

DENTISTRY IN EVOLUTION

A Practical Guide to Technological
Transition for the Clinic



ANDREI CORREA GUANDALINI

DENTAL SURGEON | IMPLANT DENTISTRY
TMD & OROFACIAL PAIN | DIGITAL DENTISTRY

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DEDICATION

To my wife, Louseane, for her unconditional support and for being my safe harbor. Even with the challenges of her own career and her many commitments, her presence and support were essential for me to walk this path.

To my daughter, Cecília, who is my greatest source of motivation and the joy that lights up all my days. You are the reason for all my effort.

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CONTENTS

Dedication, 4

Acknowledgments, 5

Preface, 8

Introduction, 9

Part 1. Fundamentals of Technological Evolution

1. The Analog Era of Dentistry: Where It All Began, 11

Conventional Impressions, 11

Imaging Diagnosis, 11

Surgical and Prosthetic Planning, 11

Clinical and Laboratory Communication, 12

Clinical Documentation and Records, 12

What This Scenario Produced, 13

2. Implant Dentistry and the New Restorative Perspective, 14

The Evolution of Prosthetic Connections, 14

Immediate Loading, 15

Advanced Surgical Techniques, 16

Soft Tissues, 16

What Implant Dentistry Demanded of the Professional, 16

3. The Digital Revolution: Scanners, CAD/CAM, and 3D Printing, 17

Intraoral Scanning, 17

Dental CAD, 17

CAM: Milling and 3D Printing, 18

In-House Fabrication versus Outsourcing, 19

What Changes in Daily Practice, 19

Part 2. The Current Frontier

4. Digital Planning and Guided Implant Surgery, 21

The Workflow, 21

Reverse Planning, 21

Planning Software, 21

Types of Surgical Guide, 22

Accuracy and Deviations, 22

Guided Surgery and Flapless, 23

Dynamic Navigation, 23

What Guided Surgery Demands of the Professional, 23

5. TMD and Orofacial Pain: Technology Applied to Treatment, 24

Diagnosis, 24

- Occlusal Splints: From Analog to Digital, 24
- Bruxism: Counseling as a Clinical Strategy, 25
- TMD and Implant Dentistry: The Integrated View, 25
- Emerging Technologies in TMD Diagnosis, 26
- 6. Artificial Intelligence in the Dental Practice, 27
 - What AI Does and What It Does Not Do, 27
 - Tools: Each One Has a Function, 27
 - LGPD and Data Security, 28
 - The Art of the Prompt: How to Formulate Effective Questions, 28
 - Practical Clinical Applications, 28
 - Practical Implementation, 29
 - Future Perspectives, 29

Part 3. Guidance for the Professional of the Future

- 7. Education and Teaching: The Professional Who Trains Peers, 31
 - Continuing Education as a Technical Necessity, 31
 - Teaching the Digital Workflow, 31
 - International Teaching and the Language Barrier, 32
 - Scientific Publication as a Tool for Dissemination, 32
 - Clinical Mentoring, 32
 - The Professional Who Teaches Learns Twice, 32
- 8. The Map of Evolution: How to Prepare, 33
 - Essential Competencies for Today's Professional, 33
 - Building a Progressive Workflow, 33
 - Smart Investment in Technology, 34
 - Clinical Research in Private Practice, 34
 - An In-House Laboratory: Autonomy and Control, 34
 - Collaboration Networks, 35
 - The Map Is Individual, 35
- Final Considerations, 37
- About the Author, 37
- References, 38

PREFACE

Dentistry has changed profoundly, but the way we learn the profession has not always kept pace with the speed of these transformations. What I present in these pages is an account from someone who lived through the transition from analog to digital and realized that technology, on its own, does not solve the problems of the practice without a clear understanding of all the processes involved.

This book grows out of a clear perception about our specialty: there is today a worldwide need for professionals who master the complete cycle. It is not enough to be good clinicians if we do not understand digital planning; it is not enough to be good planners if we do not grasp the physical limits of the laboratory and of the materials. The integration between the office, the software screen, and the laboratory bench is a universal language, essential to raising the standard of dentistry anywhere.

My intention here is not to dictate rules, but to offer content that helps build this systemic vision. This book was conceived as a starting point, helping the colleague understand how each stage connects to generate greater predictability and safety.

Technology, including Artificial Intelligence, should be seen as a precision tool that enhances our clinical judgment, but the foundation of everything remains our commitment to learning and to ethical care. I hope this reading proves useful on your journey and contributes to a broader, more integrated view of our profession.

INTRODUCTION

Dentistry has changed more in the last fifteen years than in the previous fifty. Those who graduated taking alginate impressions and planning surgeries on stone casts now work with intraoral scanners, three-dimensional simulation software, and 3D printers that fabricate surgical guides in a matter of hours. This pace created a real problem: a large share of professionals fell behind, and traditional academic training cannot keep up with the rate of change.

I wrote this book drawing on twenty years of clinical practice and seven years working with digital dentistry. My routine combines the clinical side, from intraoral scanning to computer-guided surgical planning, with the laboratory side, which includes 3D printing and CAM milling. I work with CAD software (digital design of parts and treatment plans), such as coDiagnostiX, Exocad, DentalSystem, and Blender, and I am proficient in the CAM software (fabrication of the planned parts) needed to program 3D printing and milling, such as Millbox and Chitubox. This dual experience between office and bench is what gives technical grounding to the content of the following pages. Added to this is the academic research of my ongoing master's and doctoral studies and my work as a professor, which requires me to organize and update this knowledge continuously.

The book is organized into three blocks. The first covers the fundamentals of technological evolution in dentistry, from the analog era to the consolidation of implant dentistry and the digital workflow with CAD/CAM and 3D printing. The second addresses the current frontier: computer-guided planning of guided surgeries, the application of digital technology to the diagnosis and treatment of TMD and orofacial pain, and the use of artificial intelligence in the clinical routine. The third block focuses on continuing education and career planning, with practical guidance for those who want to update without having to overhaul everything at once.

Each chapter brings protocols, workflows, and applied clinical reasoning. The goal is for the reader to come away with concrete tools to implement in their own practice, regardless of the stage they are at in the technological transition.

Andrei Correa Guandalini

Curitiba, 2025

PART I

FUNDAMENTALS OF TECHNOLOGICAL EVOLUTION

CHAPTER 1

THE ANALOG ERA OF DENTISTRY: WHERE IT ALL BEGAN

Every dentist who graduated before 2015 knows the scene. The tray loaded with alginate, the mental stopwatch counting the material's set, the patient with a gag reflex trying to cooperate. After the impression, the stone cast. After the cast, the manual wax-up. After the wax-up, the casting. Each step depended on the previous one, and any early error propagated all the way to the final result with no possibility of digital correction. It was an entirely linear, manual process.

This workflow worked for decades. It trained generations of competent professionals and produced restorations that, in many cases, still function today in patients' mouths. To ignore that would be dishonest. The problem was never the competence of those doing the work. The problem was the limitation of the materials and methods available.

Conventional Impressions

Alginate, the material most used for study and planning impressions, is an irreversible hydrocolloid with well-known dimensional instability. Once removed from the mouth, the impression begins to lose water through syneresis or absorb it through imbibition, altering its dimensions within minutes. The professional had a short window to pour the stone, and even then accuracy depended on variables that were hard to control: powder-to-water ratio, spatulation time, ambient temperature, and seating technique in the tray.

For more demanding prosthetic cases, addition silicone offered greater dimensional stability and better detail reproduction. The cost was significantly higher, which restricted its use in many offices. Even with addition silicone, the chain of possible errors remained long: voids in the impression, distortion during disinfection, setting expansion of the stone, and so on. Each step accumulated deviations that the professional only noticed at the clinical try-in.

Imaging Diagnosis

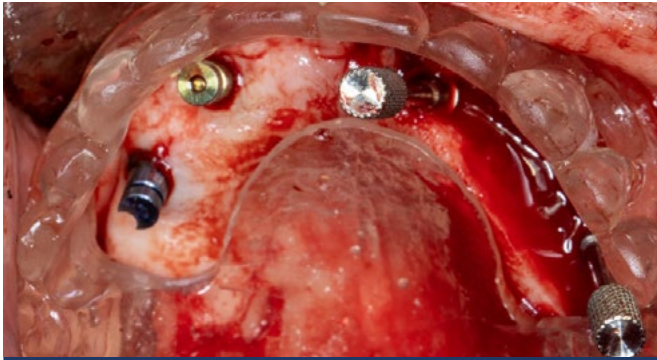
The periapical and panoramic radiographs were the standard imaging resources. The periapical provided good resolution for analyzing dental and periapical structures, with the limitation of representing a three-dimensional structure in two dimensions. Anatomical superimpositions, angulation distortions, and positioning artifacts were frequent problems accepted as part of the method.

