Aligner Systems in Invisible Orthodontics

Basic Concepts and Clinical Management

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Preface

This book provides the reader with an in-depth knowledge of the processes involved in providing aligner treatment and describes the techniques and biomechanics involved in providing orthodontic treatment solely with aligners or in combination with other types of appliances.

There has been, over the years, various opinions and contention with regard to the adequacy of providing orthodontic treatment with aligners. Some cases would certainly benefit from this technique in contrast to others that will be worse off in comparison to being treated with other techniques still considered to be the gold standard within the specialty.

Evidence supporting the clear aligner technique remains sparse; however, more studies are being carried out to prove the aligners' clinical abilities and compare them to more traditional techniques principally involving removable and fixed appliances.

Although a vast range of aligner manufacturers and types are available in the market, and this book is completely unbiased, Invisalign® by Align Technology, Inc., remains the market leader and the one most widely used by clinicians at an international level. Consequently, this position has been respected by the author and its usage was reflected during the composition and collation of the latest available information and scientific evidence for this book.

This book, innovative in nature, will provide the reader with an invaluable depth of knowledge with regard to the various types of aligners, the techniques used in their application, the practical aspects of delivery and the scientific data available to back their everyday use.

Cambridge, UK
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Stefan Abela

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Introduction

The increased demand for discreet orthodontic treatment is a widely perceived and accepted phenomenon, and this increased demand has been further exacerbated with the introduction of aligners. With the increased popularity of aligner systems, the number of adults seeking orthodontic treatment has similarly increased exponentially [1, 2]. The superiority over other orthodontic systems include the following:

- Aesthetic discreetness [3]
- Risk reduction of periodontal complications during active treatment [4]
- Comfort and adaptability [5]
- Freedom over masticatory choice [6, 7]
- Possibility of monitoring the progress of treatment remotely [8]
- Provision of efficient mechanics and satisfactory outcomes [9]
- Reduction in operator chair-side time [1, 10]
- Possibility of usage in conjunction with other orthodontic auxiliaries [11]

The current international aligner market is worth around 2 billion USD (US Dollar), but consumer data reports estimate a four-fold market increase by 2028. Reports by Statista, Inc., Ströer Content Group, GmbH, Hamburg, Germany, and by ©Grand View Research, Inc., Los Angeles, USA, are in agreement whilst reports by MarketStudyReport, Pune, India, have forecasted a year-on-year growth between 2021 and 2027 of 27 % leading to a global market value of 14 billion USD in value. The global oral care value is estimated to be around 55 billion USD by 2025, so one cannot leave the proportion dedicated to improving smile aesthetics unnoticed.

Analysis of web searching trends as a reflection of future patients' choices will also increase with a study suggesting an increase of a minimum of 6 % to a maximum of 13 % with the analysis extending to three European countries. This was drawn in direct comparison to the previous year (2021) [12].

On balance, although Align Technology, Inc., California, USA, might be viewed as the most popular aligner manufacturer, other leading aligner systems include: ClearCorrect by Straumann Group Basel, Switzerland;, Spark by Ormco™, California, USA; SureSmile® Dentsply North Carolina, USA; 3M™ Clarity Aligners, 3M Minnesota, USA; F22 Aligner by Sweden & Martina, Padua, Italy; Nuvola® Clear Aligners by GEO Srl, Vicenza, Italy; CA® Clear Aligners by Scheu-Dental GmbH, Iserlohn, Germany; iROK™ Aligners by iROK™ Digital Dental

Studio, California, USA; Angelalign by Angelalign Technology, Inc., Shanghai, China; Alineadent Aligners by Alineadent, Malaga, Spain; Orthocaps TwinAligner® System by Rocky Mountains, Indiana, USA; K Clear and Clear X by K Line, Düsseldorf-Benrath, Germany; EZ-X by DynaFlex®, Missouri, USA; eXceed aligners, by eXceed®, Witten, Germany; Accusmile® by Forestadent, Pforzheim, Germany; smart moves® by Great Lakes Dental Technologies, New York, USA; SLX™ Clear Aligner System and Reveal® by Henry Schein, New York, USA; Refine® by TP Orthodontics, Indiana, USA.

Direct consumer companies, most notably Smile Direct Club™ LLC, Tennessee, USA, aim at providing a direct aligner provision to the customers avoiding the doctor to patient interaction enabling direct entry into the market at a much lower price bracket. Other remotely monitoring aligner systems include Candid™ Aligners, New York, USA; NewSmile™ Aligners, Vancouver, British Columbia, and Byte® Aligners, California, USA, and AlignerCo, New York, USA. Emergence of new providers and cessation of existing ones is a continuously fluid model due to the related costs of production, shipping, marketing and other related costs. In-house production of aligners could also provide a challenge with increasingly user-friendly software and 3D printing facilities becoming more financially accessible.

Most of the scientific articles directly related to orthodontic aligners have been published in the last 10 to 20 years. This trend is also expected to increase as the technique becomes more widespread and clinical advances using this technique together with any accompanying auxiliaries, accomplished.

