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Principles and Biomechanics of Aligner Treatment

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Dedication

To Catherine, for her love, support, inspiration, and encouragement.

RN

To Katia, for showing me what love is and for keeping my feet on the ground. To Alessandro, Matilda, and Sveva, because you made the world a brighter place. To my friends, Francesco and Kenji, for your passion, enthusiasm, commitment, and support: you are always an example to follow. To Ravi, for your trust and friendship, for your guidance and leadership: you have translated a vision into reality. It was a wonderful journey with you; thanks for your time and for sharing your experience.

TC

I would like to dedicate this book to all my family with a special thought to my dad, mentor and a visionary, who shared with me a passion in aligner orthodontics for 20 years.

FG

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KO

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Foreword

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Aligners represent the new frontier in the art and science of orthodontics. This new frontier offers new opportunities and challenges, but also requires the need for additional knowledge. A rethinking of biomechanics and force delivery concepts is needed along with the role of materials used for aligners. There is a need for combining established concepts with new tools and technologies which aligner treatment requires.

When considering new methodologies, orthodontists should always remember that technology is a tool and not the goal. Diagnosis, treatment plan, and biomechanics are always the key elements of successful treatment, regardless of the treatment methodology. Aligner orthodontics is quite different than traditional methods with brackets and wires. Force delivery with aligners is through plastic materials. Thus, the knowledge of the aligner materials, physical properties, attachment design, and the sequentialization protocol is crucial for treatment of malocclusions. It is also imperative to understand limitations of aligner treatment and how to overcome them with the use of miniscrews and auxiliaries.

Aligner treatment requires new knowledge; the number of clinical and scientific reports about all the different aspects of aligner orthodontics is increasing year by year. This book represents an up-to-date summary of the available research in the field as well as a clinical atlas of treated patients based on the current evidence. We have made an attempt to provide benchmark for clinicians, researchers, and residents who want to improve their skills in aligner orthodontics.

We would like to express our great appreciation to all the friends and colleagues who have contributed to this book. It was a pleasure to work with all these talented orthodontists.

We would like to say thank you to the Elsevier team for their support, patience, and guidance during the challenging Covid pandemic.

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Fig. 6.17 Pretreatment records of lateral incisor agenesis with apical distance less than 5 mm. A-D intraoral pictures E panoramic x-ray

Fig. 6.18 Posttreatment records of monolateral, lateral incisor agenesis with Invisalign and fixed sectional for root control. A-E intraoral pictures

Fig. 6.19 Pretreatment records of bilateral, lateral incisors agenesis. A-D intraoral pictures

Fig. 6.20 Posttreatment records of bilateral, lateral incisors agenesis treated by space closure and teeth reshaping. A-D intraoral pictures

Fig. 6.21 Space opening by distal tipping of molars. A pre-treatment intraoral picture B post-treatment intraoral picture with implant inserted

Fig. 6.22 Pretreatment records of overerupted upper second molar. A-B intraoral pictures C panoramic x-ray

Fig. 6.23 Posttreatment records of overerupted upper second molar treated by aligners only. A-B intraoral picture C panoramic x-ray

Fig. 7.1 Case 1 initial clinical and radiographic records.

Fig. 7.2 Case 1 frontal and sagittal views of initial ClinCheck.

Fig. 7.3 Case 1 final clinical and radiographic records.

Fig. 7.4 Case 1 frontal and sagittal views of final ClinCheck.

Fig. 7.5 Case 1 lateral x-ray comparison and cephalometric maxillary superimposition before and after therapy.

Fig. 7.6 Case 2 initial clinical and radiographic records.

Fig. 7.7 Case 2 frontal and sagittal views of initial ClinCheck.

Fig. 7.8 Case 2 upper occlusal views at the beginning, after molar distalization, and at the end of therapy.

Fig. 7.9 Case 2 end of distalization; intraoral frontal, occlusal, and sagittal views.

Fig. 7.10 Case 2 final clinical and radiographic records.

Fig. 7.11 Case 2 frontal and sagittal views of final ClinCheck.

Fig. 7.12 Case 2 lateral x-ray comparison and cephalometric maxillary superimposition before and after therapy.

Fig. 7.13 Case 3 initial clinical and radiographic records.

Fig. 7.14 Case 3 sagittal views of initial, intermediate, final pre- and postjump ClinCheck.

Fig. 7.15 Case 3 final clinical and radiographic records.

