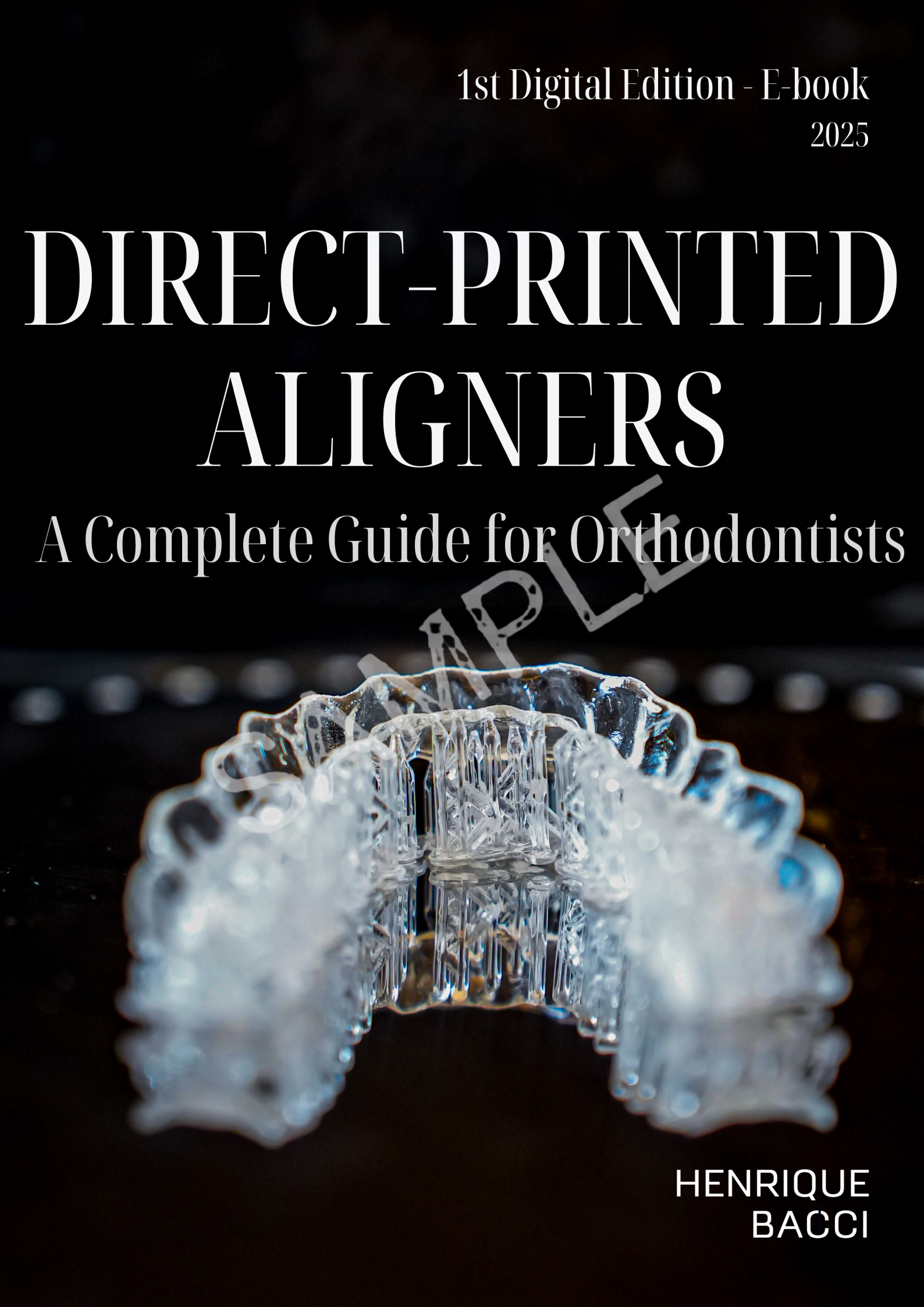
1st Digital Edition - E-book
2025

DIRECT-PRINTED ALIGNERS

A Complete Guide for Orthodontists



HENRIQUE BACCI

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A Complete Guide for Orthodontists

