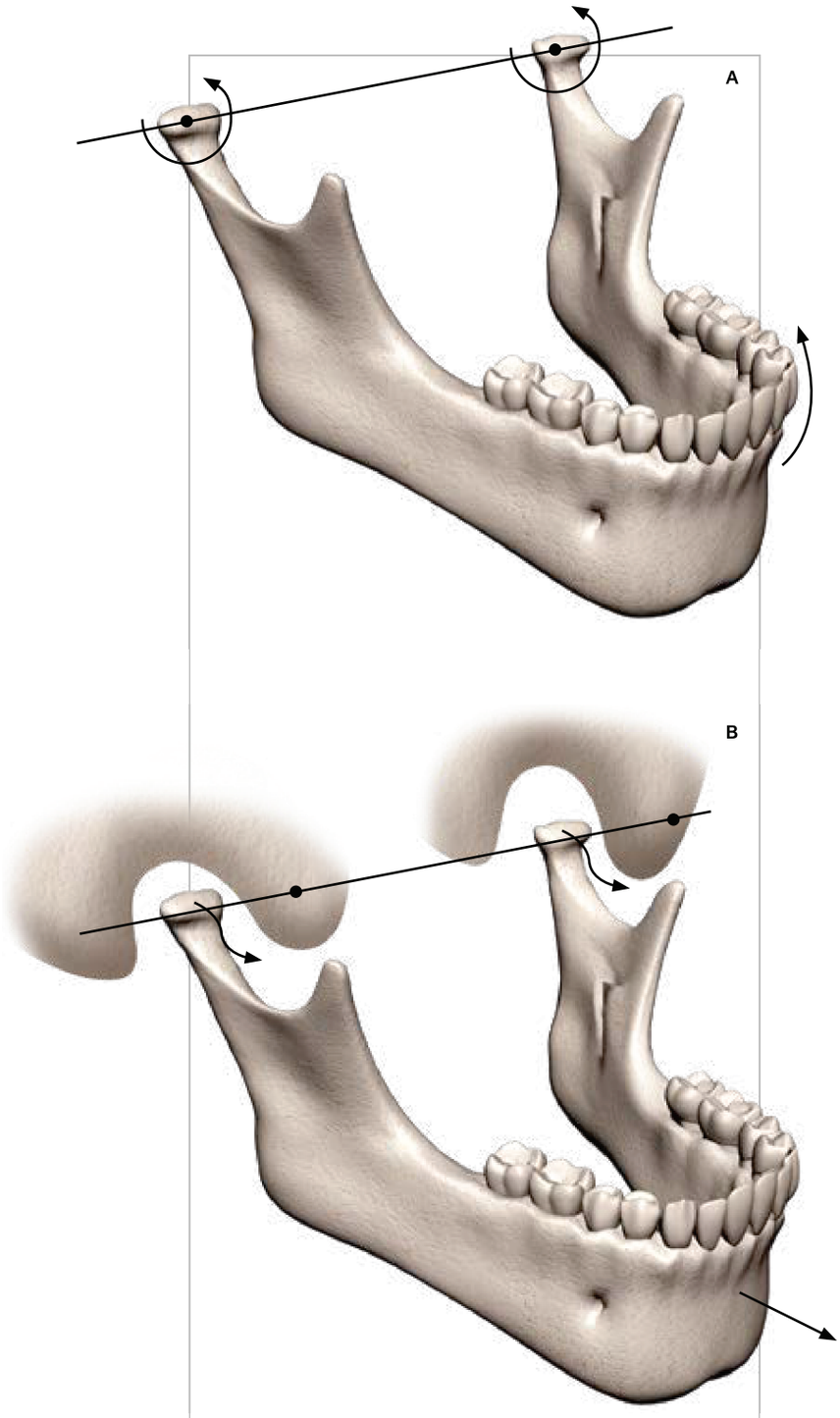


Figure 3.2 - The posterior teeth, especially the molars, have a broad root area, forming a consistent base of intraosseous insertion. Similarly, these teeth can be compared to large diameter screws that, even with short insertion, allow for high resistance to the mechanics against vertical forces.

PART 01

Centric Relationship (CR): Concept and Clinical Methods

Weber Adad Ricci | Pedro Paulo Feltrin | Henrique José Piccin



Figures 3.1A,B - Horizontal axis around which the mandibular condyles rotate **(A)**. Horizontal axis passing through the articular eminences of the temporal bone, around which the mandibular condyle is translated **(B).**

When we analyze the temporomandibular joint, we see that it is unique in relation to the other joints in the human body. Its anatomical constitution allows for two distinct types of movement: rotation and translation **(Figures 3.1A,B)** For this reason it is classified as an artroidal ginglymus. A healthy physiology of these joints is established even in the toothless infant, allowing the habit of swallowing.

The Centric Relation must be a consensus in the choice of a simple and easy method. It is physiological, independent of dental contacts, promotes muscle relaxation (the condyle is positioned with the permission of the muscles), has a close association with the head and neck posture and can be reproducible. It becomes the starting point for the study of occlusion. Its management is linked to the diagnosis of occlusal pathologies, the positioning of therapeutic measures, such as stabilizing splints, and the planning of oral rehabilitation processes. In obtaining CR, we opted for a practical technique, easy to operate.

In order for the clinician to be successful in its determination, one must always start with muscular deprogramming processes. That is because the changes on the mandibular position take on a neuromuscular reprogramming named muscle engram. This pattern could be considered a muscle memory. There are indications that its maintenance is due to occlusal contact during swallowing. Therefore, a few minutes could be sufficient for the deprogramming process. An important point is that no dental contact

would occur in this period. For this purpose there are several methods described in the literature:

Manual manipulation of the mandible.
Lucias JIG.
Long strips or Leaf Gauge.
Roca wire.
Myotens (transcutaneous electrical nerve stimulator).
Kois Deprogrammer.

The similar principle behind all these devices is the absence of dental contacts in the posterior region. The absence of contacts releases the muscles so that with an anterior contact the points of resistance are the TMJs. In other words, the formation of a plane (which geometrically requires three points) takes place between the two joints and the contact in the incisor region, assuming a tripod form of stability. According to the authors experience, each method mentioned above, present advantages and disadvantages that are described below:

Method	Comments	Materials required	Indication
Manipulation of the mandible with hands	Complex method that requires a lot of operators experience; no need for high-cost materials and laboratory processes.	Cotton roll, #7 wax or bite registration wax.	Immediate diagnostic analysis. Enables, assembly in an articulator.
Lucias JIG	Simple method that requires medium skills from the operator and requires low-cost materials such as acrylic resin and wax.	Self-curing acrylic, fine brush, Dappen dishes, #7 wax or bite registration wax.	Immediate diagnostic analysis. Allows for assembly in an articulator, as well as testing for possible increases and restablishment of VDO.
Long strips or Leaf Gauge	Simple method can be performed by beginners. It is important to present the patient to protrude the mandible; no need for high-cost materials and laboratory processes, depending only on an apparatus with stacked thin strips.	Specific apparatus; #7 wax or occlusal registration silicone.	Immediate diagnostic analysis. It allows for the assembly in an articulator, as well as the test of possible increases and restablishment of the VDO and making of a record for stabilization splints.
Roca Yarns	Simple method with less possibility of errors, and can be performed by beginners. No need for high-cost materials and laboratory processes, depending only on an apparatus with wires of decreasing thickness.	Specific apparatus; #7 wax or occlusal registration silicone.	Immediate diagnostic analysis. It allows for, the assembly in an articulator, as well as the test of possible increases and restablishment of the VDO and making of a record for stabilization splints. It can also be used rationally in processes of occlusal remodeling by selective reduction.
Miotens	Medium complexity method; requires operators skills.	Electrostimulation equipment required.	Forceful deprogramming in a patient with difficulty in performing one of the previous methods. Time required 40 minutes of use.
Kois Deprogrammer	Complex method; requires high skills from the operator; high cost due to the laboratory processes involved.	Use of one of the previous methods or processes with more complex equipment; SAA mounting; indirect laboratory execution.	Forceful deprogramming in a patient with difficulty in performing one of the previous methods. It also allows for the prior analysis of new VDO and CR reconstructions.

The CR analysis must be performed in cases where we will proceed with the following actions:

Occlusal diagnosis.
Vertical Dimension Changes.
Changing the anterior guidance.