Fig. 8.1 (A) Smile appearance of the patient. (B) Frontal picture at rest. (C) Three-quarter picture at rest. (D) Three-quarter smile appearance. (E) Profile smiling. (F) Profile at rest.

Fig. 8.2 Initial intraoral pictures.

Fig. 8.3 (A) Initial orthopantomography. (B) Initial lateral x-ray.

Fig. 8.4 ClinCheck initial stage. (A) Frontal view. (B) Right view. (C) Left view. (D) Upper arch view. (E) Lower arch view.

Fig. 8.5 Schematic representation of vertical orthodontic tooth movement design in the frontal plane (A). Amount of vertical movements for upper canines and central incisors (B).

Fig. 8.6 Schematic representation of attachments and auxiliaries required in extraction cases.

Fig. 8.7 (A) Initial smile esthetic analysis. (B) ClinCheck simulation into the smile frame of the Digital Smile Design software.

Fig. 8.8 Treatment progresses in the frontal view.

Fig. 8.9 Treatment progresses in the right view.

Fig. 8.10 Treatment progresses in the occlusal views.

Fig. 8.11 Posttreatment pictures.

Fig. 8.12 Final smile esthetic analysis.

Fig. 8.13 (A) Final orthopantomography. (B) Final lateral x-ray.

Fig. 8.14 Posttreatment extraoral pictures.

Fig. 8.15 Final stage of the ClinCheck refinement.

Fig. 9.1 Optimized extrusive attachments of the Invisalign system.

Fig. 9.2 The anterior extrusive forces and reciprocal posterior intrusive forces work in synergy to correct the anterior open bite.

Fig. 9.3 Rectangular shape attachments with beveled edge toward gingiva.

Fig. 9.4 Palatal attachments and occlusal attachments on upper molars.

Fig. 9.5 Case Study 1: Initial clinical records.

Fig. 9.6 Case Study 1: Pretreatment x-ray records.

Fig. 9.7 Case Study 1: Pre- and post-ClinCheck superimposition.

Fig. 9.8 Case Study 1: Final clinical records.

Fig. 9.9 Case Study 1: Posttreatment x-ray records.

Fig. 9.10 Case Study 2: Initial clinical records.

Fig. 9.11 Case Study 2: Pretreatment x-ray records.

Fig. 9.12 Case Study 2: Pre- and post-ClinCheck superimposition.

Fig. 9.13 Case Study 2: Invisalign with temporary anchorage devices for posterior intrusion.

Fig. 9.14 Case Study 2: End of posterior intrusion.

Fig. 9.15 Case Study 2: Final clinical records.

Fig. 9.16 Case Study 2: Radiographic control and cephalometric superimposition.

Fig. 10.1 Schematic representation of the optimized bite ramps designed by Align Technology (San José, CA, USA) and embedded into aligners. They change shape and positioning along the treatment to provide optimal support to lower incisors at every stage of treatment.

Fig. 10.2 Schematic representation of pressure areas designed by Align Technology (San José, CA, USA) and incorporated into the aligner to redirect the intrusive force along the long axis of the incisor.

Fig. 10.3 Initial extraoral photos.

Fig. 10.4 Initial intraoral photos.

Fig. 10.5 (A) Initial orthopantomography. (B) Initial lateral x-ray. (C) Initial tracing.

Fig. 10.6 Treatment stages scheme illustrating the frog protocol in which alternate intrusion movements of canines and incisors are planned. On the Y axis teeth are displayed, while on the X axis treatment stages are displayed: every stage corresponds to five aligners. The *blue lines* indicate active movements, *brown lines* indicate overcorrection stages. *Red arrows down* indicate when attachments should be placed, while *red arrows up* indicate when attachments should be removed.

Fig. 10.7 (A) Initial curve of Spee. (B) Final curve of Spee.

Fig. 10.8 Final extraoral photos.

Fig. 10.9 Final intraoral photos.

Fig. 10.10 (A) Final orthopantomography. (B) Final lateral x-ray. (C) Final tracing.

Fig. 10.11 Tracing superimposition.

Fig. 10.12 Initial extraoral photos.

Fig. 10.13 Initial intraoral photos.

Fig. 10.14 (A) Initial orthopantomography. (B) Initial lateral x-ray.

Fig. 10.15 In progress intraoral photos. Molar tubes were used on lower first molars for class II elastic anchorage.

Fig. 10.16 Final extraoral photos.