Clear aligners have seen a significant improvement in their accompanying attachments' design that play a key role with expressing the desired tooth movement [13]. The aligners' flexibility of being used with other appliances further expands their scope rendering their use in orthognathic cases very feasible [11].

The biomaterials, mainly in the form of thermoplastic polymers have also seen an improvement in their physical and mechanical properties and have been extensively researched [14, 15]. The thermoforming process normally takes place on an accurate representation of a patient's dental models and although at this early stage, the materials undergo a change in their properties, their clinical use is not compromised. Further changes to their properties are mediated with the exposure of the intraoral environment. Changes in the their physical composition are rendered tangible with the continuous exposure of moisture, elevated temperatures in comparison to room temperature, elastic deformation and increased stiffness with alterations to their crystalline morphological composition [16, 17]. This phenomenon has led to aligner manufacturers recommending a time interval between successive stages, i.e. between 7 and 14 days.

A key factor to the behaviour and characteristics of an aligner is the thickness used to manufacture it. In general, the thickness of aligners varies between 0.5 mm and 1 mm. The manufacturing process might also bear an influence on the final aligner thickness [18]. The thickness has a directly proportional relationship with the delivery of the orthodontic forces needed for tooth movement but also with the amount of ageing exhibited with intraoral use over time [19].

The future, as alluded to above, will not only see an increase and an improvement with the current techniques but also will progress to incorporate more complex digitisation processes. This will include incorporation of Cone-Beam Computed Tomography (CBCT) data to enable better prediction of crown-root movements and enable full customisation of the appliances, better integration with enhanced software systems to facilitate in-house production by individual clinicians and an increase in both industrial-scale production and direct home delivery systems.

The recently adopted technologies have helped propel aligners to an everyday proposition amongst both general dental practitioners and specialist practitioners. Technologies involving 3D printing, CAD-CAM, and thermoprocessing allowed this uptake and widespread acceptance. The next generation of aligners will adopt four-dimensional (4D) properties with the introduction of the shape memory polymers (SMPs). These new materials will possess the ability to allow changes to the aligners' shape during intraoral use to improve efficacy to yet another level [20].

Another prospective developmental advancement in aligner therapy could be in an extremely rapid turnaround time for production and delivery rendering same-day finalisation of the product very realistic, especially when considering the gigantic advancements in CAT technology. This leap could be potentially attained by the elimination of 3D model printing and thermoforming processes altogether.

The individual manufacturers claim unique selling points and advantageous characteristics over their competitors. These claims are hard to identify; however, the clinician remains solely responsible for ensuring the treatment efficacy and safety of the patient undergoing treatment. Precautions, such as optimal communication and clear outlining of expectations, will ensure successful outcomes. In the case of orthodontic aligners specifically, thorough treatment planning and an immeasurable knowledge of the planning software together with setting realistic tooth movement goals will be key in allowing the clinician to relay the results from a digital platform to a realistic dimension.

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Contents

About the Author

Stefan Abela, BChD, MFDS, MSc, MOrth Dr Stefan Abela is a Specialist, a distinguised Consultant in Orthodontics, directing private practices in London and in Ely, Cambridgeshire within the United Kingdom and an internationally renowned speaker. He obtained his first qualification from the Malta Medical School, University of Malta, Msida, Malta in 2003. To date, he has obtained numerous post-graduate qualifications from The Royal College of Surgeons of England and Edinburgh including a full membership and fellowship with consistent standout contributions to the international scientific community and to the profession. He has been actively involved in the UK's national education and training programme of postgraudate trainees and has been a former head of department at the Norfolk and Norwich University Hospital NHS Foundation Trust, Norwich, UK. Considered an international leader within the profession, he is an avid academic contributor and continuously publishes scientific articles in the highest ranking internationally peer-reviewed journals. He is also an internationally best-selling author of medical text-books with his previous textbook entitled *Leadership and Management in Healthcare: A Guide for Medical and Dental Practitioners*.

Abbreviations

ABO	American Board of Orthodontics
AI	Artificial Intelligence
A-P	Antero-posterior
BPR	Buccal power ridges
BSSO	Bilateral sagittal split osteotomy
CAD	Computer-aided design
CAM	Computer-aided manufacturing
CBCT	Cone-beam computed tomography
GCF	Gingival crevicular fluid
ICP	Intercuspal position
IDS	Invisalign Doctor Site
IMF	Intermaxillary fixation
IOSim	Invisalign® Outcome Simulator
IPR	Interproximal reduction
LL	Lower left
LR	Lower right
LRT	Lingual root torque
MM	Millimetre
OB	Overbite
OJ	Overjet
OMI	Orthodontic mini-implant
PC	Polycarbonate
PET	Polyethylene terephthalate
PETG	Polyethylene terephthalate glycol
PI	Plaque index
PP	Polypropylene
PVS	Polyvinylsiloxane
RCT	Randomised controlled trial
SM	Study model
SMP	Shape memory polymers
STL	Standard triangle language
TMJD	Temporomandibular joint dysfunction
TPU	Thermoplastic polyurethane
UL	Upper left