

Controversies in Clear Aligner Therapy

Contemporary Perspectives,
Limitations, and Solutions

Anderson T. Huang
Darren Huang

Controversies in Clear Aligner Therapy

Anderson T. Huang • Darren Huang

Controversies in Clear Aligner Therapy

Contemporary Perspectives,
Limitations, and Solutions

Anderson T. Huang
Department of Orthodontics
New York University, College of
Dentistry
New York, NY, USA

Darren Huang
Department of Orthodontics
New York University, College of
Dentistry
New York, NY, USA

ISBN 978-3-030-92809-4 ISBN 978-3-030-92810-0 (eBook)
<https://doi.org/10.1007/978-3-030-92810-0>

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Switzerland AG 2022

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

For Johnny

Foreword

Authoring an orthodontic textbook to address controversies is refreshing, ambitious, and evidence of self-reflection by the authors who have gained a good amount of experience with clear aligners. In the age of evidence-based practice in health care, this was a much-needed effort to examine critically, 22 years after the launch of *Invisalign*, the current knowledge regarding the treatment of malocclusions with clear aligners.

As Chair of the Department at New York University where Drs. Anderson and Darren Huang teach orthodontics, I am honored to write the Foreword to their book, **Controversies in Clear Aligner Therapy: Contemporary Perspectives, Limitations, and Solutions**. They are both graduates of the College of Dentistry and of the Advanced Education programs. Dr. Anderson Huang's long interest in clear aligner therapy has been well known in the Department of Orthodontics for many years. He is joined by his son Darren, a more recent graduate, who shares the same clinical interest and educational perspectives. As orthodontists, neither one is inclined to settle for less than excellence.

One of my goals as Chair of the Department of Orthodontics is to educate students to consider the best interest of the patients they care for, and therefore to adopt a best-practice approach to treatment planning. With this in mind, there is a dearth of books devoted to clear aligners other than those which explain how to use the appliances and how to plan and sequence tooth movements with the aligners. As a practitioner, I find such information much needed, and I believe that sharing one's experience on any treatment modality with one's orthodontist peers is valuable and respectable. Like many, I was at first a dubious user of clear aligners for orthodontic treatment. Some movements, such as extrusion or rotations, were difficult to accomplish and frequently required fixed appliances to achieve treatment goals to satisfaction.

It is undeniable that 20 years later, orthodontic treatment with clear aligners has become more sophisticated; for example, the software platforms have made communication with technicians easier. With software improvements, practitioners have learned to plan tooth movement better, and this brought their treatment goals and planning to higher grounds. However, despite these improvements, there are still many global questions practitioners have regarding this treatment modality no matter the type of aligner one may prefer or select.

What sets this work apart is the authors' reflections and their acknowledgement that there are debate and disagreements on the effectiveness of

clear aligners. To name a few: their use during interceptive treatment, as substitute to functional appliances, the predictability of root movements, is there too much interproximal enamel reduction being used, or excessive expansion prescribed. Additionally, how effectively can one correct an open bite with clear aligners, when many have been humbled by attempting bite closure with mere fixed appliances.

Such reflective work is welcome by all orthodontists interested in using clear aligners on a routine basis. After all, it took many years of practice and learning from mistakes to master the use of fixed appliances whether on the labial or lingual side of the dental arches. For those who first thought that clear aligners would be the panacea of orthodontic treatment, one just needs to recall the enthusiasm generated by the wide accessibility to straight-wire appliances and the belief that orthodontic treatment could be rendered by any practitioner no matter their degree of knowledge or experience.

I think you will find this book very useful and refreshing to read; you are not the only one to have questions, strong convictions, and doubts, and yet wish to better yourself in treating patients with clear aligners because you understand that they are here to stay.

I applaud Drs. Anderson and Darren Huang for researching and writing this book, for being thorough in their thinking, and for demonstrating critical judgment on the efficacy of treatment with clear aligners. With these efforts, we are all going to improve our treatment of patients with clear aligners.

Olivier Nicolay
Chair, Department of Orthodontics
New York University
New York, NY, USA
August 30, 2021

Preface

Since the introduction of the Invisalign appliance in 1999, clear aligner therapy has gradually become a significant modality of orthodontic treatment for the modern orthodontist and an area of intensive scientific research in the orthodontic field. The first clear aligners were limited to the treatment of mild malocclusions in adult patients. In the last 20 years, technological developments in clear aligner software, improvements in aligner materials and their functionality, and innovations in treatment methods have expanded the capabilities of clear aligner therapy for the treatment of complex malocclusions in children, adolescents, and adults. Clear aligner therapy is rapidly evolving and represents one of the next frontiers for orthodontic treatment.

Despite these advances, clear aligner therapy remains limited by significant deficiencies resulting in clinical dilemmas for the practitioner, from the use of clear aligners for interceptive treatment, complex movements, Class II therapy, overcorrection, to the treatment of vertical problems. With the rapid growth of clear aligner therapy within the field, there has arisen a dense forest of contradictory and controversial opinions and methodologies for treatment. Our own experience with clear aligner therapy has been a humbling but enlightening process, one in which we have had to negotiate the appliance's limitations over the course of its evolution. Additionally, aside from a limited number of systematic reviews and meta-analyses, there are few texts that deeply engage with the limitations of clear aligner therapy and their implications. Therefore, there exists a need for a critical appraisal of the current body of knowledge to determine viable treatment approaches in addressing these dilemmas.