Fig. 10.17 Final intraoral photos.

Fig. 10.18 (A) Final orthopantomography. (B) Final lateral x-ray.

Fig. 11.1 Invisalign First optimized attachments for maxillary expansion.

Fig. 11.2 Invisalign First maxillary expansion protocol staging.

Fig. 11.3 CG intercanine widths assessed at gingival level, CC intercanine widths assessed at cusp level, cG inter-E widths assessed at gingival level, cC inter-E widths assessed at cusp level, MG intermolar widths assessed at gingival level, MC intermolar widths assessed at cusp level.

Fig. 11.4 The anterior and posterior depth of the palatal vault is defined as the vertical distance from the contact line between the cusp of the right and left canine and mesiopalatal cusp tips of the right and left first molars to the palatal vault, respectively. The palatal volume was defined by the median sagittal, distal, and gingival planes as boundaries of the palate. The distal plane (*DP*) passed through two points at the distal of the first upper permanent molars. The gingival plane (*GP*) was created by intersecting the distal and median sagittal planes (*MSP*) through the center of incisive papilla, which is considered a stable point structure.³¹ All planes were perpendicular to each other.

Fig. 11.5 The palatal surface area was defined by the median sagittal (*MSP*), distal (*DP*), and gingival (*GP*) planes as boundaries of the palate. The distal plane (*DP*) passed through two points at the distal of the first upper permanent molars.

Fig. 11.6 Case 1 pre- (A) and post (B) therapy scans of the maxillary arch.

Fig. 11.7 Case 2 pre- (A) and post (B) therapy scans of the maxillary arch.

Fig. 11.8 Runner appliance. Upper arch aligner (A) and lower arch aligner (B).

Fig. 11.9 Intraoral Invisalign First with mandibular advancement feature.

Fig. 11.10 Invisalign First with mandibular advancement feature. Upper arch aligner (A) and lower arch aligner (B)

Fig. 11.11 Case 3 Initial extraoral pictures.

Fig. 11.12 Case 3 initial intraoral pictures.

Fig. 11.13 Case 3 initial radiographic records.

Fig. 11.14 Case 3 sagittal view of ClinCheck.

Fig. 11.15 Case 3 final clinical records.

Fig. 11.16

Fig. 11.17 Case 3 changes of mandibular profile and cephalometric values before and after therapy.

Fig. 11.18 Case 4 initial clinical and radiographic records.

Fig. 11.19

Fig. 11.20

Fig. 11.21 Case 4 sagittal view of ClinCheck and superimposition of initial ClinCheck with final ClinCheck (occlusal view).

Fig. 11.22 Case 4 final clinical records and changes of mandibular profile.

Fig. 11.23

Fig. 11.24 Case 4 cephalometric values before and after therapy.

Fig. 12.1 Case 1. Extraoral pictures before treatment.

Fig. 12.2 Case 1. Intraoral pictures before treatment.

Fig. 12.3 Case 1. (A) Panoramic x-ray before treatment. (B) Lateral x-ray before treatment.

Fig. 12.4 Case 1. Intraoral pictures at end of sagittal first phase.

Fig. 12.5 Case 1. Intraoral pictures before additional aligner stage.

Fig. 12.6 Case 1. Extraoral pictures at end of treatment.

Fig. 12.7 Case 1. Intraoral pictures at end of treatment.

Fig. 12.8 Case 1, (A) Panoramic x-ray at end of treatment. (B) Lateral x-ray at end of treatment.

Fig. 12.9 Case 2. Extraoral pictures before treatment.

Fig. 12.10 Case 2. Intraoral pictures before treatment.

Fig. 12.11 Case 2. (A) Panoramic x-ray before treatment. (B) Lateral x-ray before treatment.

Fig. 12.12 Case 2. Intraoral pictures before sagittal first phase.

Fig. 12.13 Case 2. Intraoral pictures before additional aligner stage.

Fig. 12.14 Case 2. Extraoral pictures at end of treatment.

Fig. 12.15 Case 2. Intraoral pictures at end of treatment.

Fig. 12.16 Case 2. (A) Panoramic x-ray at end of treatment. (B) Lateral x-ray at end of treatment.

Fig. 13.1 (A–E) Early deciduous teeth extraction leads to loss of space and canine impaction.

Fig. 13.2 (A–C) Small size lateral incisors and impacted cuspids.

Fig. 13.3 (A) Missing lateral incisors and (B) bilateral cuspid impaction.