The panoramic broadened the field of view to the entire arch, maxilla and mandible, with the trade-off of lower resolution and variable magnification across regions of the image. For implant planning, the professional estimated bone height and thickness from these two dimensions, accepting a margin of imprecision that today would be considered unacceptable. Critical structures such as the mandibular canal, the maxillary sinus, and the mental foramen were identified based on approximate anatomical references.

Another imaging option was medical CT, which allowed a 3D visualization of the structure before surgery. The cost was extremely high, access was restricted to major centers, and the image showed distortions. The restriction to predetermined slices set by the radiology clinic further limited the implantologist's analysis.

Surgical and Prosthetic Planning

Planning an implant-supported rehabilitation followed a predictable script. The surgeon reviewed the panoramic radiograph, evaluated the stone cast mounted on a semi-adjustable articulator, made a manual diagnostic wax-up, and from it fabricated a multifunctional surgical guide in acrylic resin. This guide indicates an approximate implant position, without three-dimensional control of angulation or depth. Even so, it is still used within the digital workflow, in component selection and in communicating with the laboratory about the vertical dimension of the piece and the position of the teeth.



Use of the multifunctional guide for component selection.

In practice, the final implant position depended almost entirely on the surgeon’s manual experience, on the anatomy encountered after flap elevation, and on decisions made in real time during the procedure. Experienced professionals developed a refined tactile sense that partially compensated for the lack of digital planning. Professionals in training faced a long learning curve and relied heavily on in-person mentoring.

Clinical and Laboratory Communication

Communication between the dentist and the dental laboratory was done through paper slips, often filled out by hand. Shade selection relied on visual guides such as the Vita Classical, evaluated under the clinical operating light, which rarely matched the ideal lighting for this type of assessment. The lab technician

received the stone cast, the slip with notes, and, if lucky, a printed photograph. Interpretation was subjective on both sides.

The result was predictable: remakes of prosthetic pieces due to esthetic dissatisfaction, prolonged adjustments at try-in appointments, strain on the professional relationship between dentist and technician, and frustration for the patient who did not understand why the crown looked different from what was agreed. This trial-and-error cycle was accepted as part of the process.

Clinical Documentation and Records

The chart was on paper. Clinical notes written by hand, with personal abbreviations only the author understood. Radiographs filed in envelopes. Photographs, when they existed, were developed on film and glued to cards. The traceability of a long treatment depended on the professional’s individual organization and on the legibility of their handwriting.

From a legal standpoint, this documentation was fragile. In the event of a legal challenge, the professional’s defense depended on records that were often incomplete, unstandardized, and impossible to search quickly. The volume of information per patient was small, and the capacity for retrospective analysis was limited.

Table 1 — Comparison between the analog workflow and the digital workflow

Clinical stage	Analog workflow	Digital workflow
Impression	Alginate, dimensional instability, short window to pour the stone. Addition silicone, patient discomfort and possibility of technical error	Intraoral scanner, stable digital model (STL/PLY), permanent storage
Imaging diagnosis	Periapical and panoramic (2D), superimpositions and distortions. Medical CT: high cost, difficult visualization, and restricted to preselected slices	CBCT, three-dimensional visualization with axial, sagittal, and coronal slices. The dentist can navigate the image and is not restricted to the radiologist's preselection
Surgical planning	Stone cast, manual wax-up, multifunctional acrylic guide	3D simulation software, virtual implant positioning, 3D-printed guide
Prosthetic planning	Wax-up or tooth arrangement on a stone cast, semi-adjustable articulator	CAD design on a digital model, parametrization of thicknesses and contacts. Virtual articulator.
Communication with the laboratory	Handwritten slip, visual shade guide, printed photograph	Digital file (STL/DICOM), integrated communication via software
Fabrication of parts	Casting in metal alloy, ceramic pressing	CNC milling (physical execution of the CAD/CAM) or 3D printing (photopolymer resins)
Clinical documentation	Paper chart, handwritten abbreviations, radiographs in envelopes	Digital chart, stored 3D files, complete traceability

What This Scenario Produced

Analog dentistry trained professionals with refined manual skill, clinical judgment developed through repetition, and the ability to solve problems in real time with limited resources. These competencies remain valuable. It would be a mistake to discard them. Analog techniques are still necessary in specific situations, such as fabricating complete dentures or resolving complications when the digital workflow fails during a procedure. The opposite mistake would be to think they are enough.

The central point of this chapter is to establish the baseline. Everything discussed in the following

chapters gains context when compared to what existed before. 3D printing only makes sense when you understand what it was to cast a piece in metal alloy with a torch. Intraoral scanning only takes on its full significance when you recall the instability of alginate. The digital planning of a guided surgery is only appreciated by someone who has already elevated a flap without knowing exactly what they would find.

Analog dentistry was not inferior. It was what existed. The difference is that today there is more.

CHAPTER 2

IMPLANT DENTISTRY AND THE NEW RESTORATIVE PERSPECTIVE

Implant dentistry changed the logic of restorative dentistry. Before it, losing a tooth meant grinding down the adjacent teeth to support a fixed prosthesis, or accepting a removable prosthesis with all its drawbacks. With implants, for the first time, it became possible to replace a tooth without compromising healthy structures. This permanently altered clinical reasoning.

The concept of osseointegration, described by Brånemark in the 1960s, established that titanium could integrate with bone tissue in a stable and lasting way. From this discovery, the first implant protocols required a waiting period of three to six months between placement and prosthetic loading, the time needed for consolidation of the bone-implant interface. Implants were placed submerged, covered by the mucosa, and only re-exposed in a second surgery to connect the prosthetic component. The workflow was slow, predictable, and restricted to cases of complete edentulism.

The Evolution of Prosthetic Connections

The first widely used implants had an external hexagon connection. This configuration, derived from Brånemark’s original system, presented a butt-joint interface between implant and prosthetic abutment, with a hexagon protruding from the top surface of the implant. The system worked, accumulated decades of favorable clinical evidence, and allowed prosthetic versatility. Its limitations, however, were known: bacterial microleakage at the interface, a tendency for the retention screw to loosen under oblique loads, and early marginal bone resorption, the so-called saucerization.

The internal hexagon connection represented an advance by internalizing the fit, reducing the lever arm on the screw and improving force distribution. Microleakage decreased relative to the external hexagon, in the case of platform-switched configurations, and the mechanical stability of the assembly increased.

The introduction of the Morse taper connection brought a qualitative leap. In this system, the interface between implant and abutment is conical, and the fit occurs through friction between two juxtaposed metal surfaces. This geometry produces a mechanical seal with minimal microgap, which significantly reduces bacterial infiltration and microbial colonization at the interface. From a biomechanical standpoint, masticatory forces are directed inward and along the long axis of the implant, protecting the retention screw and distributing stress more favorably to the peri-implant bone. Clinically, marginal bone preservation in Morse taper implants is consistently superior to that observed in external connections, which directly impacts esthetics in the anterior region and the longevity of the treatment.

This evolution of connections is not merely a technical detail. It changed placement protocols, altered the relationship between implant position and prosthetic emergence, and expanded rehabilitation possibilities in esthetically demanding areas. A professional who does not understand the biomechanical differences among these connections operates with a limitation that no digital equipment can offset.

Table 2 — Comparison of prosthetic connections on implants

Characteristic	External hexagon	Internal hexagon	Morse taper
Interface	Butt joint, protruding hexagon	Recessed internal fit	Conical, friction between surfaces
Microleakage	Higher (microgap)	Intermediate	Minimal (mechanical seal)
Screw loosening	More frequent	Reduced	Rare

Characteristic	External hexagon	Internal hexagon	Morse taper
Bone preservation	Early saucerization	Better than EH with platform switching	Consistently superior
Prosthetic versatility	Broad, universal system	Broad	Broad, anterior esthetic advantage
Clinical evidence	Decades of documentation	Growing documentation	Consistently favorable

Immediate Loading

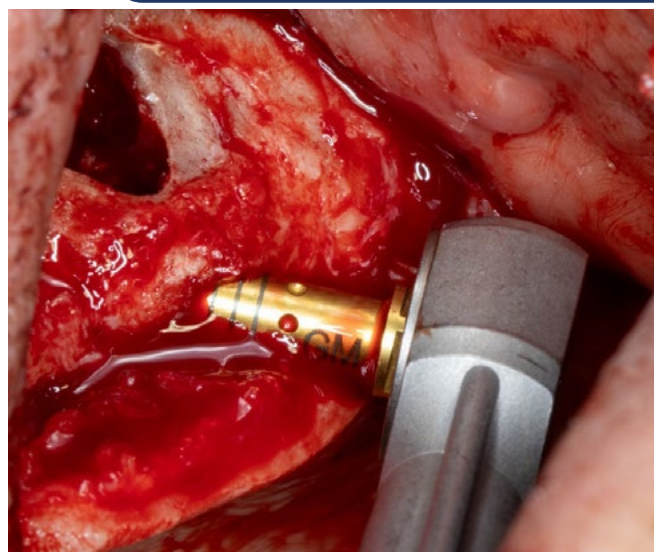
For years, the standard protocol required the implant to remain free of functional load for months until osseointegration was consolidated. This wait meant the patient was left with an edentulous space, wore a removable interim prosthesis, or simply waited. In full-arch rehabilitations, the impact on quality of life was severe.