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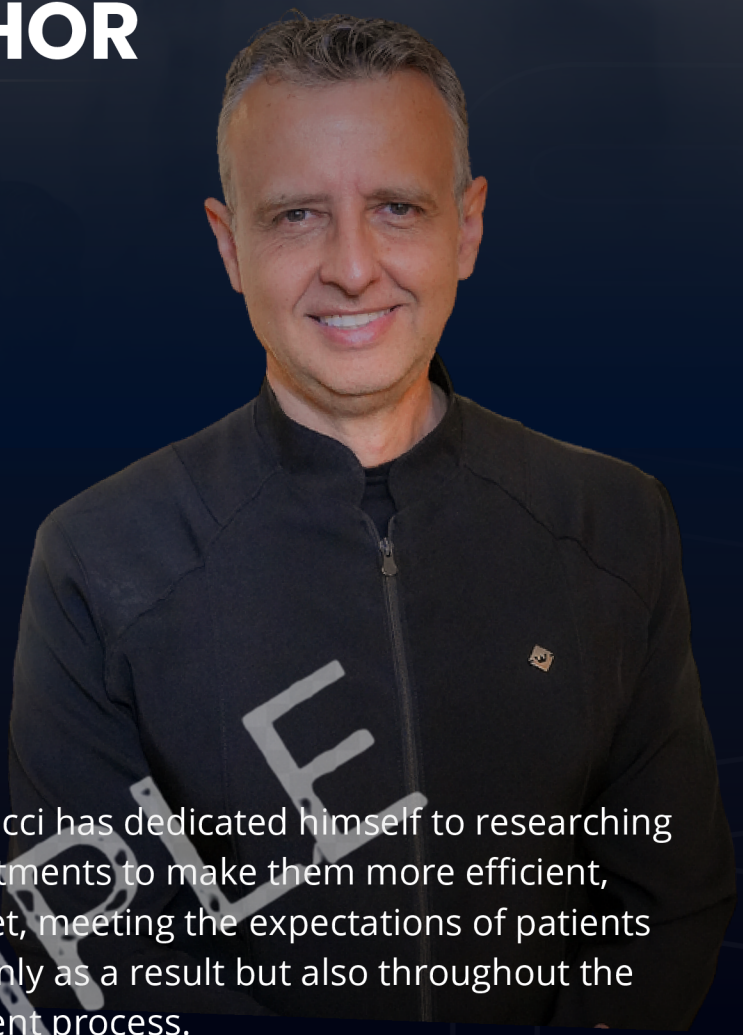
e-Book Version in English
1st Edition – March 2025
Ribeirão Preto - SP - Brazil
ISBN nº 978-65-01-33718-0

Produced by
SHAPE academy

ABOUT THE AUTHOR



Since 2002, Henrique Bacci has been the founder and leader of **Bacci – Invisible Orthodontics**, shaping his vision over the years with increasing conviction about the future of "Invisible Orthodontics." Today, this journey has evolved into the creation of Shape Clear Align®, expanding its aligner manufacturing structure and strengthening its commitment to Aesthetic and Digital Orthodontics, performed with excellence.

With over 30 years of experience, Bacci has dedicated himself to researching and simplifying orthodontic treatments to make them more efficient, comfortable, and, above all, discreet, meeting the expectations of patients who seek an aesthetic smile not only as a result but also throughout the treatment process.

Curriculum:

- Graduated from FORP-USP (Faculty of Dentistry of Ribeirão Preto, University of São Paulo- USP), Ribeirão Preto, São Paulo, Brazil, 1992.
- Master's Degree and Specialist in Orthodontics, with exclusive clinical practice and research focused on Lingual Orthodontics and Clear Aligners.
- President of ABOL (Brazilian Association of Lingual Orthodontics) for the 2023–24 and 2025–26 terms.
- Brazilian Board-Certified Orthodontist, awarded by ABOR (Brazilian Association of Orthodontics). All cases of excellence submitted were treated using Lingual Orthodontics and Clear Aligners.
- CEO of Shape Clear Align®, based in Ribeirão Preto – São Paulo-Brazil.