Fig. 13.4 (A–C) Back of right canine prominence in late mixed-dentition patient.

Fig. 13.5 (A, B) The orthopantomography refers to the patient in Fig. 13.4, Ericson and Kurol canine impaction analysis.

Fig. 13.6 Success rate of early deciduous canine extraction (from Ericson and Kurol).

Fig. 13.7 (A–C) Inclination of the canine on lateral cephalometric analysis; parents of this patient refused phase 1 treatment, and upper left canine impaction occurred 3 years later.

Fig. 13.8 (A, B) Canine eruption in alveolar mucosa.

Fig. 13.9 (A, B) Canine erupted labially with lack of keratinized gingiva and higher risk of recession.

Fig. 13.10 (A–E) Deep horizontal impaction may undermine the eruption with a good periodontal support.

Fig. 13.11 (A, B) Lateral incisor on the eruption path of the impacted canine.

Fig. 13.12 (A–C) Clinical case study baseline extraoral.

Fig. 13.13 (A–E) Clinical case study baseline intraoral.

Fig. 13.14 (A–G) Clinical case study baseline x-rays.

Fig. 13.15 (A–E) Clinical case study progression.

Fig. 13.16 (A–F) Clinical case study progression.

Fig. 13.17 (A–C) Clinical case study extraoral final.

Fig. 13.18 (A–E) Clinical case study intraoral final.

Fig. 13.19 (A, B) Clinical case study final x-rays.

Fig. 14.1 Initial intraoral pictures showing multiple restorations.

Fig. 14.2 Initial orthopantomograms.

Fig. 14.3 Clear aligner treatment with attachments and buttons was started. The upper front fixed restoration was sectioned prior the orthodontic treatment start. Class II elastics anchored on upper canines and lower first molars were used to reinforce canine class I relationship.

Fig. 14.4 An implant was placed in 1.2 area.

Fig. 14.5 Frontal view of 1.2 implant with (A) and without (B) aligner.

Fig. 14.6 Frontal view of the final upper anterior restoration.

Fig. 14.7 Final intraoral pictures.

Fig. 14.8 Final extraoral pictures and x-rays.

Fig. 14.9 Initial orthopantomogram of a patient for which a prerestorative orthodontic treatment was required. 12.2 and 2.2 were congenitally missing. The interdisciplinary treatment plan was designed to recover a proper interarch relationship and preparing the case for future restorations on upper front teeth and in the lower arch after the uprighting of 3.7 and intrusion of overerupted 1.7.

Fig. 14.10 Initial intraoral and ClinCheck lateral views in relation to the mesial tipping of 3.7, caused by the premature loss of 3.6.

Fig. 14.11 Initial intraoral and ClinCheck occlusal views in relation to the mesial tipping of 3.7.

Fig. 14.12 Attachment configuration used to recover a proper alignment and leveling of the arches and the uprighting of 3.7. Pontic was not prescribed in 3.6 area to increase the stiffness of the aligner.

Fig. 14.13 Final intraoral and ClinCheck lateral views with successful uprighting of 3.7.

Fig. 14.14 Final intraoral and ClinCheck occlusal views with successful uprighting of 3.7.

Fig. 14.15 Initial intraoral and ClinCheck lateral views in relation to the overeruption of 1.7, caused by the premature loss of 4.6.

Fig. 14.16 Initial intraoral and ClinCheck occlusal views of the upper arch.

Fig. 14.17 Attachment configuration used to recover a proper alignment and leveling of the arches.

Fig. 14.18 Final lateral intraoral and ClinCheck views of the right side showing intrusion and leveling of 1.7 obtained with the aid of a buccal miniscrew and a segmented auxiliary arch bonded on 1.8 and 1.6 after proper modification of the aligners.³⁰ Intrusion of 1.4 was planned to level gingival edge to the 2.4 one. An implant was placed in 4.6 area during the final stages of the orthodontic treatment.

Fig. 14.19 Final intraoral and ClinCheck occlusal views of the upper arch.

Fig. 14.20 Final orthopantomogram.

Fig. 14.21 Initial intraoral pictures.

Fig. 14.22 Initial extraoral pictures and orthopantomogram.

Fig. 14.23 Initial cone-beam computed tomography scans highlighting the asymmetric condyles position.

Fig. 14.24 Lower occlusal splint.

Fig. 14.25 Cone-beam computed tomography scans showing condyle repositioning due to the splint effect.