The development of treated implant surfaces, with roughness controlled by blasting and acid etching, accelerated the osseointegration process and reduced the time needed for consolidation of the bone-implant interface. The evolution in implant design and macrogeometry, with the development of conical bodies and aggressive-profile threads, allowed greater mechanical interlocking between the device and the bone tissue. This increase in primary stability, provided by the self-tapping design and lateral bone compaction, was the determining factor for the safe feasibility of immediate loading protocols. The possibility of placing the implant and connecting the interim prosthesis in the same surgical session transformed the patient experience and the dynamics of the office. Protocols such as the All-on-4, which uses four strategically tilted implants to support a fixed full-arch prosthesis, made it possible to rehabilitate complete arches in a single surgical day.

Immediate loading requires specific conditions: adequate insertion torque, measurable primary stability, prior prosthetic planning, and rigorous occlusal control in the interim phase. The concept is simple; the execution is technical. A professional who attempts immediate loading without mastering these variables puts the treatment outcome at risk.



Helix GM LG Neodent® implant, 3.75 x 20 mm, placed using the transsinus technique.



Implant placement with the aid of a Neodent® ratchet using the transsinus technique.



Final panoramic radiograph of the case treated with immediate loading. Note the difference in the cantilever between the side with the transsinus implant and the side without.

Advanced Surgical Techniques

Not every patient presents sufficient bone volume to receive implants in the ideal prosthetic position. The bone deficiency may be horizontal, vertical, or combined, and its resolution requires reconstructive techniques that significantly broadened the scope of implant dentistry.

The autogenous bone graft, harvested from the patient in areas such as the mandibular ramus, the symphysis, or the tuberosity, remains the reference in bone regeneration; however, due to the morbidity of these techniques, particularly at the donor site, there has been considerable evolution in bone reconstruction alternatives. Substitute biomaterials, such as freeze-dried bovine bone and collagen membranes, and even 3D-printed hydroxyapatite and β -TCP scaffolds for bone regeneration, expanded the options and reduced donor-site morbidity. Techniques such as guided bone regeneration, using titanium-reinforced membranes, made it possible to achieve vertical gains that were previously considered poorly predictable.

Maxillary sinus floor elevation, whether by the lateral window technique or the transalveolar technique, made it feasible to place implants in the posterior maxilla, an area historically challenging due to sinus pneumatization and low bone density. More recently, zygomatic implants and distal tilting techniques have come to offer alternatives for severely atrophic maxillae without the need for grafting.

Soft Tissues

Modern implant dentistry has understood that peri-implant health depends as much on the bone as on the soft tissues around the implant. The presence of keratinized mucosa,

the thickness of the gingival tissue, and the emergence profile of the restoration directly influence tissue stability and the esthetics of the result.

Connective tissue graft techniques, free gingival grafts, and flap repositioning came to be incorporated into the planning of implant cases, especially in the anterior region. The professional who masters these techniques achieves results that go beyond functional tooth replacement and deliver gingival harmony compatible with the adjacent teeth.

What Implant Dentistry Demanded of the Professional

Implant dentistry did not merely add a procedure to the dentist's repertoire. It required a new set of competencies: reading computed tomography, understanding applied biomechanics, mastering reconstructive surgical techniques, knowing prosthetic materials over implants, and the capacity for reverse planning, starting from the ideal prosthetic position to define the surgical position.

This expansion of scope transformed the profile of the restorative professional. Those who once performed preparations, impressions, and cementations now needed surgical training, an understanding of tissue regeneration, and a three-dimensional view of the case. The learning curve was long, in-person mentoring was the main teaching method, and the volume of cases operated was what separated the confident professional from the beginner.

It was this new professional profile that, in the next stage, encountered the digital tools. And the impact of that combination is the subject of the next chapter.

CHAPTER 3

THE DIGITAL REVOLUTION: SCANNERS, CAD/CAM, AND 3D PRINTING

The digital transition in dentistry did not happen all at once. There was no single moment when offices simply swapped stone for the computer. What happened was a sequence of gradual substitutions, in which each new tool solved a specific bottleneck of the analog workflow. The scanner replaced alginate. CAD software replaced manual wax-up. The milling machine and the 3D printer replaced casting. And when these tools began to talk to one another, the entire workflow changed.

This change required a dual competency from the professional. It is not enough to know how to operate the scanner if the file it generates is not properly used in the planning software. It is not enough to design a piece in CAD if the milling machine does not execute that project faithfully. Whoever masters the entire workflow, from scanning to the finished piece, gains control over the result. Whoever masters only one stage depends on third parties for the rest.

Intraoral Scanning

The intraoral scanner captures the topography of the oral tissues through structured or confocal light projection and converts this information into a three-dimensional digital model, usually in STL or PLY format. The process takes a few minutes, causes no significant discomfort to the patient, and eliminates the distortions inherent to conventional impression materials.

The scanners available on the market vary in capture technology, accuracy, speed, and software ecosystem. Devices such as the TRIOS (3Shape), the i700/i900 (Medit), the Primescan (Dentsply Sirona), and the Sirios (Straumann) serve different profiles of use and budget. The common point among them all is that the digital model generated can be sent immediately to the laboratory, imported into planning software, or used for in-house fabrication, without depending on the physical transport of stone models.

The clinical advantage goes beyond comfort. The digital model is stable, does not undergo

dimensional change, can be stored indefinitely, and revisited at any time. Comparisons between scans from different dates allow monitoring of tooth movement, gingival recession, and occlusal wear with millimetric precision. This traceability was unthinkable in the analog workflow.

Dental CAD

CAD (Computer-Aided Design) is the software that transforms the digital model into a prosthetic project. It is where the crown, the framework, the surgical guide, the occlusal splint, or any piece to be fabricated is designed. There are platforms oriented to the laboratory, platforms oriented to the office, and open platforms that serve both.

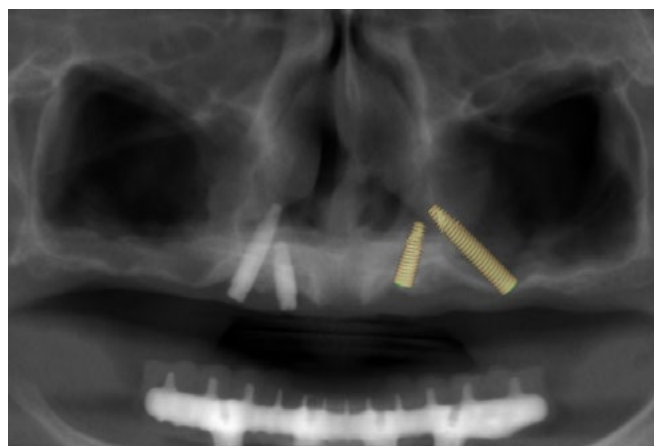


Diagnostic wax-up performed with Exocad software.

DentalSystem (3Shape) is one of the most widely used software programs in digital prosthetic laboratories, with an extensive component library and direct integration with TRIOS scanners. It is a software that, although it does not support many modifications during the CAD workflow, is more intuitive and relatively easier to use. Exocad has established itself as a reference in flexibility and open architecture,

allowing connection with practically any scanner, milling machine, or printer on the market. This vendor neutrality made Exocad popular among laboratories that work with multiple brands of implants and equipment. Another interesting software is Blender, an open 3D design program that supports the purchase of modules, such as B4D. This makes for a software even more open than Exocad, low-cost and with free updates. However, it does not support several CAD libraries from major brands such as Straumann and Neodent, and it requires advanced knowledge to use.