PREFACE

Orthodontics with direct-print aligners (DPAs) marks the definitive transition of the specialty from the analog to the digital era. If, in the past, orthodontists' hands bent archwires and manually positioned brackets, today, they operate software, envision biomechanics, and plan treatments on a computer screen.

This e-Book brings together the essence of the entire journey of DPAs—the most remarkable representation of the digital transformation in Orthodontics. The path to this point has been far from simple, and the evolution of this technology is still ongoing. However, the effort and dedication invested have culminated in this compendium of modern Orthodontics. **For the first time in the history of the specialty, a publication explores this subject with such depth.**

The reader will witness yet another venture by the author into the world of innovation—the first being in the early days of Lingual Orthodontics, one of the most sophisticated (and complex) approaches to practicing the specialty. Just as the Lingual Technique once was, DPAs today represent a field still in its infancy, with few adopters. Not due to a lack of relevance, but because its complexity had not yet been fully unraveled. With this material, the reader will gain access to new knowledge, grounded in Science and detailed in the *Fundamentals Section*.

A Science that, in Chapter 1, is explored through *Scientific Evidence*, providing a critical and observational analysis of the most relevant studies on the subject. In fact, throughout this work, the reader will find a compilation of information drawn from over 100 scientific articles, consolidating the theoretical foundations that support this revolution in Orthodontics.

PREFACE

No new approach can be applied without a return to the Foundations of Therapeutics. In Chapter 2, we revisit the fundamental principles of thermoformed aligners, understanding their limitations and the reasons why the time has come to consider their replacement with direct-print aligners. Or perhaps, should we call them Shape Memory Aligners?

This new type of aligner, manufactured from an innovative resin, marks a true turning point in Orthodontics. DPAs are not merely the geometric representation of a digital file converted into a physical object. They represent a sophisticated approach to tooth movement, based on unprecedented thermal properties—a concept explored in Chapter 3.

We then arrive at the crucial moment: bringing digital files into the physical world. This process is explored in Section 2, Production, where we understand that the digital-to-printed material conversion requires meticulous planning. Within this context lies Chapter 4, Design Planning, an essential step to ensure that the concept becomes reality with maximum efficiency and predictability.

Printing aligners demands not only a high level of detail but also strategies that enable their practical application. At this point, scientific literature has played a fundamental role, allowing the author to suggest small modifications in the printing process that can be decisive in reducing costs and optimizing production. In Chapters 5 and 6, the reader will grasp the responsibility involved in aligner manufacturing—including the post-curing phase—and the importance of following each step of the process with precision.

PREFACE

We have now reached the moment to give voice to clinical experience, explored in the *Clinical Insights Section*. Chapter 7 begins this journey with a careful and realistic analysis of biocompatibility parameters, which are essential to ensuring the safety of DPAs as intraoral devices.

In Chapter 8, the author proposes an innovative and responsible approach to reducing reliance on attachments in aligner therapy. The *Attachments-Free Start* methodology is presented through a critical lens, considering its feasibility and biomechanical implications. While this proposal may initially face resistance, time will prove that its foundations make sense within the context of the Orthodontics of the future.

And as we review all the progress made, we arrive at the *Reflections* Chapter. Here, the author reassesses the role of Orthodontics in a society transformed by recent challenges, including the pandemic, and discusses how DPAs fit into this new landscape. Furthermore, it explores how the orthodontic industry must rethink its own direction to keep pace with this evolution.

The inevitable conclusion is that we are only at the beginning of a new era. If this work can contribute to the learning process, inspire new researchers to delve deeper into the subject, and pave the way for a more efficient and innovative Orthodontics for clinicians and patients, then its purpose will have been fully achieved.