The diagram below illustrates the advantages and disadvantages of obtaining the CR:

Position of reference CR		
Advantages	Disadvantages	Indications
Reproducible position	Understanding TMJ function principles	Complex controls
Limit position	Understanding muscle control principles	Pathological occlusion
Hypoactivity	Training records	Increased VDO
		Reconstruction of the anterior guidance

A frequent question on the part of clinicians is regarding which occlusal scheme he should choose for rehabilitation procedures: CR or MHI? An occlusal scheme in MHI should not be classified as pathological. In asymptomatic patients for mechanical joint pathologies, this scheme may have full functionality. Thus, in single-unit restorative processes, the attempt to transform the patient from MIH to CR is not indicated. For oral rehabilitation of one or both arches as well as for the positioning of stabilizing splints, the search for CR should be pursued by the clinician. Another important aspect is the close relationship between this horizontal reference and the vertical reference of the VDO. As described in the diagram below, we have the following aspects to consider:

Centric Relationship		
CR with increased VDO	High Magnitude	Occlusal adjustment
	Low Magnitude	No occlusal adjustment
CR without increased VDO	High Magnitude	Occlusal adjustment
	Low Magnitude	

PART 02

Posterior Support (PS): Importance of Mandibular Stability

Weber Adad Ricci | Pedro Paulo Feltrin | Henrique José Piccin

We can conceptualize posterior support or mandibular stability as the way the stomatognathic system supports and controls the incidence of loads exerted by chewing, swallowing and resistance to dysfunctional forces directed at the bone structures that compose it. The main functional elements that support the loads are the teeth, the alveolar bone that houses them and the TMJs. The greatest amount of occlusal support (represented by interdental contacts and their respective roots) is provided by the posterior teeth. The functions of the Posterior Support, when well balanced, are to withstand the forces of chewing, swallowing and, sometimes, the variations of a parafunctional occlusion. Notwithstanding this, it also maintains the vertical dimension of occlusion, offering the masticatory system comfort and efficiency to exercise its physiological functions. The posterior teeth are in a line of action of the elevator muscles, having a significant impact on masticatory efficiency. However, for optimal function, these teeth must maintain the Vertical Dimension at optimal muscle length. Reduced or excessively long dimensions hinder muscle action and, consequently, generate less chewing force. The full functionality of a muscle occurs at its correct length because the fibers slide in all their fullness. For this reason, in natural toothed individuals, the living organism has physiological mechanisms for maintaining this dimension. Through passive eruption (about 30 to 50 µm/year), a compensation for physiological tooth wear takes place. The contention cusps will maintain the facial proportion by maintaining the Vertical Dimension. It is worth mentioning that if there is an exaggerated speed of tooth wear resulting from severe parafunctional habits or through acid erosion, this compensatory mechanism for maintaining height through the Posterior Support will be limited. In these habits the wear can reach almost 400µm/year. Thus, both for the integrity of the system and for its rehabilitation, the clinician must be aware of possible needs for recovery of the posterior support to readjust the altered vertical dimension. The clinician must be aware of the choice of restorative materials with an abrasion index similar to natural enamel.

In all clinical cases where a diagnosis is essential for correct treatment planning, the situation of the components of the Posterior Support is taken into account, namely:

(a) number of teeth (including tooth-borne and implant-borne abutments);

(b) number of contacts and of course;

(c) the quality and quantity of bone support available.

These components play the role of a shared occlusion between the TMJs and the posterior teeth in terms of system protection. When mandibular closure occurs, there is an intensive loading of forces on the posterior teeth. In contrast, in the mandibular eccentric movement, it is the anterior teeth that assimilate the disocclusion loads, disengaging the posterior teeth. This fact, described earlier in this chapter with mutual protection, shows the importance of the Posterior Support provided by the posterior teeth and their respective frameworks.

Another important and controversial topic is shortened arches due to loss of molar teeth, compromising the stability of anterior teeth. In fact, when there is a loss of the Posterior Support and the anterior teeth must support the load. There are four possible conditions according to the table bellow:

Angle class I incisor relationships	Stable anterior segment with intact alveolar bone	
Angle Class II Division 1 and Class II Division 2 Incisors Relationships	Super closing of the mandible causing deep bite and trauma of soft tissues on the palate of the incisors	
Flaring and creation of diastemas in the upper anterior teeth	Modification of the three-dimensional alignment of anterior teeth (flare opening)	
Wear of anterior teeth and consequent reduction in VOD	Patient will present a more horizontal chewing pattern	

PART 03

Anterior Guidance (AG): Excursive Orientation

Weber Adad Ricci | Pedro Paulo Feltrin | Henrique José Piccin

The term anterior guidance, or the so-called excursive guidance, conceptually can be understood by interpreting the role of anterior teeth in the posterior teeth disocclusion. This disocclusion usually occurs between the incisor and canine teeth. With the canine guidance there is a separation of the posterior teeth as the teeth move, moving away from MHI for their end-to-end relationships. It includes protrusive, lateral and all latero-protrusive movements. The term anterior refers to the anterior teeth as opposed to the posterior teeth and not to the upper part of the mandible as opposed to its posterior part. When the incisors guide a protrusive movement and the canines guide a lateral movement, then their combined effects can be called the anterior guidance. It should also be evaluated when the guide on the working side is a group function (involving canines, premolars and molars) guiding lateral and protrusive movements; so the lateral movements are no longer guided by the anterior teeth and in this case a generic term of excursive guidance or excursive orientation is better used. The excursive guidance describes all the mandibular movements from the MHI. The functions of the anterior guidance are highlighted in the table:

Reference for posterior teeth disocclusion.
Influence on posterior occlusal morphology.
Influence on phonetics.

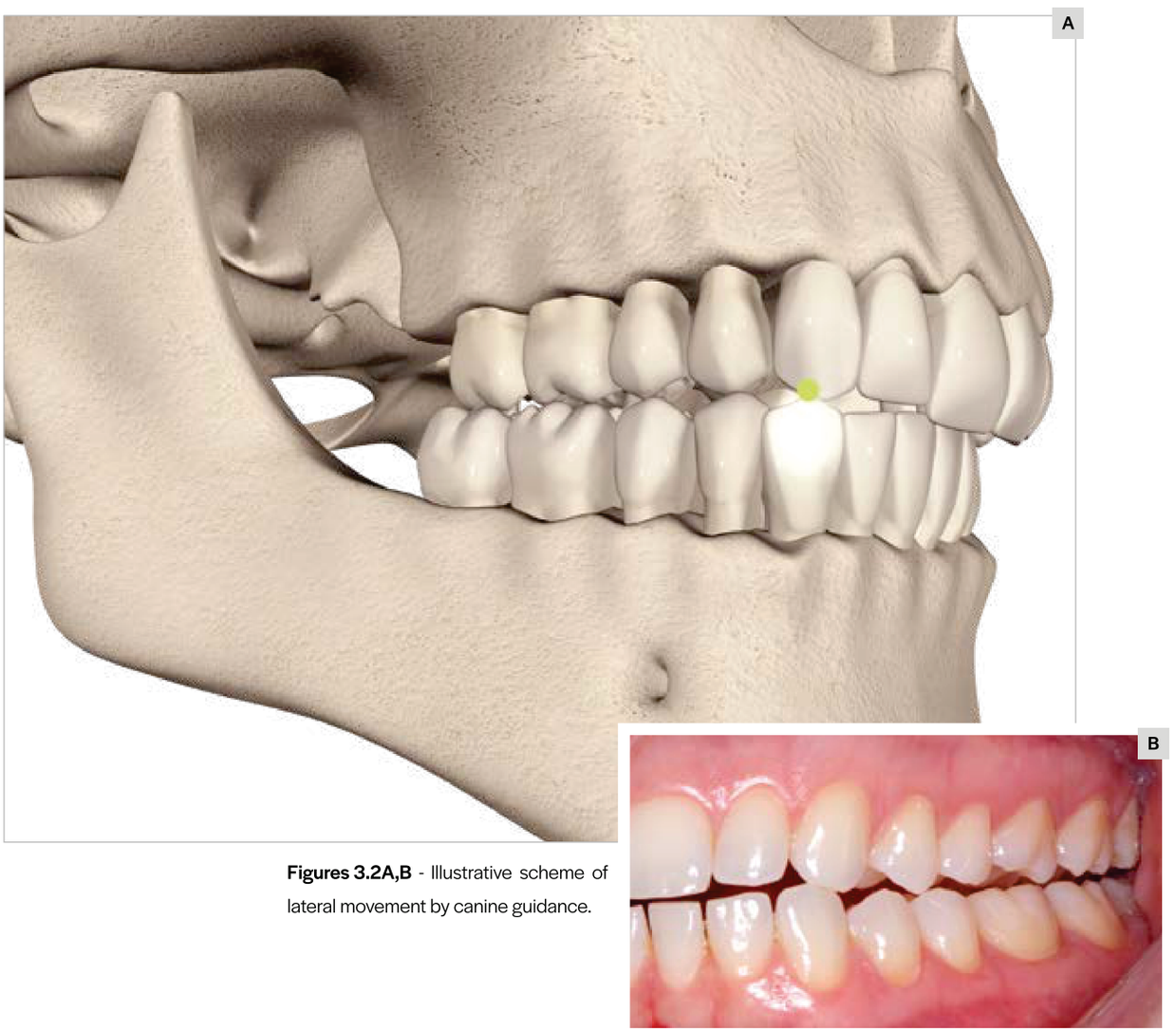
The anterior guidance is the reference for the concept of mutual protection. This came to be used in the description of a mutually protective interrelation of posterior teeth closure and the anterior teeth excursive guidance. This concept states that the posterior teeth protect the anterior teeth during closure and that the anterior teeth protect the posterior teeth during mandibular excursions.