For guided surgery planning, coDiagnostiX (Straumann/Dental Wings), Implant Studio (3Shape), and Exoplan (Exocad) are the reference platforms. They integrate computed tomography with the digital model from the scanner, allowing implants to be positioned virtually and surgical guides to be designed for 3D printing. The professional visualizes the final implant position before touching the patient, with control of angulation, depth, and distance from critical anatomical structures.



Planning of transsinus surgery with the aid of coDiagnostiX software.

Beyond these specific platforms, software such as Meshmixer, originally developed for generic 3D modeling, came to be used by professionals who need advanced control over complex geometries. Mesh editing, reconstruction of damaged areas in digital models, and customized adaptations that conventional dental software does not offer become possible with these tools. The learning curve is steeper, and so is the result.

Table 3 — Main CAD and planning software

Software	Manufacturer	Main application	Architecture
DentalSystem	3Shape	Design of prostheses and components over implants	Integrated (3Shape/TRIOS)
Exocad	Exocad GmbH	Prosthetic CAD design, high flexibility	Open
coDiagnostiX	Dental Wings / Straumann	Guided surgery planning, surgical guides	Open
Exoplan	Exocad GmbH	Implant planning, Guide Creator module	Open (integrated with DentalCAD)
Implant Studio	3Shape	Implant planning, guides and interim restorations	Integrated (3Shape)
Blender	Blender Foundation	Mesh editing, complex geometries	Open (free software) with paid modules

CAM: Milling and 3D Printing

CAM (Computer-Aided Manufacturing) is the stage that transforms the digital project into a physical piece. There are two main paths: milling (subtractive) and 3D printing (additive).

Milling uses a CNC machine that grinds down a block of material, whether zirconia, lithium disilicate, PMMA, wax, or titanium, until it obtains the geometry designed in the CAD. Four- and five-axis milling machines allow complex

geometries with precise fits. The advantage of milling is the density and homogeneity of the final material, since the industrial block undergoes factory quality control. The limitation is material waste and the impossibility of fabricating hollow internal geometries or those with pronounced undercuts.

3D printing works by deposition or photopolymerization of successive layers. In dentistry, the most widely used technologies are SLA (stereolithography) and DLP (digital light

processing), both based on the polymerization of photosensitive resins by ultraviolet light. Applications include study models, surgical guides, interim restorations, custom impression trays, occlusal splints, and, in certified resins, definitive prostheses. There is a trend toward the introduction into dentistry of some deposition printers that produce already-pigmented prostheses and titanium pieces; however, the cost is still very high.

The 3D printer brought to the office and the laboratory something that previously depended exclusively on industrial processes: on-demand fabrication. A surgical guide that took days to be produced externally can now be printed in a few hours, within the practice itself. This gain in speed and autonomy changed the logistics of treatments and reduced dependence on outsourced suppliers.

Table 4 — Milling (subtractive) vs 3D printing (additive)

Criterion	Milling (CNC)	3D printing (SLA/DLP)
Principle	Machining of an industrial block	Layer-by-layer photopolymerization
Materials	Zirconia, disilicate, PMMA, titanium	Resins for models, guides, interim restorations, splints
Accuracy	High (axis-controlled)	High for external geometries
Advantage	Density and homogeneity of the material	On-demand fabrication, hollow geometries, reduced cost
Limitation	Material waste, restricted internal geometries	Mechanical properties inferior to blocks
Typical applications	Definitive crowns, frameworks	Surgical guides, models, interim restorations

In-House Fabrication versus Outsourcing

The decision between producing internally or outsourcing depends on case volume, equipment investment, learning curve, the level of control desired over the result, and the financial break-even point to justify the in-house workflow. Whoever sets up an internal laboratory with a 3D printer and milling machine takes on fixed costs of equipment, materials, and maintenance, but gains speed, quality control, and operational independence. Whoever outsources transfers those responsibilities to the partner laboratory, with the trade-off of longer turnaround time and less control over each stage.

In practice, most digital offices operate in a hybrid model. Pieces of high esthetic complexity, such as layered porcelain crowns, continue to be produced by specialized technicians. Functional pieces requiring geometric precision, such as surgical guides, interim restorations, and working models, are fabricated in-house. This balance tends to shift increasingly toward local production, as printable materials evolve and compact milling machines become more accessible.

What Changes in Daily Practice

The digitalization of the workflow did not eliminate the need for technical knowledge. It redistributed that knowledge. The professional who once needed manual skill to wax now needs digital skill to design. What was once tactile is now visual and parametric. Precision stopped depending on the hand and came to depend on mastery of the software and calibration of the equipment.

This redistribution is the point that many professionals underestimate. Buying a scanner and a 3D printer makes no one digital. What makes a professional digital is understanding the complete workflow, from scanning to delivery, and knowing how to intervene at each point when something does not go as planned. Whoever depends on the automatic button is one failure away from rework.

The previous chapters described what existed and what changed. From the next chapter on, the focus shifts to what is at the frontier: computer-guided planning of guided surgeries, technology applied to the diagnosis of TMD, and artificial intelligence in the clinical routine.

PART II

THE CURRENT FRONTIER

CHAPTER 4

DIGITAL PLANNING AND GUIDED IMPLANT SURGERY

In the previous chapter, I described how the scanner, CAD, and the 3D printer digitalized the prosthetic workflow. This chapter addresses the moment when these tools meet surgery. Digital implant planning and guided surgery represent the most complete integration between imaging diagnosis, simulation software, and on-demand fabrication. The practical result is that the professional enters surgery knowing exactly where each implant will be positioned, with three-dimensional control of angulation, depth, and distance from critical anatomical structures.

This changes the nature of the surgical act. The decision that was once made in real time, with the flap open and the bone exposed, is now made days earlier, calmly, in front of a screen, over measurable data. The surgeon still operates. The difference is that they operate with a map.

The Workflow

The digital planning of a guided surgery follows a defined sequence. The first step is the acquisition of the cone beam computed tomography (CBCT), which provides the three-dimensional volume of the bone, the position of the anatomical structures, and the density of the available tissue. The second step is intraoral scanning, which captures the topography of the soft tissues, the position of the remaining teeth, and the occlusal relationship. The final step for a complete plan is the use of the virtual diagnostic wax-up that will indicate the position of the future prosthesis.

These three data sets, the volumetric (DICOM), the surface (STL), and the virtual wax-up, are imported into the planning software and superimposed through a process called fusion or registration. The accuracy of this fusion is the first critical factor of the workflow. If the superimposition between tomography and scan is misaligned, all subsequent planning carries that error.

With the data fused, the professional positions the implants virtually. The choice of diameter, length, angulation, and depth is made based on the patient's real anatomy, visualized in simultaneous axial, sagittal, and coronal slices. The distance to the mandibular canal, the maxillary sinus floor, the mental foramen, and the roots of adjacent teeth is measured with millimetric precision. The virtual implant can be repositioned as many times as necessary until the ideal position is defined.

Reverse Planning

The logic of guided surgery starts from the prosthesis, not from the bone. This concept, called reverse planning or prosthetically driven implant placement, inverts traditional reasoning. Before, the surgeon placed the implant where the bone allowed, and the prosthodontist resolved the prosthetic position afterward. With reverse planning, the final position of the crown or prosthesis is defined first, and the implant is positioned to support that restoration at the ideal angulation and emergence.

This requires the professional to design the prosthetic restoration before surgery. In software such as coDiagnostiX and Exoplan, it is possible to import the digital wax-up or the prosthetic model and use it as a reference to position the implants. The prosthesis stops being a consequence of surgery and becomes its starting point.

Planning Software

coDiagnostiX, developed by Dental Wings and distributed by Straumann, is one of the most widely used platforms for guided surgery planning. Its implant library covers the main manufacturers on the market, and the software offers tools for automatic nerve detection, guide simulation, and direct export for 3D printing. Integration with the Straumann ecosystem facilitates the workflow for those who already use the brand's implants and components, but the open architecture allows work with systems from other manufacturers. The great advantage

of coDiagnostiX is the possibility of simulating the implant abutments, including angled ones, and it supports exporting the implant position to a prosthetic CAD platform – enabling the fabrication of an interim restoration prior to surgery with the platform connection.



Planning of single-unit guided surgery with coDiagnostiX.

Exoplan, by Exocad, follows the same neutrality philosophy that characterizes the company’s products. The software operates with an open architecture, accepts data from any scanner, and integrates natively with DentalCAD for the design of prostheses over implants. The Guide Creator module allows the surgical guide to be designed within the software itself and exported for printing, with no need for intermediate platforms.