Fig. 14.26 Acrylic provisionals used to keep the new mandible position during the orthodontic treatment.

Fig. 14.27 Initial stage of the ClinCheck.

Fig. 14.28 Final stage of the first ClinCheck.

Fig. 14.29 Intraoral pictures at the end of the first set of aligners.

Fig. 14.30 (A) Lateral and (B) posteroanterior x-rays at the end of the first set of aligners.

Fig. 14.31 Intraoral pictures at the end of the second set of aligners.

Fig. 14.32 Final stage of the second ClinCheck.

Fig. 14.33 (A) Final orthopantomogram and (B) lateral x-ray.

Fig. 14.34 Intraoral pictures showing the lower implants and the final prosthodontic restorations.

Fig. 14.35 Final extraoral pictures.

Fig. 15.1 The Beneslider appliance is based on one or two mini-implants with exchangeable abutments.

Fig. 15.2 The aligners can cover the bonded connection like a big attachment. After distalization, steel ligatures are to modify the active Beneslider into a passive anchorage device.

Fig. 15.3 The aligners can be cut out in this connection area ("button cutout"). Springs are removed in this case to modify the active Beneslider into a passive anchorage device.

Fig. 15.4 A 37-year-old female patient with an angle class II malocclusion characterized by anterior crowding and a deep bite.

Fig. 15.5 After insertion of two Benefit mini-implants in the anterior palate (A) and installation of the Beneslider mechanics (B). Superimposition of an intraoral picture of the maxillary arch and the ClinCheck to demonstrate desired tooth movement directions (C).

Fig. 15.6 Beneslider was activated by pushing open springs distally after delivery of the aligners. Connection areas of the Beneslider with the molars are covered by the aligner ("big attachment").

Fig. 15.7 Radiographs after 5 months of treatment. Orthopantomography and lateral x-ray after 5 months of treatment.

Fig. 15.8 Intraoral pictures after 8 months.

Fig. 15.9 Intraoral pictures after 10 months showing many small spaces due to the semisequential distalization.

Fig. 15.10 Intraoral pictures after 12 months. Molars are distalized in a Class I occlusion. The Beneslider is modified into a molar anchorage device by two steel ligatures, which are deactivating the Beneslider. From this moment, bicuspid, canine, and incisor retractions are following.

Fig. 15.11 Intraoral pictures after 14 months.

Fig. 15.12 Upper arch after 15 months. All spaces were to be closed to the distal. Subsequently, the Beneslider was removed for refinement.

Fig. 15.13 Treatment result after 19 months.

Fig. 15.14 Superimposition of before and after cephalograms (S-N). Upper incisor retraction is significant.

Fig. 16.1 Pathologic tooth migration in an old man.

Fig. 16.2 Pathologic tooth migration in a young woman. (A) Intraoral picture highlighting the tissue breakdown. (B) Extraoral picture (please note the position of element 2.1). (C) Scheme representing tissue breakdown.

Fig. 16.3 Transseptal fibers balance loss and pathologic tooth migration.

Fig. 16.4 Preliminary evaluation of an ortho-perio patient.

Fig. 16.5 In this class II adult patient, incisors are crowded, extruded, and proclined. Soft and hard tissue grafting can be helpful before orthodontic treatment to prevent the development of recessions.

Fig. 16.6 In this adult patient, a previous excessive orthodontic expansion promoted a gingival recession on teeth 13 and 23. The occlusal instability has led to orthodontic relapse.

Fig. 16.7 Orthodontic relapse in a young patient; teeth 33, 32, and 43 are located outside the buccal bone. The twisted retainer, probably not passive, allowed a radicular torque movement⁴⁸ on tooth 32 that promoted a gingival recession with lack of adherent gingiva.

Fig. 16.8 Different tooth shapes.

Fig. 16.9 Center of resistance variation in case of bone loss.

Fig. 16.10 In this patient, a stainless steel power-arm has been bonded to tooth 12, and retraction has been performed using maximum anchorage.

Fig. 16.11 Mesialization of lower third molars.

Fig. 16.12 Selective intrusion of worn teeth.

Fig. 16.13 Baseline intraoral view.

Fig. 16.14 Baseline smile.

Fig. 16.15 Working contacts.

Fig. 16.16 Baseline status.

Fig. 16.17 Baseline periodontal chart.

Fig. 16.18 Reevaluation chart.