In the protrusion movement, which starts from the position of centric occlusion with the sliding of the mandibular incisors against the lingual surface of the maxillary incisors (anterior or incisor guidance), the right and left mandibular condyles move downward and to symmetrically (condylar guide), with posterior teeth disocclusion. This mechanism, which adapts to the principles of a mutually protected occlusion, allows the integrity of the posterior teeth and the supporting structures, since it protects them from the horizontal forces, which are potentially traumatogenic to these teeth **(Figure 3.1).**

Figure 3.1 - In the protrusive movement, the principle of mutually protected occlusion protects the posterior teeth from receiving horizontal loads which are harmful to this dental group.

Normally, the two maxillary central incisors with the four mandibular incisors are involved in this protrusive movement, or the four maxillary incisors with the mandibular four incisors.

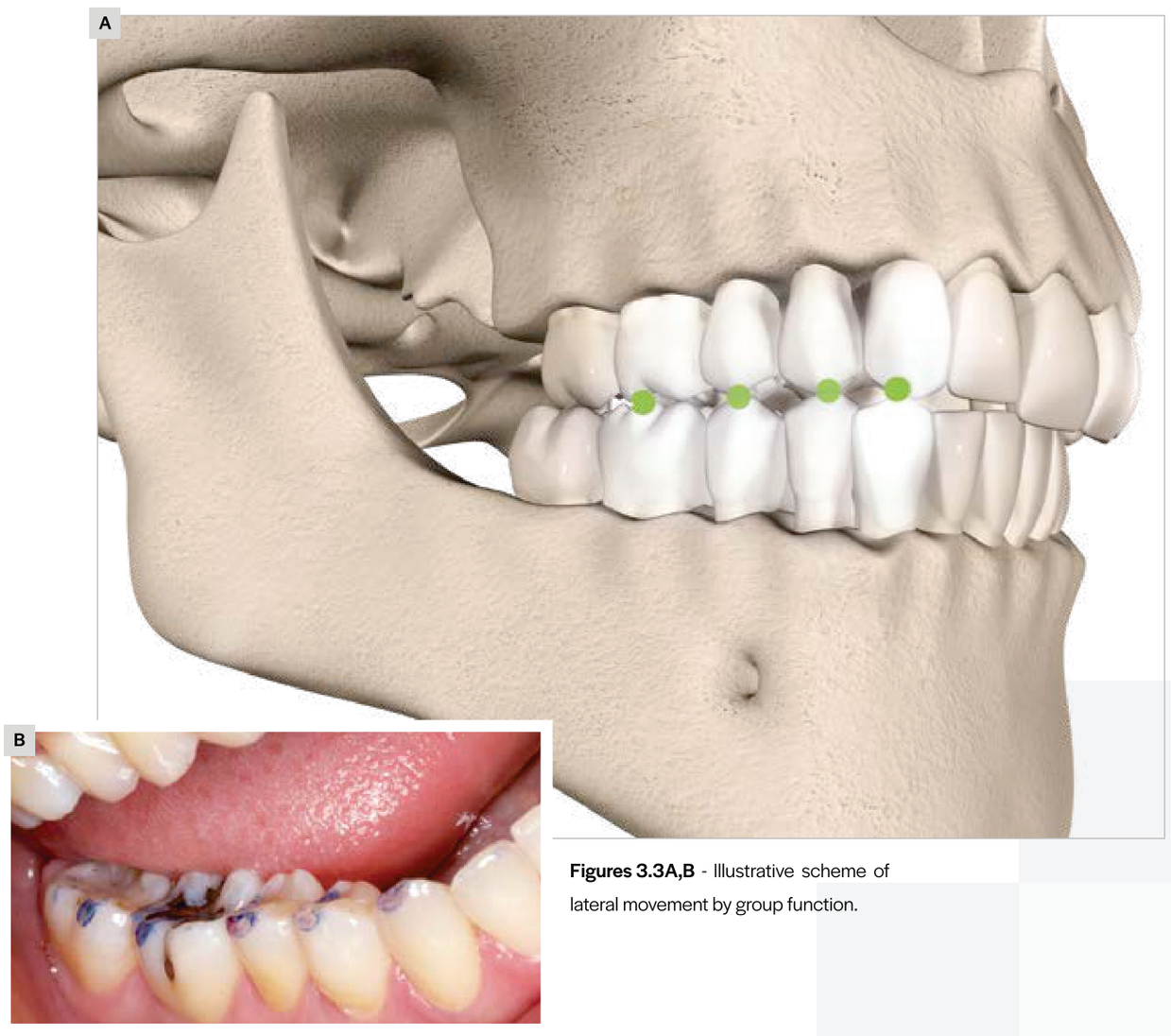
Also for lateral movements, the principle of mutually protected occlusion is present. The disocclusion takes place either by the unique action of the canines (canine guidance), or by the joint action of a group of teeth (group functions). In the first case, it is the canines that act as a movement guide, decoupling all other teeth during lateral jaw excursions **(Figures 3.2A,B)**. In the group function, all smooth slopes of the mandibular buccal cusps fall into the cutting slopes of the maxillary buccal cusps on the working side, from the canine to the molar, distributing lateral forces to this



Figures 3.2A,B - Illustrative scheme of lateral movement by canine guidance.

group of teeth where the magnitude of the con - tact of the physiologically canine should be the largest, with a progressive reduction in the posterior direction **(Figures 3.3A,B).**

From the point of view of the rehabilitation, in which we reconstruct occlusions, we prefer to opt for disocclusion via canines for several reasons. According to DAmico there are neurological, topographic and anatomical reasons. Neurological due to the higher concentration of nociceptors in the anterior region and in the periodontal ligament of this tooth; topographic due to being located in an area of greater resistance of the skull (canine pillar region); and anatomical due to its size, since the crown-root ratio is 1 to 3, which makes this tooth extremely resistant to stress.



Figures 3.3A,B - Illustrative scheme of lateral movement by group function.

PART 04

Changing the Vertical Dimension of Occlusion (VDO) in Clinical Practice with Science and Consciousness

Marcelo Calamita | Christian Coachman | Newton Sesma | John Kois

The change in the vertical dimension of occlusion (VDO) has been one of the most controversial aspects in restorative dentistry for a long time. Many of these controversies have been grounded empirically in articles, some published almost 100 years ago, which have not been scientifically validated so far.

The VDO is of extreme clinical relevance, as it must be managed by every dentist when performing extensive restorative treatments. Vertical changes in the relationship between the maxilla and the mandible have functional, biological, biomechanical and esthetic implications, since the initial references of maximum intercuspation and anterior teeth relationships must be reconstructed in a new dimension of space. Although the literature has shown that changing the VDO is a safe procedure when indicated and performed properly, problems can occur. Due to the irreversibility of some procedures, the complexity of the work involved and the financial aspect of this type of treatment, the clinician must be fully convinced of the therapeutic objectives to change the patients VDO from a restorative perspective.

This chapter critically analyzes the literature on VDO with the aim of proposing a treatment rationale to guide dentists in the oral rehabilitation of dentate patients.

Literature Review

Most of the articles found when searching for VDO are related to treatment with complete dentures, and different techniques are recommended to increase or restore the VDO. On the other hand, the reduction of the VDO itself has limited indications that refer to cases of skeletal discrepancies, such as vertical maxillary excess or anterior open bite, or when there is a need to replace existing prostheses or extensive rehabilitation in cases where the final VDO is not esthetically or functionally appropriate.

Among the most commonly accepted techniques for determining VDO are morphological or facial proportions, physiological (based on physiological resting position), phonetic, and cephalometric. As none of these techniques has been shown to be sufficiently consistent and accurate to be used in isolation, the clinician must understand its principles and use one of these associations to ensure greater accuracy, according to the requirements of the patients case.