Implant Studio, by 3Shape, completes the trio of most widely used platforms. Its integration with TRIOS scanners and with DentalSystem offers a closed, efficient workflow for offices that operate within the 3Shape ecosystem. The Implant Planner version serves professionals who plan and send the case to the laboratory,

while the full version allows the design and internal fabrication of the surgical guide.

The choice between platforms depends on the professional’s equipment ecosystem, case volume, and preference for open or integrated workflows. Mastery of more than one platform broadens flexibility and makes it possible to handle cases with different brands of implants and equipment.

Types of Surgical Guide

The surgical guide is the physical device that transfers the virtual plan to the patient’s mouth. There are three main types, classified by their support.

The tooth-supported guide rests on the remaining teeth. It is the most stable and the most predictable, indicated for partial cases where there are enough teeth to ensure precise seating. The mucosa-supported guide rests directly on the mucosa and is used in edentulous patients. Its stability depends on adaptation to the ridge and, in many protocols, on fixation with anchor pins. The bone-supported guide requires flap elevation and rests directly on the bone tissue. It is indicated in situations where the mucosa does not offer a reliable reference or when the case requires simultaneous bone regeneration.

All guides are fabricated in biocompatible resin by 3D printing and receive metal sleeves that direct the drills during the osteotomy. The sleeve system controls the diameter, depth, and angulation of the perforation, limiting operative variability to the minimum planned.

Table 5 — Types of surgical guide

Type	Support	Indication	Stability	Flap
Tooth-supported	Remaining teeth	Partial cases	High	No
Mucosa-supported	Ridge mucosa	Fully edentulous	Variable (pins recommended)	No (with fixation)
Bone-supported	Bone tissue	Mucosa without a reliable reference, simultaneous regeneration	High	Yes

Accuracy and Deviations

Systematic reviews published in the literature show that guided surgery with static guides

presents mean deviations of approximately 1.2 mm at the implant entry point and 1.4 mm at the apex, with a mean angular deviation of around 3.5 degrees. These values are significantly lower

than those observed in conventional freehand surgeries, where deviations at the entry point

can exceed 2.5 mm and angular deviations can reach 9 degrees or more.

Table 6 — Accuracy: guided vs conventional surgery

Parameter	Guided surgery (static guide)	Conventional surgery (freehand)
Deviation at entry point	~1.2 mm	>2.5 mm
Deviation at apex	~1.4 mm	>3.0 mm
Angular deviation	~3.5°	>9.0°

Source: data compiled from systematic reviews (Verhamme et al., 2015).

The final accuracy depends on a chain of factors: quality of the tomography, accuracy of the scan, precision of the data fusion, calibration of the 3D printer, seating of the guide in the mouth, and the operator's surgical technique. A perfectly planned guide that seats poorly in the mouth produces a worse result than a simple guide that seats with stability. Every link in this chain must be controlled.

Guided Surgery and Flapless

One of the great advantages of guided surgery is the possibility of operating without flap elevation, the so-called flapless technique. Access to the bone is achieved by transmucosal perforation, directly through the guide. This approach reduces surgical trauma, bleeding, postoperative edema, and the patient's recovery time.

The flapless technique requires that the plan have considered the thickness of the mucosa, the presence of sufficient keratinized mucosa around the implant, and the absence of a need for simultaneous bone correction. Not every case allows flapless. The decision between operating with or without a flap is clinical and must be made during planning, based on each case.

Dynamic Navigation

Beyond static guides, there is the alternative of dynamic navigation. In this system, optical cameras track the position of the drill relative to the patient's anatomy in real time, displaying the planned trajectory on the computer screen during the osteotomy. The surgeon operates without a physical guide, following the drill position on screen in real time and adjusting the trajectory according to the visual feedback.

Dynamic navigation offers flexibility to modify the plan during surgery, which can be advantageous in unforeseen situations. The disadvantage is that accuracy depends entirely on the operator's hand-eye coordination and on the calibration of the tracking system. Comparative studies show similar accuracy results between static guides and dynamic navigation when both are operated by trained professionals.

What Guided Surgery Demands of the Professional

Guided surgery does not simplify implant dentistry. It transfers the complexity of the surgical moment to the moment of planning. The professional who plans poorly operates poorly, with or without a guide. What changes is that digital planning makes errors visible before they happen in the patient's mouth.

Operating with a guide requires mastery of the planning software, understanding of the principles of image fusion, knowledge of the system's accuracy limits, and the ability to identify, during surgery, whether the guide is seating as planned. It also requires knowing when to abandon the guide and convert to conventional surgery, if the clinical situation demands it. Technology is a tool. Clinical judgment remains.

Although the planning and fabrication of the guide can be outsourced, communication between the surgeon and the planner is indispensable. This integration gives the clinician full control over the case and prior mastery of each surgical stage, ensuring that the digital plan is perfectly aligned with the patient's biological reality.

CHAPTER 5

TMD AND OROFACIAL PAIN: TECHNOLOGY APPLIED TO TREATMENT

Temporomandibular Disorder (TMD) is the leading cause of non-dental pain in the orofacial region. It affects the temporomandibular joint (TMJ), the masticatory musculature, and the associated structures, and can manifest as local or referred pain, limited mouth opening, joint clicking, recurrent headache, and discomfort during chewing. The prevalence is high and the etiology is multifactorial, which makes diagnosis and clinical management particularly demanding.

Many professionals treat TMD as an isolated occlusal problem. This oversimplification can lead to irreversible interventions on a condition that, in most cases, responds well to conservative therapies. The current literature is clear: occlusal adjustment by selective grinding has no evidence to support its use as a treatment for TMD, and the relationship between occlusal factors and TMD is less direct than was believed decades ago. Effective treatment depends on precise differential diagnosis, a conservative approach, and longitudinal follow-up.

Diagnosis

The diagnosis of TMD starts from a structured clinical examination. Protocols such as the DC/TMD (Diagnostic Criteria for Temporomandibular Disorders) standardize the assessment through muscular and joint palpation, measurement of mandibular range of motion, and identification of joint sounds. This examination, when well performed, makes it possible to classify the condition into muscular, articular, or mixed subtypes, and to direct treatment rationally.

Cone beam computed tomography (CBCT) contributes to the evaluation of the bony structures of the TMJ, especially when there is suspicion of degenerative changes, condylar erosion, or ankylosis. Magnetic resonance imaging remains the standard for evaluation of the articular disc and soft tissues, although its use in private practice is still limited by cost and availability. The combination of a careful clinical

examination and complementary imaging when indicated reduces diagnostic errors and avoids mistaken treatments.

Occlusal Splints: From Analog to Digital

The Michigan-type stabilization splint remains the standard device in the management of muscular TMDs and in the protection of the stomatognathic system. Its action is based on three main pillars.

The first is protection and load distribution. The splint acts as a physical interface that protects the dental and periodontal structures against the wear and trauma caused by parafunction during sleep.

The second is the biomechanical reduction of force. Use of the splint promotes a stretching of the muscle fibers through the increase in vertical dimension. According to biomechanical principles, this state of muscle lengthening during contraction prevents the muscle from generating its maximum force, resulting in a significantly lower occlusal load than in tooth-to-tooth contact.

The third is orthopedic repositioning. Because it has a smooth surface free of interferences, the splint eliminates the habitual dental interlocking. This allows the mandible to seek a more physiological orthopedic position relative to the maxilla, facilitating correction of the maxillomandibular relationship, whether spontaneously or with the aid of physical therapy.



Milled PMMA splint.

In the analog workflow, fabricating the Michigan splint required an impression with silicone or alginate, a stone cast, mounting on a semi-adjustable articulator, waxing of the splint, and pressing in heat-cured acrylic resin. The process involved multiple laboratory steps, dependence on the technician, and prolonged clinical adjustment. Any error in the impression or in the mounting was reflected in the final fit of the device.

The digital workflow simplified this process. Intraoral scanning generates a precise digital model of the arch, which is imported into the CAD software for the splint design. The

thickness, the occlusal surface, the contacts in centric relation, and the disclusion guides are defined virtually, with numerical control that manual waxing did not offer. The splint is then fabricated by PMMA milling or by 3D printing in certified resin.

The practical gain is significant. The time between scanning and delivery of the splint decreases, the accuracy of the fit increases, the need for clinical adjustment drops, and the reproducibility of the result improves. If the patient loses or fractures the splint, the digital file is stored and allows a new piece to be fabricated without repeating the scan.