Fig. 16.19 (A) Tooth-by-tooth diagnosis. (B) Tooth-by-tooth prognosis.

Fig. 16.20 Periodontal status and chart at reevaluation.

Fig. 16.21 Regenerative therapy on tooth 14. (A) Bone sounding, (B) incisional photos, (C) flap photos.

Fig. 16.22 Regenerative therapy on tooth 14: biomaterial photos. (A) Defect cleaning. (B) Emdogain (EMDs). (C) Pref Gel (EDTA). (D) BioOss.

Fig. 16.23 Regenerative therapy on tooth: suture photos.

Fig. 16.24 Regenerative therapy on incisors. (A) Incision photos and, (B) flap photos.

Fig. 16.25 Regenerative therapy on incisors: biomaterial photos. (A) Defect cleaning. (B) Emdogain (EMDs). (C) Pref Gel (EDTA). (D) BioOss.

Fig. 16.26 Osseous resective surgery 6-degree sextant.⁹⁴⁻⁹⁶ Alternative therapies: periodontal supportive therapy,^{85,91,97} conservative surgery,⁹⁸⁻¹⁰¹ resective bone surgery.⁹⁴⁻⁹⁶

Fig. 16.27 Resective surgery: bone remodeling.

Fig. 16.28 Orthodontic records.

Fig. 16.29 ClinCheck beginning (A) and end (B): frontal view.

Fig. 16.30 ClinCheck beginning (A) and end (B): upper arch.

Fig. 16.31 ClinCheck beginning (A) and end (B): lower arch.

Fig. 16.32 ClinCheck beginning (A) and end (B): right side.

Fig. 16.33 ClinCheck beginning (A) and end (B): left side.

Fig. 16.34 End of preprosthetic orthodontics.

Fig. 16.35 Implant 1.5, 1.7.

Fig. 16.36 Implant placement.

Fig. 16.37 Implant placement photos.

Fig. 16.38 Implant placement: biomaterials. (A) Bony window. (B) Sinus membrane elevation. (C) BioOss. (D) BioOss and membrane positioning.

Fig. 16.39 Final orthodontic x-rays.

Fig. 17.1 Surgical splint with holes to be used in a patient undergoing orthognathic surgery using Invisalign as the only appliance for orthodontic treatment. Note that no labial orthodontic appliances are present.

Fig. 17.2 Surgical final splint without occlusal coverage to be left for 4 to 5 weeks postsurgically due to a three-piece-maxilla osteotomy.

Fig. 17.3 Three-dimensional virtual surgical plan. (A) Presurgery. (B) Planned osteotomies consisting of three-piece-maxilla with impaction of the posterior segments and mandibular advancement with genioplasty.

Fig. 17.4 Postsurgical occlusion deviating slightly from the planned occlusion. A) Right buccal, B) Left buccal, C) frontal occlusal views.

Fig. 17.5 Occlusion seated with intermaxillary elastics and clear aligners to the planned outcome after 3 months. A) Right buccal, B) Left buccal, C) frontal occlusal views.

Fig. 17.6 Pretreatment extraoral photos. A) Frontal lips relaxed, B) smile, C) profile, D) Oblique, E) Oblique smiling views.

Fig. 17.7 Pretreatment intraoral photos. A) Right buccal , B) Frontal, C) Left buccal occlusion. D) Maxillary and E) Mandibular occlusal views.

Fig. 17.8 Pretreatment digitized lateral cephalogram.

Fig. 17.9 Pretreatment panoramic radiograph.

Fig. 17.10 (A) Three-dimensional (3D) virtual surgical plan presurgery. (B) Landmark changes with the planned surgery in 3D. (C) Counterclockwise rotation of the maxillomandibular complex.

Fig. 17.11 Planned postsurgical occlusion with overcorrection. A) Right buccal, B) Frontal, C) Left Buccal views of the planned occlusion

Fig. 17.12 Extraoral photos 2 weeks postsurgery. A) Frontal, B) Profile, and C) Smiling views.

Fig. 17.13 Intraoral photos 2 weeks postsurgery. A) Right buccal, B) Frontal and C) Left buccal views of patient in occlusion.

Fig. 17.14 Reduction of facial swelling 2 months postsurgery. A) Frontal, B) Profile, and C) Smiling views.

Fig. 17.15 Intraoral photos 2 months postsurgery. A) Right buccal, B) Frontal, and C)

Left buccal views.