In 1928, Turner and Fox recommended that VDO should be determined according to the external appearance of the face, with reference to the conformation of the nasolabial folds, the harmony between the lower third and the other thirds of the face, and consistent with the patients age. Willis, in 1930, suggested that the distance from the outer corner of the eye to the lip commissure was equal to the distance from the base of the nose to the chin and developed Willis compass for this measurement. Niswonger, in 1934, proposed the use of free functional space (FFS) to determine VDO. In 1951, Pleasure also stated that the physiological resting position provides a stable reference for obtaining the VDO, with the 3.0mm mean FFS between the upper and lower teeth, with the mandible at rest. Silverman, in 1951, suggested that VDO be determined by phonetics. According to this author, the evaluation of the mandibular position during the pronunciation of certain sounds would identify the smallest vertical dimension of pronunciation. Pound, also in 1951, reported that phonetic tests were auxiliary methods for obtaining a reliable functional

and esthetic diagnosis. He suggested adopting the s sound, based on the fact that the mandible had a memory of the vertical and horizontal position when the patient pronounced the s sound during phonation. Shanahan, in 1955, proposed using salivary swallowing as a basis for establishing mandibular occlusal positions. In 1954, Pyott and Shaeffer considered the validity of using radiographs to measure VDO. The cephalometric analysis would also provide the ideal orientation and position of the occlusal plane of the anterior teeth. In 1962, Nagle and Sears stated that VDO is not static throughout life and reflects the patients period of growth, development and maturity. Rivera-Morales and Mohl, in 1991, concluded that, as in any measurable biological aspect, VDO should not be rigid, specific and immutable.

In 2000, Misch emphasized that the vertical dimension of rest is not a stable and accurate parameter, and depends on several factors, such as head posture, emotional state, time of day, presence or absence of teeth and para function. In 2006, Spear observed that the use of an occlusal splint for a period of time to assess the viability of a new VDO would not be valid because the splint lacks natural contours, does not provide maximum stability and interferes with phonetics, although it can be useful for deprogramming of the neuromuscular system and determination of the maxillomandibular relationship. From the literature review, it is important to highlight that many authors have stated that, from a clinical point of view, there is no single, static and immutable position of VDO, but a vertical range of possible VDOs, called the comfort zone. Discussions about the restoration of VDO and the extent to which it should occur have a long history in Dentistry. The clinician should be aware that wear on the anterior dentition does not necessarily indicate a loss of VDO. In most cases (Angle Class I and Class II patients), the anterior teeth wear down when the patient advances the jaw and performs attrition movements in this anteriorized position, usually due to dysfunctional or parafunctional activities. Angle Class III patients generally exhibit anterior wear of the teeth because the end-to-end relationship predisposes them to this. The incisal edges gradually wear out and the mandibular position tends to be subsequently positioned in the anterior direction. A severe degree of attrition of the anterior teeth is necessary so that the posterior teeth are also compromised, and a real loss of VDO occurs. Clinically, to confirm this loss, one must observe the condition and position of the posterior teeth, as they are responsible for maintaining the VDO. In general, if they are well positioned and with minimal signs of wear, a loss of VDO is unlikely to have occurred. On the other hand, in cases with collapse of the posterior bite or in patients with complete dentures, loss of VDO is common **(Figures 3.1A-C)**.

Figures 3.1A-C - Etiology of a real loss of VDO. A dentate patient with no signs of dental wear **(A)**. Collapse of the posterior bite: the loss of VDO depends on the amount of posterior support lost **(B)**. Edentulous patient: the loss of VDO is inevitable and evident **(C)**.

05

Semi-Adjustable Articulators

Characteristics and indications

Emílio Carlos Zanatta | Henrique José Piccin

Knowledge of the concepts of occlusion is essential for the practice of Dentistry, whether is applied to a single or multiple restorations.

Clinical procedures performed directly on the mouth are known as direct methods; while others, made in the laboratory, whether they are traditional (analog) or using state-of-the-art (digital) equipment, are known as indirect methods.

In the indirect methodology, it is necessary to transfer data collected in the mouth, as well as craniofacial references that are transferred to the laboratory through stone models, facebow, interocclusal registration and semi-adjustable articulator (SAA).

Recently, new techniques have emerged with the possibility of making these data collections digitally. They are tools that optimize the work of professionals who practice dentistry. In many cases, these digital techniques meet the expectation of treatment. In other cases they are still not satisfactory, and analogue procedures are recommended.

In this phase of technological transition from analog to digital, access by both professionals and patients is still very low. Regardless of the technique chosen, academic fundamentals are indispensable for successful treatment. Therefore, clinical and laboratory analog procedures are part of a safe and accessible method.

The aim of this chapter is to clarify the traditional analogical procedures for obtaining clinical data, such as transferring and accurately simulating the kinematics of the stomatognathic system using a semi-adjustable articulator.

Concepts and Importance of Semi-Adjustable Articulators (SAAs)

Semi-adjustable articulators can be defined as mechanical devices that allow fixation of stone or printed models based on craniofacial references. Therefore, allowing a three-dimensional representation of the static and dynamic relationships of dental occlusion with a high degree of reliability.

The assembly of stone models in a SAA complements the anamnesis and clinical, photographic and radiological examinations with high quality for the correct diagnosis, predictable planning, and an effective treatment with longevity.

The analysis of stone models of dental arches in SAA is important from a functional point of view. The axis of rotation of the SAA is close to the axis of human mandibular rotation **(Figure 5.1)**.

This difference is of significant relevance when compared to a hinged or non-adjustable articulator. Widely known as hinges or occlusors, the only position for analysis is the static, in which the models are fixed. The axis of rotation is in a different location than the patients, in a shorter radius, resulting in the wrong trajectory of mandibular movements and allowing occlusal interferences of greater magnitude in the posterior region **(Figure 5.2)**.

With current technological advances, digital articulators are being developed (see Chapter 10).

Figure 5.1 - This rotation axis is defined in the mandible by the medial poles of the condyles, which in the SAA is represented by the condylar sphere.

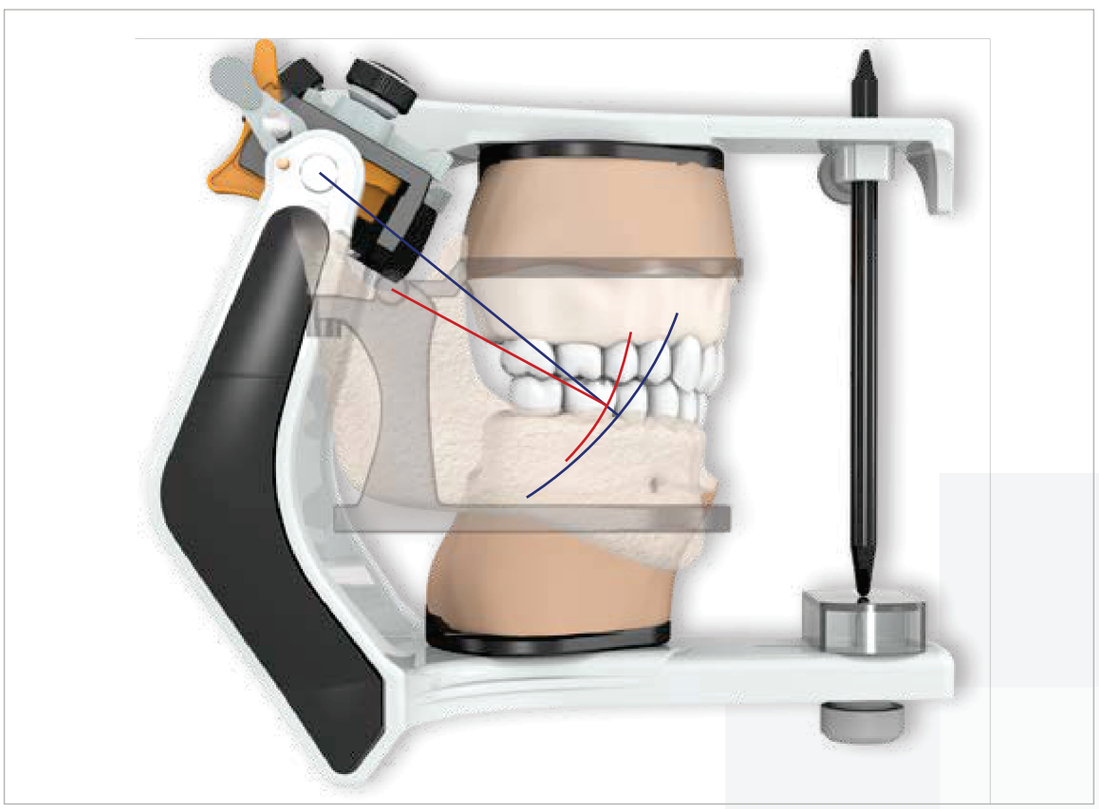


Figure 5.2 - Representation of the molar cusp trajectory: SAA (blue) and hinge (red).