Table 7 — Michigan occlusal splint: analog vs digital workflow

Stage	Analog workflow	Digital workflow
Arch registration	Impression with silicone or alginate	Intraoral scanning
Working model	Type IV stone, articulator	Digital model (STL), virtual articulator
Splint design	Manual wax-up	CAD design with numerical control
Fabrication	Pressing in heat-cured resin	PMMA milling or 3D printing
Clinical adjustment	Frequent and prolonged	Reduced
Reproducibility	Low (depends on a new impression)	High (stored digital file)

Bruxism: Counseling as a Clinical Strategy

Sleep bruxism and awake bruxism are distinct conditions with different mechanisms. Sleep bruxism is a movement disorder associated with microarousals and centrally regulated, with little influence from peripheral occlusal factors. Awake bruxism, in turn, is linked to conscious or semiconscious parafunctional habits, such as tooth clenching during activities requiring concentration, stress, or poor posture.

The occlusal splint protects the dental structures from the mechanical effects of sleep bruxism, but the evidence on its capacity to reduce bruxist muscle activity itself is limited. For awake bruxism, the splint has little indication. What works is behavioral counseling: making the patient aware of the moments when they clench their teeth during the day, guiding them on the resting position of the mandible (lips together, teeth apart, tongue on the palate), and proposing self-regulation strategies.

This type of intervention costs nothing in materials and has a measurable clinical impact.

Adequately counseled patients show a reduction in tooth fractures, a lower rate of screw loosening in implant-supported prostheses, less wear of restorations, and a decrease in muscular symptoms. Counseling is underused because it requires appointment time and communication skill, competencies that not every professional prioritizes.

TMD and Implant Dentistry: The Integrated View

The relationship between TMD and implant dentistry requires a sequential and strategic approach. It is a common mistake to confuse TMD with bruxism; while bruxism can generate mechanical overload, TMD involves articular and muscular conditions that must be stabilized before any definitive intervention. Rehabilitating with implants in a scenario of active TMD, with pain, degenerative processes, or joint instability, compromises the predictability of the treatment and the longevity of the prosthesis.

The role of the specialist is to promote prior treatment of the TMD to establish the foundations of the rehabilitation. The initial focus should be control of the symptoms and definition of the essential clinical parameters.

The first is the determination of the OVD. Before the prosthetic phase, it is necessary to reestablish the Occlusal Vertical Dimension therapeutically, ensuring that the functional space is respected.

The second is the orthopedic relationship. The goal is to find the most physiological and comfortable maxillomandibular position for the patient, removing habitual guides and allowing a stable articular seating.

Evaluating and treating the TMJ condition before starting implant dentistry is a requirement for defining the treatment plan. Only after orthopedic and muscular stabilization should one invest in complex rehabilitations. This clinical sequence protects the patient's biological health, avoids rework due to positional planning

errors, and ensures that the load on the implants occurs in a balanced system.

Emerging Technologies in TMD Diagnosis

Surface electromyography makes it possible to assess the electrical activity of the masticatory muscles at rest and in function, providing quantitative data on muscular asymmetry and hyperactivity. Portable sleep-bruxism recording devices, such as intraoral mandibular-movement sensors, are beginning to offer objective data on the frequency and intensity of bruxist episodes, information that previously depended exclusively on the patient's report or on high-cost polysomnographic studies.

Digital occlusal analysis software, such as T-Scan, records the temporal sequence and the distribution of forces during dental contact, making it possible to identify occlusal interferences and prematurities with precision superior to that of conventional articulating paper. These tools do not replace the clinical examination, but they add layers of objective information that assist in decision-making.

CHAPTER 6

ARTIFICIAL INTELLIGENCE IN THE DENTAL PRACTICE

Dentistry moved from the analog era to the digital era in little more than a decade. Scanners replaced alginate, software replaced manual wax-up, 3D printers replaced casting. Now, a new layer is superimposed on this workflow: the algorithmic era. Artificial intelligence tools are already available to any professional with a computer and an internet connection. The question is no longer whether the dentist will use AI. The question is whether they will use it with judgment.

This chapter gathers the content I have been applying in workshops for dentists on the practical use of AI in the clinical routine. The focus is instrumental: which tools to use, what they are for, how to formulate questions that generate useful answers, what safety precautions to observe, and how to start without complicating what already works.

What AI Does and What It Does Not Do

Language models (LLMs, from Large Language Models) work by statistical prediction. The AI processes the sequence of words it receives and calculates the most probable word in the following sequence. It does not think. It does not reason. It calculates patterns based on the massive volume of text on which it was trained. This means that AI can produce articulate, technically plausible, and grammatically perfect answers that are wrong. The professional who uses AI without verifying what it returns is delegating clinical decision-making to a probability calculator.

Two phenomena deserve attention. The first is hallucination: the AI invents data with conviction. False bibliographic references, nonexistent dosages, fabricated protocols. If the link does not open, the source probably does not exist. The second is sycophancy: the AI's tendency to agree with the user's mistaken premises in order to appear helpful. If the professional states that an obsolete technique is effective, the AI

invents reasons to agree. The antidote to both is the same: verification. The AI suggests; the professional validates. Copying and pasting without critical reading is clinical recklessness.

Tools: Each One Has a Function

There are three main categories of AI tools useful in the clinical routine, and each serves a different purpose. Using the wrong tool for the wrong task produces a poor result and creates the false impression that the technology does not work.

Text generation tools are indicated for drafting clinical documents, communicating with patients, technical translation, and creating educational content. They are efficient at turning loose bullet points into formal surgical reports, drafting detailed referral letters, generating postoperative instructions customized by procedure type, and translating scientific texts with appropriate technical vocabulary.

Search tools with source citation are indicated for pharmacological consultation, protocol verification, and evidence-based clinical decisions. The distinguishing feature of these tools is that each statement comes accompanied by its source, allowing traceability. For pharmacology, drug interactions, and management protocols for medically compromised patients, traceability is non-negotiable.

Document analysis tools operate with anchoring technology (RAG, Retrieval-Augmented Generation). The professional uploads their own files (PDFs of guidelines, articles, internal protocols) and the AI responds exclusively based on that material. This eliminates the risk of external hallucination and creates a secure consultation base, customized for the practice or for individual study. It is the safest tool for interrogating scientific documents, comparing articles, and extracting statistical data from multiple studies.

Table 8 — Categories of AI tools in the clinical routine

Category	Main function	Clinical applications	Main risk
Text generation	Writing, translation, communication	Reports, referrals, postoperative instructions, technical translation	Hallucination (fabricated data)
Search with source citation	Evidence-based consultation	Pharmacological protocols, interactions, management of medically compromised patients	Outdated sources
Document analysis (RAG)	Answers anchored in the user's files	Guidelines, article comparison, data extraction	Limited to the loaded content

LGPD and Data Security

The rule is simple: never enter a full name and taxpayer ID in the same query to an AI tool. Use initials, “Patient X,” or only clinical data without identification. Language models may use the entered data for future training, which means that sensitive information typed today may appear, in some form, in a response to another user tomorrow. Professional confidentiality prevails over any technological convenience.

In practice, this requires a simple change of habit: before typing the clinical case into the tool, the professional removes any data that identifies the patient. The time spent on this step is minimal. The risk of exposing sensitive data, if ignored, can have serious legal and ethical consequences.

The Art of the Prompt: How to Formulate Effective Questions

The quality of the answer depends on the specificity of the question. A generic prompt generates a generic answer. A prompt with context, a defined task, and a requested format generates a useful answer. The structure is: who the professional is (context), what they want to know (task), and how they want the answer (format).

Bad example: “Analgesic for pain.” Generates a generic and potentially dangerous answer.

Effective example: “I am a dental surgeon. Female patient, 65 years old, has been taking sodium alendronate 70 mg orally for 4 years for osteoporosis. She wishes to have 2 implants placed in the mandible. What is the current safety protocol and the risk of osteonecrosis? Respond based on AAOMS (American Association of Oral

and Maxillofacial Surgeons) guidelines and cite the sources.”

Box 1 — Anatomy of an effective clinical prompt

Component	Function	Example
Context	Defines the professional and the situation	“I am a dental surgeon. Female patient, 65 years old, alendronate 70 mg oral for 4 years.”
Task	Specifies what is to be known	“What is the safety protocol and osteonecrosis risk for 2 implants in the mandible?”
Format	Defines how the answer should come	“Respond based on AAOMS guidelines and cite the sources.”

The difference between the two prompts is the difference between a disposable answer and a clinically usable answer. Training in prompt formulation is a new competency that the professional needs to develop, in the same way they learned to interpret a panoramic radiograph or read a tomographic slice.

Practical Clinical Applications

The most immediate applications of AI in the clinical routine include five areas that can already be incorporated safely.