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GEOMETRIC ACCURACY OF DPAs

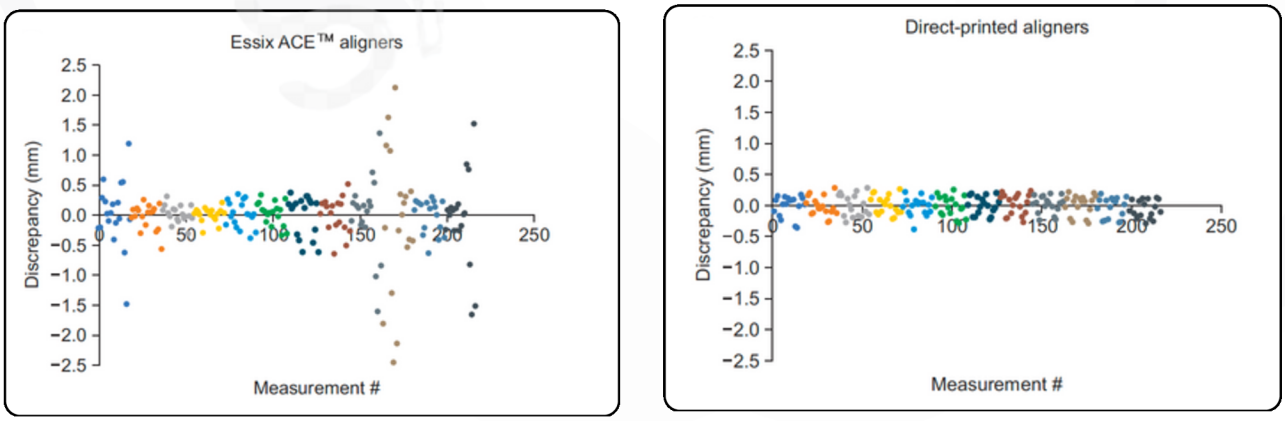
Comparison of dimensional accuracy between direct-printed and thermoformed aligners[1]
Korean J Orthod. 2022

Study Type: Experimental Comparative

What did the authors research?

The study aimed to evaluate and compare the dimensional accuracy of thermoformed aligners and directly printed aligners. The researchers created controlled conditions to directly compare different groups—specifically, two types of thermoformed aligners (Zendura FLX™ and Essix ACE™) with directly printed aligners using Tera Harz™ TC-85 resin (Graphy, South Korea).
The internal adaptation discrepancies were recorded and graphically represented.

RESULTS



The figures above show that the discrepancies are much more evident in the thermoformed aligners (on the left) than in the DPAs (on the right).

"In a way, the DPAs can be considered analogous to NiTi wires, providing gentle and consistent forces over a considerable range of displacements."[15]

The year 2019

The corporate race for Direct-printed Aligners begins.

"The greatest advancement in clear aligner treatment was the introduction of the first resin for direct printing.[1]"

SETTING UP PLANNING STEPS WITH DPAs

One of the main differences between digital planning for thermoformed aligners and DPAs lies in the configuration of the steps, or the amount of movement programmed for each aligner. Due to the unique mechanical properties of DPAs, it is possible to achieve expressive tooth movements with each aligner, thereby reducing the total number of stages needed to achieve the final result.