06

Occlusal Remodeling

Selective reduction/addition

Pedro Paulo Feltrin | Weber Adad Ricci

The study of dental occlusion is a fascinating and extremely important field for the clinician due to the challenges presented by natural dentition in the maturation and aging process, as well as in rehabilitation procedures. Some authors even claim that this is the most important branch of Dentistry. This is due to the fact that, when analyzed in the light of the principles that rule the establishment of occlusion by the living organism, it is noted that the tooth gearing occurs at the end of a series of factors established before the appearance of the teeth. The most crucial point of this process is the stabilization of an adequate and comfortable position for the condyles associated with a definition of functional muscle lengths. Thus, the infant, even toothless, swallows by means of a visceral process where the tongue is interposed between the gum rims, providing a stability of the condylar positioning as well as an adequate length of the musculature to create a harmonious swallowing space. In this way, a healthy relationship between muscles and joints is the first step towards a healthy occlusion. As a linguistic definition, occlusion means closing. However, it becomes explicit that in Dentistry the occlusion must be understood much more than that. In a literature review, there is a stir in relation to reliable guidelines. When we analyze the term ideal occlusion, we see that the concepts have changed since the 1920s to the present. The agreement on definitions related to the vertical dimension, centric relation, orientation plans and execution of occlusal adjustments adjustments also evolved. In particular, it is clear that in an area with major controversies, two situations can be the driving forces: (a) lack of a well-defined analysis methodology or (b) wide complexity and multiple contexts, which is still very preliminary elucidated by contemporary science. After analyzing several schools of occlusion, published studies and researches, books and written handouts, there seem to be an agreement that the way in which knowledge is interpreted and applied clinically is more important than the data itself. They all converg that all concepts seek common objectives seeking to harmonize structures, in order to provide the means for a better functioning of the stomatognathic system.

Historically, the study of occlusion gains strength from reports of major tooth loss and the need for prosthetic treatments. It appears that this branch of Dentistry was in its beginnings based on the search for knowledge on how to introduce an artificial apparatus in the replacement of missing teeth. However that, was mimetic to the living being. Later, it was Periodontics that turned its attention to the study of the possibility that harmful forces could destroy dental support. With this understanding, oral rehabilitators began to pay more attention to the theme culminating in the founding of the California Gnatological Society in 1926 by McCollum. The concepts that emerged from these authors and their followers became known as the Gnatological School. Two great contributions of this school are still in force today: (1) the concept of occlusion protected by the canine defended by DAmico and (2) the systematization of the occlusal adjustment defended by Schuyler. In the area of mandibular movements, the most notable contribution was made by Posselt, who, when examining natural teeth, concluded that: (a) the maximum intercuspation was anterior and inferior to the retrusive contact position; (b) that the maximum opening position

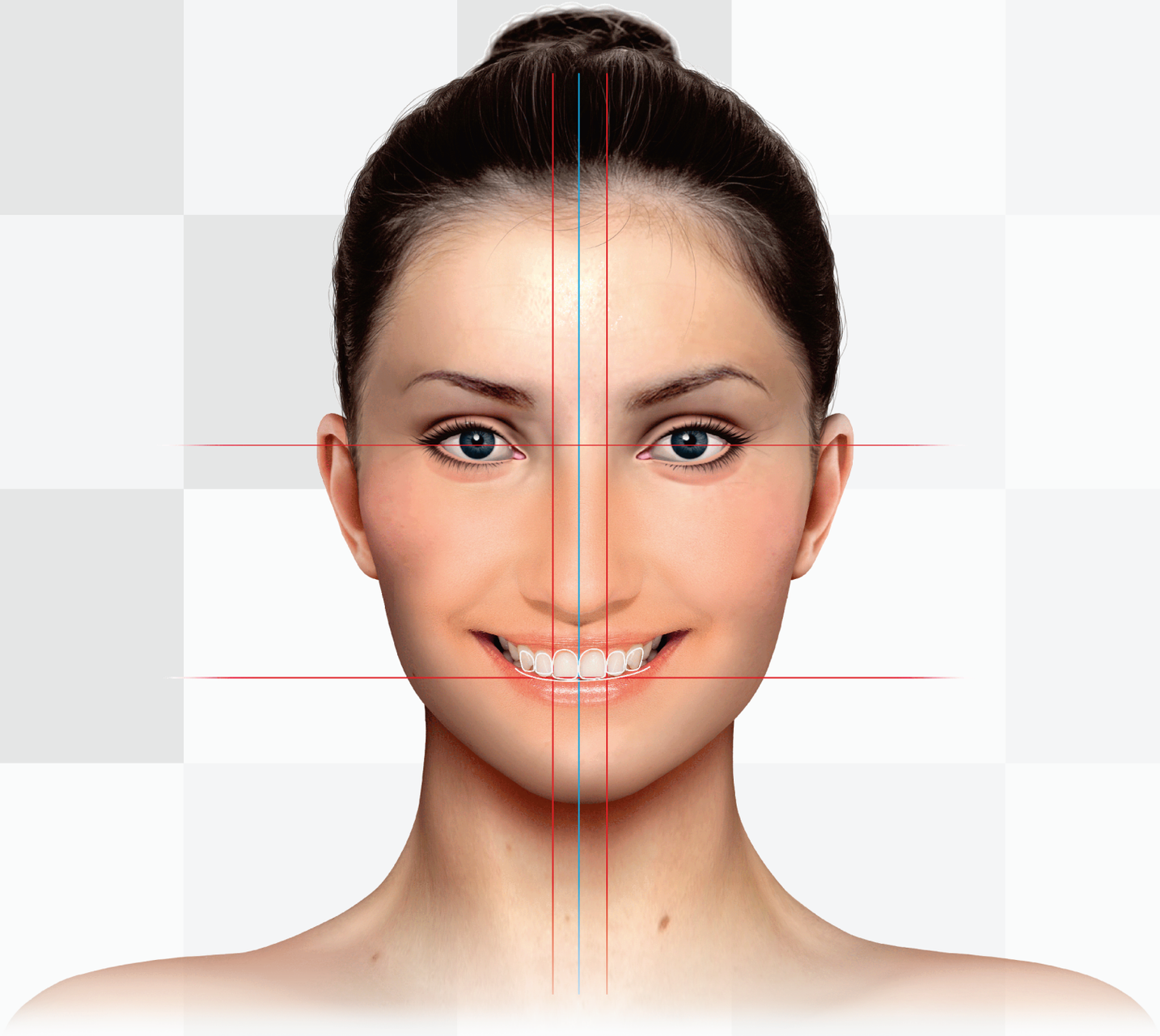
required movements of rotation and translation of the condyles; (c) that the jaw could perform opening and closing movements on an axis and (d) the jaws edging movements were reproductible. However, the most interesting complement to the study of occlusion came with the contribution of Jankelson on the following aspects: (a) during chewing, dental contacts rarely occur; (b) occlusion occurs during swallowing and (c) the mandible, during swallowing, is brought to maximum retrusion when there is no interference.

Concepts

In order to have a safe approach during the occlusal adjustment process, it is extremely important that the clinician masters concepts which are inherent to the analysis of occlusion. The three-dimensional positioning of the mandible in relation to the maxilla is defined by means of a vertical axis called Vertical Dimension and by a horizontal axis defined as Centric Relation **(Figures 6.1A,B).**

The Vertical Dimension may be defined as the distance between two points being one above and one below the mouth. It is responsible for the proper positioning of the jaw in space, favoring muscle action at an optimized length. Changes in this dimension can affect the performance of the muscle and disrupt the entire system in relation to its components. In the interval between meals, it assumes a dimension of rest where the teeth are not in contact and the muscles remain with muscle tone in a low electromyographic activity. The distance adopted by the mandible between this dimension defined as the Vertical Dimension of Rest and the Vertical Dimension of Occlusion (situation of occurrence of dental contact) is denominated as Free Way Space and presents an average value of 3mm **(Figures 6.2A,B).**

Achieving such muscular rest from where functional movements start is the initial objective of the process of verifying occlusal stability and harmony. The homeostasis of this musculature can be broken by the occurrence of interference, especially immediately after an occlusal disarrangement (Eg. a recently performed restoration with a premature contact without being adjusted) generating a pathology of muscular incoordination called protective co-contraction. This demonstrates how occlusal contacts have an intimate connection with muscle functionality.