Safety protocols for medically compromised patients. Patients taking anticoagulants, bisphosphonates, immunosuppressants, or with conditions such as renal failure and hepatopathy require protocol adaptation. AI, when consulted with specific clinical data and a request for source citation, provides updated

information on dose adjustment, medication suspension window, and local hemostasis measures. Verification against the drug label and the institutional protocol remains mandatory.

Anesthetic dose calculation. For low-weight patients, children, and patients with hepatic or renal impairment, calculating the maximum number of anesthetic cartridges is a task AI performs quickly. The professional provides the patient's weight, the anesthetic salt, and the vasoconstrictor concentration, and the AI calculates the cartridge limit. The result must be checked before administration.

Surgical reports. AI turns loose bullet points from memory into formal, complete text. The professional lists the anesthesia used, the incision technique, the instruments employed, the complications, and the type of suture, and the tool generates a report structured in technical language. The time savings is relevant, and the quality of the documentation improves, which has a direct impact on the professional's legal protection.

Referrals between specialties. Detailed referral letters, with relevant history, procedures performed, and an objective request, are generated in seconds. This improves communication between professionals and reduces errors from incomplete information.

Communicating bad news. AI can suggest approaches for communicating complications, changes in the treatment plan, or unfavorable prognoses to the patient, maintaining an empathetic and professional tone. The generated text serves as a script draft, not as a final script. Human sensitivity remains irreplaceable.

Practical Implementation

The professional who wants to start using AI in the practice should follow three steps. First, choose a simple, repetitive task from the routine, such as writing postoperative reports or postoperative instructions. Second, use the tool for that specific task for two weeks, comparing the result with what they produced manually. Third, progressively expand its use to other tasks, one at a time.

Trying to change everything at once generates frustration and abandonment. Starting with the safe basics, validating the result, and expanding with judgment is the approach that works in practice.

Future Perspectives

Current AI operates predominantly with text. The next phase involves multimodality: simultaneous processing of text and image. Automatic reading tools for radiographs and tomographies already exist in an experimental phase, with algorithms trained to identify periapical lesions, bone loss, proximal caries, and root fractures. The accuracy of these systems improves with each update, and the trend is that they will become auxiliary triage tools in the coming years.

Whoever masters the use of AI with text today will find it easier to incorporate imaging tools when they reach clinical practice. The learning curve will be shorter for those who already understand the logic of prompts, the limits of the technology, and the need for constant human validation.

AI is a tool. The stamp belongs to the professional. In case of error, the responsibility lies with the one who signed, not with the algorithm that suggested.

PART III

GUIDANCE FOR THE PROFESSIONAL OF THE FUTURE

CHAPTER 7

EDUCATION AND TEACHING: THE PROFESSIONAL WHO TRAINS PEERS

Dentistry is a profession learned by doing. Books teach concepts, courses teach techniques, but clinical competence develops through supervised repetition, through error corrected in real time, and through direct exchange with those who have already walked the path. This holds for the alginate impression learned in undergraduate school and it holds for the digital planning of a guided surgery taught today in specialization courses. The vehicle changed. The logic remains.

This chapter addresses the role of teaching in professional development. Teaching is not an activity reserved for academics. Every professional who mentors a younger colleague, who presents a clinical case at a scientific meeting, or who publishes a case report is training peers. This activity multiplies the reach of individual knowledge and raises the standard of the profession as a whole.

Continuing Education as a Technical Necessity

The speed of updating in current dentistry makes unworkable the model in which the professional graduates, completes a specialization, and considers their education finished. Planning software receives annual updates. New restorative materials reach the market every six months. Surgical protocols are revised as new evidence is published. Whoever stopped studying five years ago operates with outdated knowledge in areas that evolve quarterly.

This reality raises a question about the lifelong-certification model, contrasting with the system adopted in the United States, where renewal of the professional license occurs every two years tied to proof of continuing-education credits. Similar models are applied in the United Kingdom and Australia, through mandatory periodic cycles that turn technical development into a legal requirement for maintaining professional registration.

Effective continuing education combines three elements: evidence-based theoretical updating, hands-on training with supervision, and clinical application with outcome follow-up. Courses that offer only theory produce professionals who can describe the technique but do not know how to perform it. Courses that offer only mannequin practice produce professionals who perform without understanding why. The combination of the two approaches, with the support of the digital workflow and follow-up of real cases, is what produces genuine competence.

Teaching the Digital Workflow

Teaching the digital workflow to professionals trained in the analog model requires a specific approach. The professional who spent twenty years taking silicone impressions and working with stone models does not absorb an entire workflow change in a weekend course. The transition must be gradual, starting with one stage of the workflow (usually intraoral scanning), consolidating that stage in the clinical routine, and only then advancing to the next.

In teaching practice, what works is the immersion model with a real case. The student brings a case from their own office, performs the scan, plans in the software, prints the guide, and operates under supervision. They leave the course with a resolved case and with the experience of having gone through the complete workflow at least once. From there, repetition in the office consolidates the learning.

Teaching guided-surgery planning in software such as coDiagnostiX or Exoplan follows the same logic. The student must import the tomography, superimpose the scan, position the implants, design the guide, and follow the surgical result. Each of these stages has critical points that only become clear when the professional makes a mistake and corrects it under guidance. Software is not learned by watching. It is learned by operating.

International Teaching and the Language Barrier

Dentistry is global, and the protocols that work in Curitiba work in Bogotá, in Bangkok, and in Toronto. The difference lies in the implant systems available locally, in the accessible materials, and in each country's regulations. The core technical content, from planning to execution, is universal.

Teaching courses in other languages broadens the reach of knowledge and allows the Brazilian professional to contribute to the training of colleagues in different clinical contexts. This exchange is bilateral: the instructor who teaches in another country learns from the solutions that local professionals developed for the problems they face with the resources they have. Teaching outside one's own environment forces an adaptation of reasoning and enriches the technical repertoire.

Scientific Publication as a Tool for Dissemination

The clinical case report is probably the most accessible form of publication for the professional working in private practice. Documenting a case rigorously, describing the protocol used, presenting the results with follow-up, and discussing the findings in light of the literature transforms an individual experience into shareable knowledge. Publishing a case of a transsinus implant with immediate loading in an atrophic maxilla with clinical and radiographic follow-up, for example, contributes to a body of evidence that is still scarce in the literature on this specific technique.

Publication also compels the professional to organize their reasoning, review the literature, compare their results with those of other authors, and accept peer review. This intellectual exercise has formative value independent of the journal's impact factor. Publishing is a way of accounting for what one does in the clinic, with transparency and rigor.

Clinical Mentoring

Mentoring is the oldest and probably the most effective teaching format in dentistry.

An experienced professional accompanies a professional in training during real clinical procedures, correcting in real time, explaining decisions, and pointing out risks that the less experienced one does not yet see. This format requires availability, patience, and a willingness to explain what, for the mentor, is already automatic.

In implant dentistry, mentoring is particularly relevant because the surgical learning curve depends on case volume and exposure to varied situations. No theoretical course prepares the professional for the complication that happens in the middle of the osteotomy. Whoever has been through it and resolves it knows what the student needs to learn. And they know that this learning only happens beside the patient, under supervision.

The Professional Who Teaches Learns Twice

There is a positive side effect in teaching that is rarely mentioned. Preparing a lecture forces a review of the content. Answering students' questions forces thinking from different angles. Supervising another professional's clinical case forces verbalizing decisions that, in one's own routine, are made by habit. This process of making tacit knowledge explicit refines the instructor's reasoning as much as the student's.

Whoever teaches regularly keeps their knowledge updated out of operational necessity. The commitment to the student works as a mechanism of constant competency validation that prevents complacency. And contact with professionals of different contexts and levels of experience broadens the clinical perspective in a way that the office routine, on its own, cannot offer.

The training of peers is what ensures that technical knowledge survives the professional who produced it. Whoever develops a technique and keeps it to themselves dies with it. Whoever teaches it sets in motion a chain of transmission that raises the standard of the entire profession.

CHAPTER 8

THE MAP OF EVOLUTION: HOW TO PREPARE

The previous chapters described what changed in dentistry and why. This chapter addresses how the professional can organize their own updating without having to overhaul everything at the same time. The technological transition in dentistry is continuous, and the most common mistake is trying to adopt everything at once. Whoever buys a scanner, a 3D printer, a milling machine, and planning software in the same month and has never operated any of that equipment will waste money, lose time, and become frustrated. The approach that works is progressive.