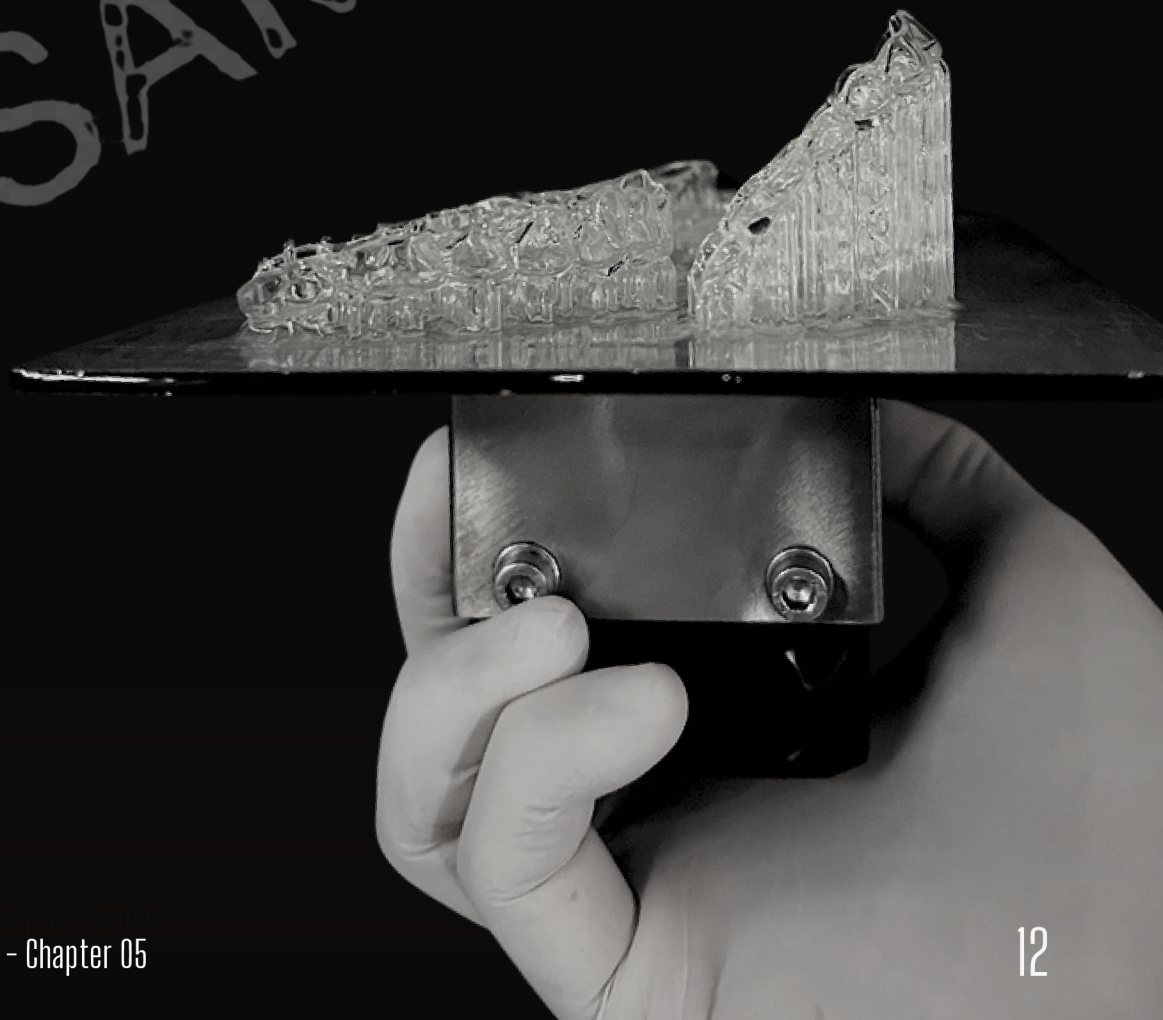
In thermoformed aligners, the limitation in step amplitude is due to the flexibility of the thermoformed material and the risk of tracking loss. On the other hand, DPAs, being directly printed with highly precise and customizable resins, allow for broader and more predictable movements per aligner, without compromising tracking.

The following Table presents a configuration routinely used by the author for the planning of DPAs, comparing it with the configurations traditionally applied to thermoformed aligners.

PRINTING ANGLE FOR DPAS: VERTICAL, HORIZONTAL, OR OBLIQUE?

Just like the other factors discussed so far, the spatial orientation of a DPA aligner during printing has an impact on the workflow. The author proposes a specific printing orientation and, in this section, will detail the arguments that support this choice.