07

Rehabilitation Planning

Project execution

Felipe Miguel Saliba | Mateus Voigt | Victor Clavijo | Fernando A. Feitosa | Hilton Riquieri

PART 01

Integration of Esthetics and Function

Felipe Miguel Saliba | Mateus Voigt | Victor Clavijo

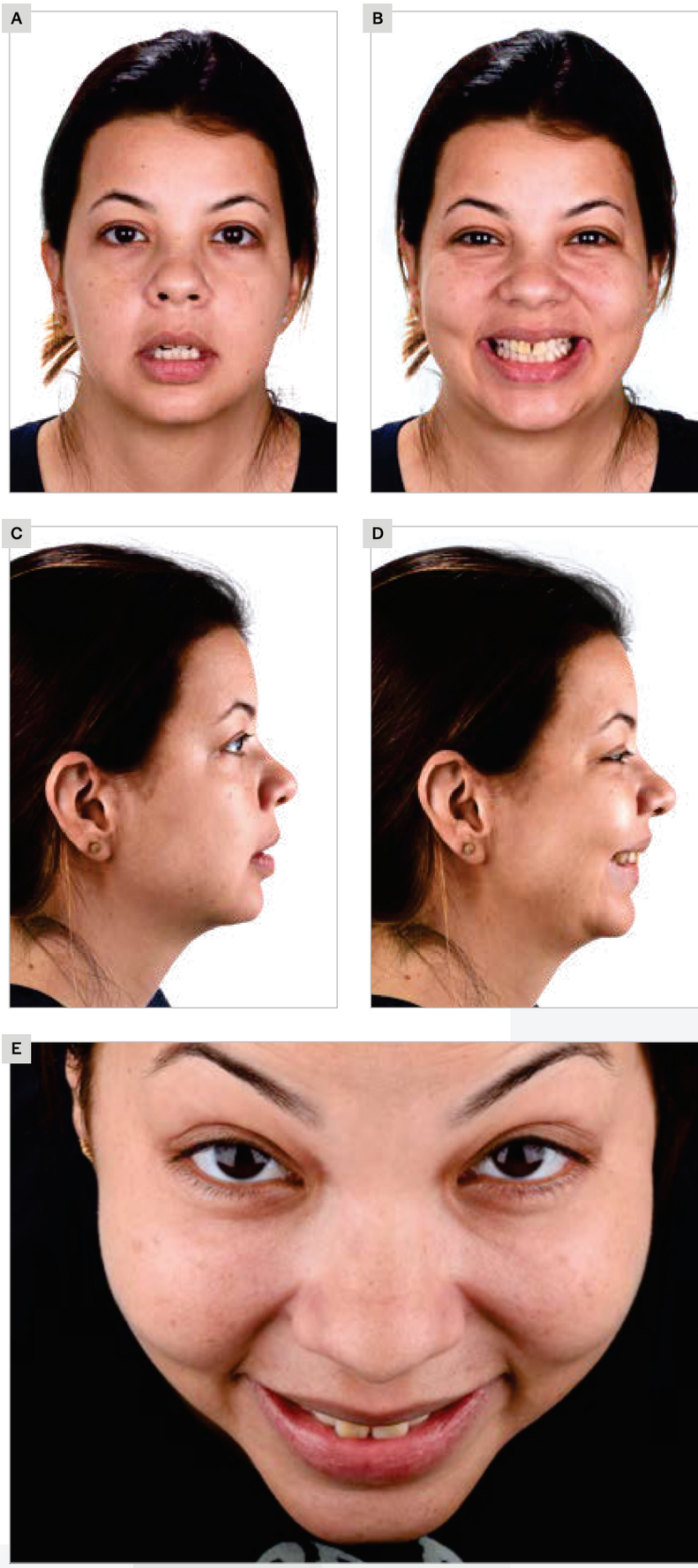
The demand for highly esthetic and personalized treatments is growing. The dentist must be qualified to use concepts and techniques that expand their esthetic vision for diagnosis, in order to guide the treatment planning and clinical procedures.

To start any esthetic dental treatment, we must always start by analyzing the face, the lip movements, and only then the dental esthetics. This rationale determines a harmony between the patients face and smile.

Ideally a trial of the treatment plan should be done before starting the actual treatment. This way the planned treatment can be check in relation to the face. This will allow for a better diagnosis and, consequently, better planning in an individualized way.

To start this initial esthetic planning, we must always photograph the patients. These initial photographs must be taken in a way that involves the patients face, as shown in the example beside.

We understand that planning must initially be guided by esthetic criteria and, then, these will guide the maintenance or reconstruction of the structures, function, and biology of the masticatory system.



Figures 7.1A-E - Frontal photograph with patient at rest **(A)** . Frontal photograph with the patient smiling and with the arches slightly apart **(B)** . Profile photograph at rest **(C)**. Profile photo smiling **(D)** . Photography 12 hours **(E)**.

08
Occlusion in Prosthodontics

Daniel Telles | José Virgílio de Paula Eduardo | Paulo Vicente Rocha

PART 01

Complete Removable Prosthesis

Daniel Telles | José Virgílio de Paula Eduardo

Occlusal disharmony in complete prosthesis has been associated with masticatory deficiencies, impaired stability and retention, increased bone resorption of the remaining alveolar ridge, soft tissue injuries, patient discomfort and even temporomandibular disorders.

When occlusal masticatory forces occur, complete prosthesis are subjected to challenges of support, stability and retention. These factors are properly addressed when:

(a) the patient has favorable anatomical characteristics (such as a broad bSAAI area, ridges with parallel slopes and medium-sized tuberosities);

(b) proper impression is taken;

(c) an assembly and a correct adjustment of the occlusion are delivered in the installation and in the long-term follow-ups. It is the clinicians responsibility to carefully conduct the case following the principles of adequate occlusion for this type of prosthesis.

What are the Characteristics of an Ideal Occlusion in Complete Prosthesis?

An ideal occlusion for a double Complete Denture (CD) should have the following characteristics:

(1) Occlusal Plane.

(2) Functional Vertical Dimension of Occlusion (VDO).

(3) Teeth with low cusps.

(4) Teeth positioned according to the shape of the remaining ridge.

(5) Stability in centric position.

(6) Eccentric movements made easy.

Occlusal Plane

The occlusal plane is the imaginary line that passes through the tips of the cusps and incisal edges of the teeth on both sides of the dental arch. As it is established in the geometric concept that 3 points form a plane, it is linked to the relationship of the mandibular central incisors with the occlusal table of the first molars. Through the mechanical method of determination the clinician will use craniofacial references to transfer this orientation plan (acrylic base + wax rim).