Essential Competencies for Today's Professional

The profile of the professional who stays relevant in the current market combines three pillars: solid clinical technique, mastery of digital tools, and critical thinking to evaluate what is worth adopting and what is merely a passing novelty. No pillar stands on its own. The professional who has impeccable manual technique and ignores the digital workflow loses efficiency and predictability. The professional who masters the software but lacks clinical foundation produces plans that look good on screen and poor results in the mouth. The professional who adopts every novelty without a filter spends resources on technology that will be replaced before it pays for itself.

Critical thinking is what connects the other two pillars. It allows evaluating whether a new material has sufficient evidence for clinical use, whether a new software solves a real problem in the office, whether an update course delivers applicable content or only a certificate. This filtering capacity develops through study of the literature, participation in scientific congresses, discussion of cases with colleagues, and longitudinal follow-up of one's own results.

Building a Progressive Workflow

The first step for those still operating in the analog workflow is to incorporate intraoral scanning. The scanner replaces conventional impressions, eliminates the dimensional instability of impression materials, and generates a digital file that can be used in multiple stages of treatment. The learning curve is short, the impact on the clinical workflow is immediate, and the return on investment is measurable through the reduction of re-impressions and the increase in accuracy of prosthetic pieces. It is worth noting that the scanner has limitations in full-arch cases, both in complete dentures (a functional impression is still necessary) and in implant-supported prostheses due to the matter of passivity between abutments.

The second step is to learn to operate at least one planning or CAD design software. For those working in implant dentistry, digital planning with superimposition of tomography and scan is the natural entry point. For those working in prosthetics, CAD design of single units and guides is the logical path. The choice of software depends on the equipment ecosystem the professional already has and on the type of case they most often handle.

The third step is fabrication. A 3D printer for surgical guides, models, and interim restorations is the investment with the best cost-benefit ratio for those who want to produce internally. Nowadays there are even resins to fabricate complete dentures and even crowns in definitive resin. The milling machine, more expensive and more complex to operate, serves professionals with a high case volume and a need to fabricate definitive pieces in zirconia, PMMA, or lithium disilicate. Whoever does not have the volume to justify the investment in milling can outsource that stage and keep control of the digital workflow up to the export of the file.

Table 9 — Progressive technological-updating workflow

Stage	Tool	Investment	Learning curve	Clinical impact
1st	Intraoral scanner	Moderate	Short (days to weeks)	Eliminates conventional impressions, improves accuracy
2nd	CAD or planning software	Low to moderate	Medium (weeks to months)	Control over the prosthetic or surgical project
3rd	3D printer and/or milling machine	Moderate to high	Medium to long	In-house fabrication, operational autonomy

Smart Investment in Technology

Digital dental equipment has a shorter update cycle than analog equipment. An office compressor lasts decades. An intraoral scanner gets competitors with superior technology every two or three years. This requires the professional to think about the technology investment differently: the goal is to solve a current clinical problem, generate a return within a reasonable time, and accept that, at some point, that equipment will be replaced by a better version.

The mistake is buying technology out of market pressure, out of fear of falling behind, or on impulse after a congress. The right move is to buy technology that solves a bottleneck identified in one's own workflow. If the bottleneck is the impression, the investment is the scanner. If the bottleneck is dependence on the laboratory for surgical guides, the investment is the 3D printer. If the bottleneck is surgical planning, the investment is the software and the training to operate it. The order matters.

However, adherence to the digital workflow does not necessarily require the immediate acquisition of hardware. The professional who chooses not to invest in their own scanner at the moment can enjoy all the technological precision through outsourcing intraoral scanning or virtual case planning. This approach allows the clinician to focus on diagnosis and execution, delegating the capture and processing stage to specialized centers or partner laboratories.

Clinical Research in Private Practice

Research is not exclusive to the university. The professional working in private practice produces clinical data every day. Documenting

this data rigorously, following results over time, and comparing them with the existing literature transforms clinical practice into a source of evidence. Case reports, case series, and retrospective studies can be produced from well-organized records, without the need for external funding or a formal institutional affiliation.

The decision to begin a master's or doctoral program broadens this capacity. Research training teaches method: how to formulate a question that can be answered, how to design a study that minimizes bias, how to analyze results with statistical rigor, and how to submit the work to peer review. These competencies change the way the professional evaluates their own practice and the literature they consume. Whoever has gone through this training reads a scientific article with a different eye.

An In-House Laboratory: Autonomy and Control

Setting up a laboratory within the practice, even a compact one, changes the dynamics of the office. The printing of models and guides comes to be done internally, with control of turnaround and quality. The milling of interim restorations and pieces in PMMA reduces dependence on suppliers and speeds up the workflow. Laboratory knowledge, from calibrating the printer to selecting the printing material, is a competency that few clinicians develop and that generates a real competitive edge.

This combination of clinical and laboratory competencies allows the professional to see the case from scanning to the finished piece. When something goes wrong, they can identify at which stage the error occurred. When everything works, they know how to reproduce

it. This integrated view of the workflow is what turns an equipment operator into a truly digital professional.

Collaboration Networks

No professional masters every area. Implant dentistry in complex cases requires interface with periodontics, prosthodontics, orthodontics and, in cases of chronic pain, with neurology and physical therapy. The digital workflow facilitates this collaboration: planning files can be shared among professionals, cases can be discussed remotely based on digital models and tomographies, and communication between surgeon and prosthodontist gains precision when both operate in the same digital ecosystem.

Building a collaboration network with colleagues who work in complementary areas multiplies the capacity to resolve complex cases and reduces the risk of decisions made in isolation. Participating in study groups, attending scientific

meetings, and keeping open channels of communication with trusted colleagues is as important to professional development as any investment in equipment.

The Map Is Individual

Each professional has a different starting point, a different case volume, a different budget, and a different area of interest. The evolution map of an implantologist who performs guided surgeries daily is not the same as that of a general practitioner who does single-unit fixed prosthetics. What is common to all is the need to evolve in a planned way, based on clear objectives and defined priorities.

The professional who has read this book up to here already has a view of the complete journey: where dentistry came from, where it is now, and where it points. The next step is yours. Identify the bottleneck in your workflow, choose the tool that solves it, learn to operate it, and apply it. Repeat.

FINAL CONSIDERATIONS

Dentistry went from the alginate impression to three-dimensional planning with artificial intelligence in less than two decades. Whoever followed this trajectory closely knows that the speed of change is not slowing. The professional who graduated working with stone and periapical radiographs today lives with scanners, guided-surgery software, 3D printers, and language models that process scientific literature in seconds. This reality will not reverse.

Each chapter of this book described a stage of this evolution. The analog era provided the technical base and the clinical sense that remain indispensable. Implant dentistry expanded the scope of rehabilitation and required competencies that traditional undergraduate education did not cover. The digital workflow redesigned the routine of offices and laboratories. Computer-guided planning of guided surgeries brought predictability to procedures that previously depended almost exclusively on manual skill. TMD showed that technology complements clinical reasoning without replacing it. Artificial intelligence opened a new layer of possibilities, with benefits proportional to the judgment of whoever uses it. And the training of peers ensured that this knowledge did not remain restricted to whoever produced it.

The thread that connects all these themes is the capacity for adaptation. Technology changes. Materials change. Protocols change. What does not change is the need for a professional who knows how to evaluate what works, discard what does not, and apply what has evidence with technical competence and clinical responsibility.

This book was written for the professional who wants to update with direction. The content reflects clinical experience, teaching, and research accumulated over twenty years of practice and seven years of work with digital dentistry. If the reader identified, throughout the chapters, at least one point of their workflow that can be improved with the tools and reasoning presented, the goal was achieved.

The next step is the reader's. The technology is available. The knowledge is accessible. The decision to evolve is individual.

ABOUT THE AUTHOR

Andrei Correa Guandalini is a dental surgeon with more than twenty years of clinical experience, a specialist in Implant Dentistry and in Temporomandibular Disorders and Orofacial Pain. He has worked for seven years with digital dentistry, combining clinical practice (intraoral scanning, computer-guided surgical planning) and laboratory practice (3D printing, CAM milling) in his daily workflow, with command of the coDiagnostiX, Exocad, DentalSystem, and Blender platforms.

A master's and doctoral candidate in Implant Dentistry at ILAPEO, he conducts research in a randomized clinical trial comparing zirconia and titanium implants, in partnership with UNESP. His teaching activity includes the specialization chair in TMD and Orofacial Pain at the Tuiuti University of Paraná (UTP) and the role of guest instructor in international courses at ILAPEO.

He has worked for twenty years in private practice, where he applies the entire digital workflow in an integrated way, spanning the laboratory, surgical, and restorative stages, in addition to the specialized diagnosis and treatment of TMD and Orofacial Pain.

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