Fig. 17.16 Lateral open bite on the right is still present 5 months after surgery. A) Right buccal, B) Frontal, and C) Left buccal views of patient in occlusion.

Fig. 17.17 Cantilever arm extended from bonded lower right molar tube to upright this tooth using an elastic from the maxillary miniscrews; aligner cut distal to the lower right canine to allow eruption of the buccal segment.

Fig. 17.18 Extraoral photos 12 months postsurgery.

Fig. 17.19 Intraoral photos 12 months postsurgery. A) Right buccal, B) Frontal, and C) Left buccal views of patient in occlusion.

Fig. 17.20 Posttreatment extraoral photos. A) Frontal, B) Smiling and C) Profile views.

Fig. 17.21 Posttreatment intraoral photos. A) Right buccal, B) Frontal, and C) Left buccal views of patient in occlusion. D) Maxillary and E) Mandibular occlusal views.

Fig. 17.22 Posttreatment lateral cephalogram.

Fig. 17.23 Posttreatment panoramic radiograph.

Fig. 17.24 Superimposition of the skeletal and soft tissue changes.

Fig. 18.1 Trajectory of dental pain after orthodontic procedures.

Fig. 19.1 Examples of relapse after orthodontic treatment, where either the patient failed to wear the retention appliances after rapid maxillary expansion (A-C) or the retention regime selected was insufficient for a noncompliant patient; the rotational relapse of lateral incisors (D-F) and palatal movement of upper left canine (G-I) shown could have been prevented by bonding a fixed retainer and including problematic teeth.

Fig. 19.2 Calculus accumulation and gingival inflammation around the lower bonded retainer (A and B).

Fig. 19.3 Examples of failures of bonded retainers. (A) The detachment of a composite resin layer is usually a consequence of bonding errors. (B) The loss of the adhesive layer due to mastication or premature contact on the bonded retainer. (C) Premature contact on the retainer wire, wire fatigue, or selection of a wire with insufficient mechanical properties (small diameter dead-soft wire) resulting in fracture of the wire. (D) Extending the upper retainer to the canines increases the risk of fracture, with consequent wire activation and unwanted tooth movement.

Fig. 19.4 Two distinct types of unexpected complication of lower bonded retainers: opposite torque on two adjacent incisors (X effect; A, B) and opposite inclination of contralateral canines (Twist effect; C, D). Both X effect and Twist effect may be accompanied by severe gingival recession (A, C).

Fig. 19.5 Unexpected complication of lower bonded retainer (Twist effect): lower left canine moving out of the bony envelope (A-C). Significant bony dehiscence can be identified on dental cone-beam computed tomography (B, C).

Fig. 19.6 Treatment of a complication associated with a lower bonded retainer. (A-C) Lower left central and lateral incisors severely proclined by a fractured bonded retainer and lingual gingival recessions occurring on both incisors. (D-F) Retreatment with a full lower fixed appliance corrected the torque of the incisors and was followed by a periodontal reconstructive surgery. (G-I) Final reconstruction with full porcelain crowns and bonding of a new lower fixed retainer.

Fig. 19.7 When long-term retention is indicated, regular recalls are necessary to check

retainers; however, attendance of patients decreases in the retention period, as seen on this graph.

Fig. 19.8 Hawley retainer with frontal bite plane in occlusal (A), front (B), and lateral (C) views.

Fig. 19.9 Vacuum-formed thermoplastic retainer in the upper jaw in frontal view (A) and smile (B).

Fig. 19.10 Retention activator after class II treatment in lateral right (A), frontal (B), and lateral left (C) views.

Fig. 19.11 Different types of commonly used fixed retainers. Upper retainers can include incisors only (A), or even both canines, either continuous (B) or segmented (C); the segmented version is more suitable because premature contact on the retainer can be avoided, thereby decreasing both the incidence of fracture and the adhesive layer. (D) Lower fixed retainer usually includes canines and incisors. Vestibular retainers can be used after difficult extraction space closure (E) or as a space maintainer prior to implant placement (F).

Fig. 19.12 Examples of typical indication in which use of fixed retainers is recommended. (A, B) Difficult extraction space closure. (C, D) Large midline diastema closure in a periodontally compromised patient. (E, F) Space closure in a patient with generalized spacing. (G, H) Severe crowding and tooth rotations.