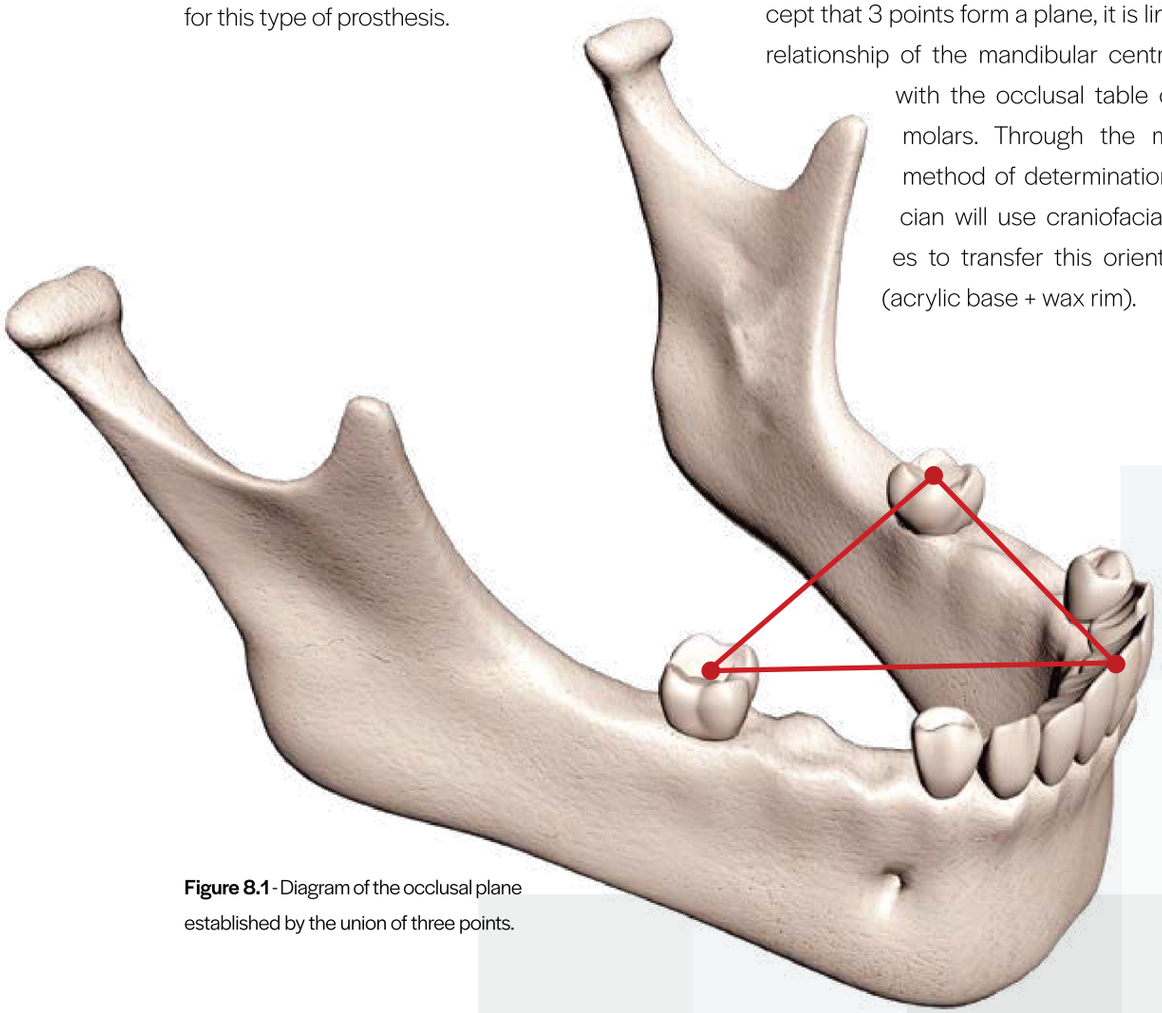


Figure 8.1 - Diagram of the occlusal plane established by the union of three points.

PART 02

Implant-Supported Complete Prosthesis (ISFP)

Paulo Vicente Rocha

Contemporary dentistry considers the use of implants an established, feasible and, therefore, predictable and safe alternative.

However, implant prosthesis, like all other types of prosthesis, also fails. These failures can be of biological origin, with bacteria as the causative agent (in conventional prosthesis - caries, gingival inflammation, loss of pulp vitality and in implant prosthesis - mucositis, peri-implantitis, among others) and of mechanical origin, where the occlusal loads are considered a failure factor (fracture or chipping of the ceramic, loosening of the screw, decreased bone support, loss of osseointegration, among others).

Analyzing this perspective, prosthetic rehabilitation is strongly influenced by three factors:

Adequate technical execution: which includes good data collection, allowing a well-executed diagnosis, careful planning and manufacturing of prosthesis within the technical characteristics of each material and according to the situation of the tissues supporting the prosthesis.

Bacterial control: which must be carried out from the previous decontamination process until the prosthetic treatment is carried out and maintained in sessions after the prosthesis delivery, avoiding inflammatory and infectious conditions.

Control of occlusal forces: the control of occlusal forces is performed primarily by promoting an adequate occlusal scheme for each case. It is essential to understand the concepts of occlusion, mastering the biomechanical principles of each type of prosthesis and each type of prosthetic connection system, in addition to paying attention to factors that change the occlusal forces, such as parafunctions (eg sleep bruxism and awake bruxism).

The clinical success of any prosthesis model depends on the correct control and mastery of the occlusion and, therefore, the occlusal pattern of implant-supported prosthesis must respect the biomechanical factors, which are fundamental to avoid complications in implant-supported rehabilitation. Some aspects must be observed in order to adapt the rehabilitation to the reality of each patient. Among these factors are: adequate bone support, crown/implant ratio, location and number of implants, which will depend on the extent of the prosthesis and where the implants will be placed. In addition, attention should be paid to the extension of the occlusal platform, static and dynamic occlusal guides, vertical dimension of occlusion, premature contacts, parafunction, among others **(Table 8.1).**

Parafunctional activities and deficient occlusal scheme can lead to occlusal overload and intensify the mechanical loads (and stress) in the bone ridge, in the prosthetic components on the implant and in artificial teeth. This can be one of the main causes of marginal bone loss and/or failures in implant prosthesis, such as: loosening, loss of retention or fracture of the prosthesis screw or abutment, fracture of restorative materials, failures in the cementation interface, implant fracture and even loss of osseointegration **(Table 8.2).**

Table 8.1 - Specific factors to be observed in each patient.

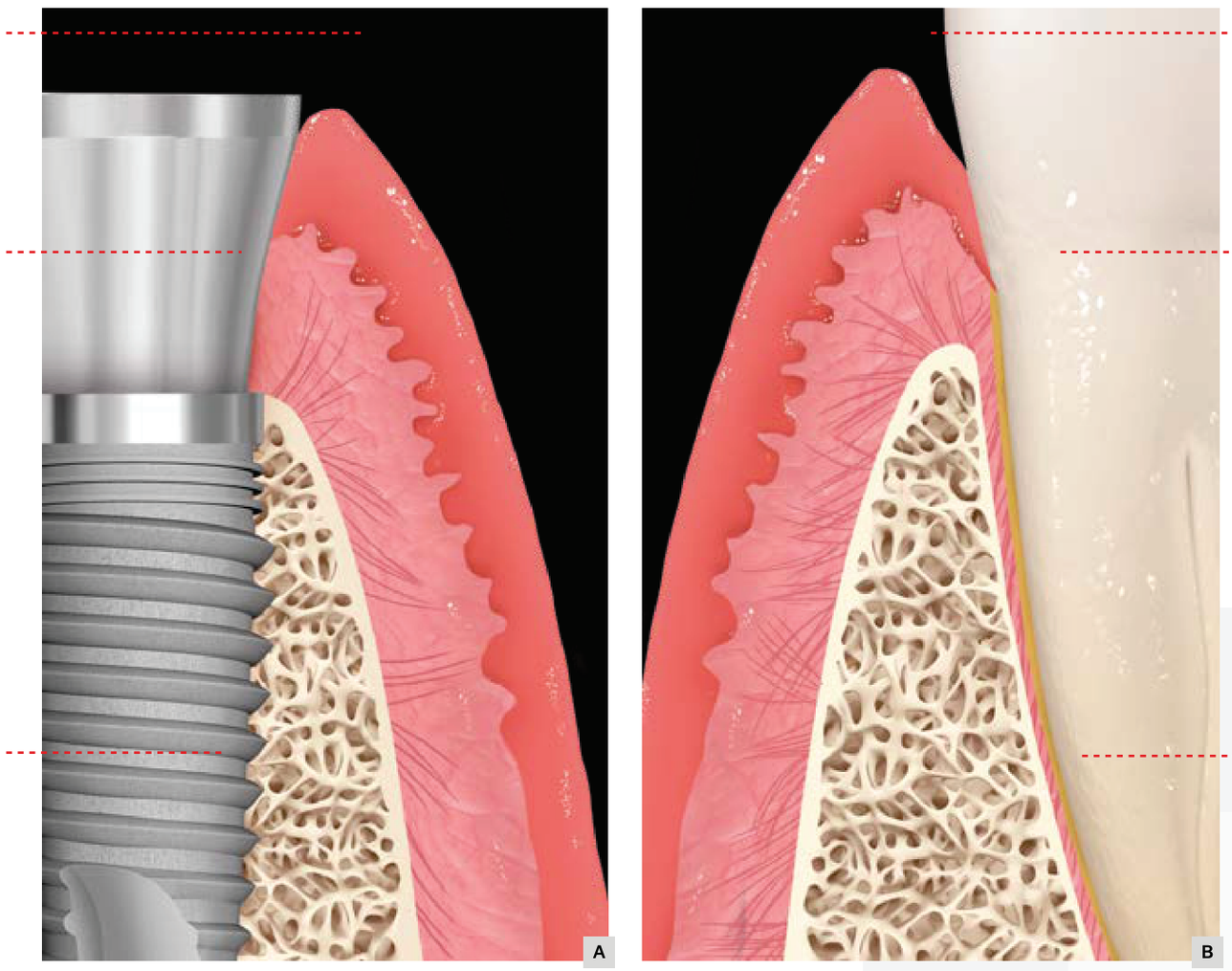
Adequate bone support	Occlusal platform extension
Crown - implant ratio	Static occlusal guides
Implant location	Dynamic occlusal guides
Number of implants	Vertical dimension of occlusion (VDO)
Presence of parafunction	Occlusal interference

Table 8.2 - Damage to a deficient occlusal scheme associated or not with the parafunction.

Loosening the prosthesis screw	Marginal bone loss
Fracture of the prosthesis screw	Loosening the abutment screw
Fracture and/or wear of restorative materials	Cementing failures
Implant fracture	Loss of osseointegration

The comparison between an implant that forms a rigid and direct connection with the surrounding bonee that are intimately connected to the socket through the periodontal ligament. It is to reduce excessive forces to the bone crest, leads us to think carefully about the occlusal scheme to be proposed in the different clinical situations **(Figures 8.1A,B).**

Figures 8.1A,B - Illustrative aspect of the difference in connection between bone x tooth and bone x implant, highlighting the presence of the periodontal ligament, with an important role in the absorption of masticatory forces.