Anyone who has worked with printing orthodontic models knows that the vertical printing position for thermoformed models allows more units to fit on the platform. The same applies to DPA aligners. The vertical position offers an advantage in this regard, while the horizontal position accommodates fewer aligners per print. On the other hand, a horizontal arrangement reduces printing time by requiring fewer layers and also relies on shorter supports.



EQUIPMENT FOR DPAs PRODUCTION (Shape Memory Aligners®)

The production of DPAs, specifically following the protocol for generating Shape Memory Aligners®, represents a recent technological innovation that requires specialized equipment and refined technical expertise. Below are the key pieces of equipment used in the process:

Printing (or Curing) Phase

3D Printer

Post-Cure Process

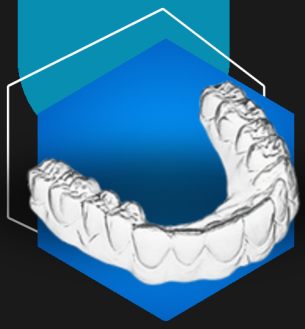
Compressor

Centrifuge

Ultrasonic Cleaner with Heating

Nitrogen Curing Unit

07 BIOCOMPATIBILITY ANALYSIS



We cannot control what happens to us, but we can control how we react.

INTRODUCTION

The oral mucosa is constantly exposed to a wide variety of potentially irritating and sensitizing substances. Due to continuous interaction with food, dental materials, medications, and environmental agents, the mucosa is susceptible to reactions ranging from mild irritation to severe hypersensitivity. This exposure is particularly relevant with orthodontic appliances, such as aligners and retainers, which maintain prolonged contact with oral tissues.

The unique characteristics of the oral environment—heat, moisture, and the presence of saliva—can amplify the release of certain chemical components from materials, increasing the likelihood of irritation or allergic responses.

Newly launched products in the market always demand attention regarding their potential health effects on both patients and clinical staff. This chapter addresses the study of biocompatibility and possible implications of aligner use, especially concerning the new modality of direct printing of these devices.

ECO-FRIENDLY ALIGNERS

The environmental impact caused by industrial production, including the manufacturing of aligners, is a global concern. Non-recyclable materials accumulate in nature, compromising ecosystems and the lives of countless species. In dentistry, from the creation of traditional models to 3D printing, millions of disposable models are produced annually, worsening the problem of waste.

In the case of thermoformed aligners, after the plasticizing and finishing of the appliances—a process that generates even more plastic waste—the models become obsolete and are discarded. Despite this, the environmental impact of these practices is still frequently underestimated.

DPAs emerge as a more sustainable alternative by eliminating the need for physical models. If recyclable, they could represent a significant advancement over thermoformed aligners, establishing an even more eco-friendly approach in Orthodontics.

The intention was never to criticize the use of aligners, but rather to alert the orthodontic community to the potential risks of uncontrolled use of non-recyclable materials and the concerning trend of improperly discarding these materials directly into nature[12,13].

COMMERCIAL STRATEGIES

New products often raise questions, especially regarding how to structure the financial relationship with the patient in a balanced and mutually beneficial way. Clear and transparent communication is essential, especially considering the Orthodontist's credibility when introducing a new treatment modality. Since the perceived value of DPAs is still limited, it is crucial to present the treatment benefits to the patient clearly and objectively.

Considering it is a recent technology, the benefits of treatments with DPAs should always be remembered.

2. DPAs FOR REFINEMENT AND FINISHING

Description:
In this model, the primary treatment is carried out with thermoformed aligners, and DPAs are used in the final stages for more precise adjustments and movement refinement.

Three DPAs were suggested for this purpose—an approximate number for low to moderate-complexity cases, with possible variations.

Advantages:

- Excellent alternative for correcting minor finishing discrepancies using only a few aligners;
- Low cost, considering the limited effectiveness of refinements with thermoformed aligners.

Disadvantage:

- Dependence on the quality of the previous treatment with thermoformed aligners to avoid the need for significant adjustments.

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