Fig. 19.13 (A, B) Lateral open bite often occurs after aligner treatment. (C, D) The clinical picture at the end of treatment may thus differ when compared to the final situation depicted in the treatment planning software. (E, F) However, the clinical situation after 2 years in recall shows that the teeth will eventually settle into the desired position.

Fig. 19.14 Natural settling of teeth after orthodontic treatment in recall after 6 months, as visualized on T scans of a patient wearing a Hawley retainer at nighttime (A, B) and a thermoplastic retainer (C, D).

Fig. 19.15 Treatment of an open bite with aligners that was facilitated by intrusive force in the lateral segments.

Fig. 19.16 Relapse of anterior open bite due to short retention thermoplastic retainers and consequent extrusion of second molars. Situation after treatment (A-C) and 1.5 years in recall (D-F).

Fig. 19.17 Treatment planning software can be used to plan the position of lower incisors exactly, avoiding unwanted proclination of the lower incisors and thus preventing the risk of relapse.

Fig. 20.1 Initial intraoral photographs of adult patient with class I malocclusion dentoalveolar contraction in both arches.

Fig. 20.2 Intraoral photographs during aligner therapy with composite buttons.

Fig. 20.3 Final intraoral photographs after 20-step aligner treatment.

Fig. 20.4 Initial intraoral photographs of a young patient with skeletal and dental class III and narrow upper jaw.

Fig. 20.5 Rapid palatal expansion with arms for Delaire mask on deciduous second molars.

Fig. 20.6 Hybrid expander with dental and skeletal anchorage in upper jaw and arms for Delaire mask.

Fig. 20.7 Intraoral photograph during aligner therapy.

Fig. 20.8 Final intraoral photographs after 11-step aligner treatment.

Fig. 20.9 Initial intraoral photographs of adult patient with skeletal contraction of upper jaw, class III tendency and gingival recession in both arches.

Fig. 20.10 Rapid palatal expansion with skeletal anchorage (MAPA method).

Fig. 20.11 Intraoral photograph during aligner therapy.

Fig. 20.12 Final intraoral photographs after aligner therapy.

Fig. 20.13 Initial occlusal intraoral photographs of an adult patient with severe rotation of the upper incisors (A) and right lower canine (B).

Fig. 20.14 Occlusal intraoral photographs during treatment with composite buttons on the lingual surfaces of teeth 1.3, 2.1, 2.2, and 4.3.

Fig. 20.15 Intraoral photograph during aligner therapy.

Fig. 20.16 Final intraoral photographs after 20-step aligner treatment.

Fig. 20.17 Initial photographs of a young patient with rotation greater than 20 degrees of left upper canine and left second premolar.

Fig. 20.18 Application of microtubes on rotated, mesial, and distal teeth.

Fig. 20.19 Occlusal photographs. (A) Upper arch with thermal NiTi 0.013 sectional. (B) Upper arch with aligner covering thermal NiTi 0.013 sectional. (C) Lower arch with thermal NiTi 0.013 sectional. (D) Occlusal photograph of lower arch with aligner covering thermal NiTi 0.013 sectional.

Fig. 20.20 Final intraoral photographs after seven-step aligner treatment.

Fig. 20.21 Initial intraoral photographs of young patient with anterior open bite and maxillary contraction.

Fig. 20.22 Bite-block expander with anterior grille.

Fig. 20.23 Frontal intraoral photograph after the first stage of treatment with palatal expander and grille.

Fig. 20.24 Intraoral photograph during aligner therapy.

Fig. 20.25 Final intraoral photographs after 10-step aligner treatment.

Fig. 20.26 Initial intraoral photographs of a young patient with deep bite and class II.

Fig. 20.27 Lateral intraoral photograph during aligner therapy combined with class II elastics.

Fig. 20.28 Final intraoral photographs after 14-step aligner treatment.

Fig. 20.29 Right initial intraoral photograph of a patient with class II subdivision and contraction of the upper jaw.

Fig. 20.30 Lateral intraoral photograph during aligner therapy combined with class II elastics.

Fig. 20.31 Right lateral intraoral photograph lateral after aligner treatment.

Fig. 20.32 Left initial intraoral photograph of a patient with class II subdivision and contraction of the upper jaw.

Fig. 20.33 Rapid palatal expansion and pendulum with skeletal anchorage (MAPA method).

Fig. 20.34 Lateral intraoral photographs during aligner therapy (A) and combined with class II elastics (B).

Fig. 20.35 Left lateral intraoral photograph after aligner therapy.