09

Occlusal Splints

Types and indications

Simone Saldanha Ignacio de Oliveira | Alexandre Cardoso

Introduction

The current vision of Occlusion and Temporomandibular Disorder (TMD) results from constant adjustments of principles and concepts in relation to new discoveries. The interest and the need to know more about the theme are due, specially , to the emergence of modern life pathologies, related to an emotional component and its consequences on the occlusion and the stomatognathic system. Neuroscience brought a progressive awakening to life balance, possibly due to the lack of answers that permeate the theme. There is a search for quality of life in the different areas of health care to promotes healthy aging. Awareness regarding the disorders generated by painful symptoms with consequent- limitations arising from the temporomandibular disorder creates conditions for changes in behavior and incapabilities. One of the therapies for imbalance, limitations and disabilities of the stomatognathic system is the use of occlusal splints, which can also act as protective devices for the dental arches.

The aim of this chapter is to help understanding the types and indications of the most common occlusal splints in the treatment of TMD signs and symptoms. Besides, presenting their importance during pre- and post-rehabilitation treatment in symptomatic patients. Provided that the condition of normality of the components of the masticatory system are reestablished and the principles of occlusion, which must not only be respected and restored, act in harmony with the positions and mandibular movements for the proper functioning of the temporomandibular joint (TMJ).

Temporomandibular Articulation

All occlusion principles are based on harmony with the temporomandibular joint (TMJ) during mandibular movements.

The TMJ is a complex structure due to its hinge movement in a single plane - which classifies it as ginglymoid; while providing sliding movements which classifies it as diarthroidal. It is considered a ginglymoarthroidal, right and left bi-articular, composed of the right and left condyle (head of the jaw) and the articular fossa. These surfaces are interposed by the articular disc, which divides the TMJ into two compartments: a superior one, with the articular fossa, and an inferior one, with the condyle, presenting a synovial fluid that has the function of lubricating and nourishing the structures. This entire joint is surrounded by a capsule composed of fibrous tissue. The TMJ muscles are responsible for mandibular movements. This joint is part of the stomatognathic system that involves muscles, teeth, ligaments and nerves. Changes in disc morphology may be caused by biomechanical changes during function. The ligaments also play an important role in protecting these structures by restricting movement; however forces can cause stretching, thus impairing its function. The lower compartment, composed of the condyle and the articular disc, allows for the physiological rotation movement to be performed. The articular disc is firmly attached to the condyle through the medial collateral and lateral ligaments (disc). During the rotation movement, the condyle rotates on its own axis, which can also be called a hinge movement. When the interarticular pressure increases, the condyle seeks stability in the thinnest (intermediate) area of the disc, as the anterior and posterior portions are the thickest. The disc shape and joint pressure influence the maintenance of the condyle-disc complex coordination. The biconcave shape of the articular disc di-

Figure 9.1

Figure 9.2

rects the normal relationship of the condyle-disc complex at the 12 oclock position with the mouth closed (imaginary line drawn in the middle of the condyle, distal from the posterior portion of the disc and middle of the articular fossa) and in the position of 12 hours of open mouth (imaginary line drawn in the middle of the condyle, middle of the intermediate portion of the disc and middle of the joint eminence) **(Figures 9.1 and 9.2)**As the interarticular pressure increases, the articu lar disc moves forward due to the action of the superior lateral pterygoid muscle. The subsequent stretching of the retrodiscal lamina will influence the functional relationship of the condyle-disc complex during the opening and closing movement promoting a change at the articular closing position.

Temporomandibular Disorder: Clinical Approach

Temporomandibular disorders (TMDs) belong to a heterogeneous group of musculoskeletal and neuromuscular conditions involving the temporomandibular joint complex, musculature and adja cent components. The most frequent diagnosis is based on clinical history, previous treatments, physical examination and diagnostic imaging tests. Diagnostic imaging can be beneficial when intra-articular abnormalities are suspected. Magnetic resonance imaging of the TMJ is recognized as the gold standard for the diagnosis of joint TMD in order to visualize the discoordination of the condyle-disc complex in the closed position until the maximum opening.

10

Digital Technical Evolution

Eduardo Miyashita | Guilherme de Siqueira F. A. Saavedra | Marcelo Lucchesi Teixeira

Digital dentistry is a reflection of the huge technological changes that are occurring worldwide at an amazing speed. As a consequence, the routine of todays practices is affected by new technolo - gies, changind the way of work, treatment plan, execution and documentation of rehabilitations. With the raise of the so-called 4th industrial revolution, new equipment and technologies, increasingly affordable, at an increasing speed of launch.

Within this context, it is important that professionals know how to drive the transition to new technologies, without adhering to fads. This can generate unnecessary changes to new (learn ing) curves, mistreatments and, consequently, financial prejudice to the professional and to the health of the patients. To obtain a new technology, it must fulfill one of the three key factors:

(1) increase efficiency, represented by the reduction of cost and/or time to carry out the treatment;

(2) increase the accuracy of clinical practice;

(3) increase the level of predictability[1].

It is also important to carefully assess whether a technological approach is advantageous in relation to the person who is used to successfully executing it, as there is still no of superiority of one approach over another[2].

As there are many technologies available, for this chapter, four pieces of equipment were selected that directly impact the study of occlusion and, therefore, the diagnosis, planning and execution of rehabilitations:

computer-assisted condylar axiography;

virtual articulator;

virtual temporomandibular axiography and;

computer-assisted occlusal contact detector.

Computer-Assisted Condylar Axiography

Historically, an accurate record of jaw movements has always been a goal. The more precise the articulator is, the more accurate the occlusal diagnosis, and less damage will be caused by the installation of prosthetic parts. These movements can be recorded by approximation in semi-adjustable articulators or precisely in fully adjustable articulators. Within this context, pantographs were developed, as well as the axiographs (devices used to record patient jaw movements), in order to program ful - ly adjustable articulators to precisely simulate these movements[3].

The axiograph can also be used as a diagnostic tool to compare and evaluate the degree of reproducibility of mandibular movements in relation to the established norms. Besides, it assesses the severity of the incoordination, which allows for a diagnosis of the range of the parameters of normality from the trajectory resulting from the traces[4]. The use of axiography, however, is not very popular due to its complexity and the great time required for its correct execution, reaching 2.5 to 4 hours to be performed. These are the reasons for the great

popularization of semi-adjustable articulators. They are simplified systems that use average values from these registers[5]. Okeson[5] reported that the main advantage of fully adjustable articulators is their ability to accurately replicate mandibular movement. When used correctly, restorations that accurately fit the patients occlusal requirements can be developed, requiring minimal intraoral adjustment. However, the main disadvantages of the fully adjustable articulator are related to its high cost and the considerable amount of time that must be invested in the adequate transfer of patient information to the articulator. That time and expense must be weighed against the benefits. For performing simple restorative procedures, the use of a fully adjustable articulator is not justified, it is easier to use a semi-adjustable articulators and compensate for its deficiencies with minimal intraoral adjustment of the restorations.

When using a fully adjustable articulator, three procedures are necessary to record effectively: **(1)** exact location of the terminal axis of rotation; **(2)** location and pantographic record of condylar movements and **(3)** an interocclusal record of the central relation (CR) position in healthy individuals or reference position (RP) in individuals with intra-articular disorders[5,6].

With the advent of new technologies, this record is no longer purely mechanical and analogical (difficult and very time-consuming) and has incorporated digital technology, being monitored by a computer. In the past, the first two procedures were performed by mechanically recording condylar movements in a millimeter flag. Currently, these mechanical tables have been replaced by devices that allow you to accurately record digitally all three-dimensional movements of the jaw, in addition to store this information to track the clinician when adjusting the articulator. Examples of this type of equipment are: Cadiax 4® (Gamma Dental, Austria), Axioquick Recorder® ultrasonic axiograph (SAM Dental, Germany), ARCUS Digma II® ultrasonic axiograph (Kavo Dental, Germany).

The Cadiax® system allows for the measurement and qualification of the axis of rotation, determining the characteristics of the condylar path. These digitally acquired records are analyzed within the systems software, which assists in the articulators programming. This system is useful for the occlusal analysis focusing on the exact position of each condyle, for planning high complexity cases and also to evaluate the effectiveness of the results of the proposed therapy.

A great advantage of this system is in the detailed diagram of tracings on the computer monitor. This allows for the detection of small changes that are not possible to diagnose by relatively small mechanical devices in, for example, initial displacements of the disk. It also allows for evaluation of some parameters that were previously impracticable, such as the precise movement of each axis in the three-dimensional space and the acceleration or deceleration of the condylar movement, which can be fundamental in the diagnosis of muscle or

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