To address this need, we do not intend this book to be an exhaustive survey of clear aligner therapy or a stepwise guide with generalized formulas for the management of malocclusions with clear aligners. Instead, our aim is to provide rigorous, scientific evidence-based evaluations of the current status of knowledge regarding controversial dilemmas within clear aligner therapy, while mapping out solutions for their management. Each chapter will focus on a dilemma, which we have frequently encountered in clinical practice and the scientific literature. We will comprehensively analyze each dilemma with a discussion of the current state of affairs in the context of the latest research, its clinical implications including the limitations the dilemma bears on the treatment of specific malocclusions, and our strategies for solutions. As learning tools, we have included numerous cases for study with their virtual setups. Additionally, we have incorporated a series of prototypes, figures

illustrating suggested technological modifications, and future clinical applications with clear aligners.

Because we aim to be as impartial and comprehensive as possible in our evaluations of these dilemmas, we have included discussions of clear aligner systems alternative to Invisalign. However, this is not always possible because certain aspects of clear aligner therapy with the Invisalign system are currently significantly advanced and not yet available in the alternative systems, such as a developed bite jump function or optimized attachments. Nevertheless, we believe these alternative systems, in addition to clinician-printed aligners (via in-office 3D printers), will become increasingly viable for the treatment of both simple and complex malocclusions.

This book seeks to address the ambiguity and confusion surrounding the most pressing and troubling clinical dilemmas in clear aligner therapy. It intends to provide the clinician greater clarity and understanding on these dilemmas, as well as paradigms for their resolution. We hope this book can serve as a valuable contribution to the discussion surrounding these topics and that it will assist readers in making more informed and effective clinical decisions in their delivery of clear aligner treatments.

New York, NY
New York, NY

Anderson Huang
Darren Huang

Acknowledgments

We are deeply grateful to Dr. Olivier Nicolay, Dr. Jae Hyun Park, and Dr. George Anastassov, who believed in this project from the very start and offered their early support and invaluable guidance. We sincerely thank Springer Nature and our generous and perceptive editors, Alison Wolf, Priyadarshini Vasudevan, and Shilpa Sheetal, for graciously offering us the opportunity to realize our project and patiently directing us from proposal to publication.

We thank the New York University College of Dentistry Department of Orthodontics for their commitment to an evidence-based best-practice approach to orthodontic practice, their continued innovations in clear aligner research and therapy, and for creating space for us to nurture our ideas for optimal patient care.

We thank Dr. Mitchell J. Lipp for his insight, friendship, and support.

We would like to express our love and gratitude for our family, Jennifer and Madeline, for their patience, enthusiasm, and support, throughout this entire project.

Contents

1	Optimizing Diagnosis and Treatment Planning with Clear Aligner Software.	1
	Clear Aligner Software: A Brief History	1
	Major Deficiencies in the Invisalign Clincheck Software.	2
	Single Tooth Movement: Incompatibilities in Attachment Design	2
	Single Tooth Movement: Limitations in Torque Application	5
	Single Tooth Movement: Limitations during Extraction Therapy	8
	Deficiencies in Hard and Soft Tissue Modeling	9
	Limitations in the Correction of Skeletal Discrepancies	9
	Limitations in Diagnostic Tools	10
	The 3M Software	11
	Optimizing Single Tooth Movement: Capabilities and Limitations of Attachment Design	11
	Optimizing Single Tooth Movement: Torque Application and Bite Opening	12
	Hard and Soft Tissue Modeling	13
	Limitations in the Treatment of Complex Malocclusions.	14
	Dentsply Sirona Suresmile Software	14
	Optimizing Single Tooth Movement: Attachment Design	14
	Optimizing Single Tooth Movement: Torque Application and Bite Ramps.	15
	Hard and Soft Tissue Modeling	15
	Treatment of Complex Malocclusions	16
	uLab Software.	16
	Optimizing Single Tooth Movement: Attachment Design	16
	Optimizing Single Tooth Movement: Torque Application and Bite Ramps.	18
	Hard and Soft Tissue Modeling	18
	Treatment of Complex Malocclusions	18
	The Ideal Clear Aligner Software	19
	Optimizing Tooth Movement: Attachment Design.	19
	Optimizing Tooth Movement: Torque Application.	20

Hard and Soft Tissue Modeling	20
Treatment of Complex Malocclusions	20
3D Printer Compatibility.	21
References.	21
2 Adapting Clear Aligner Therapy to Interceptive Treatment for Early Mixed Dentitions: Are They the Same as Late Teen or Adult Treatment?	23
Clear Aligner Therapy for Interceptive Treatment: Challenges and Considerations	23
Major Features of Clear Aligner Interceptive Treatment	24
Expansion	24
Eruption Compensation	25
Optimized Attachments.	25
Mandibular Advancement.	26
Phase II Treatment	26
Frequent Midcourse Corrections.	27
Duration of Aligner Wear	27
Treatment Applications.	27
The Deficiencies of Interceptive Treatment with Clear Aligners.	34
Limitations in Growth Modification and Prediction.	34
Range of Expansion	34
Adaptation to Short Clinical Crowns	34
Software Calibration for Treatment Planning.	36
Availability of Clinical Preferences	36
Post-Interceptive Treatment Retention	40
Solutions to Current Limitations in Clear Aligner Interceptive Treatment	40
Incorporating Orthopedic Appliances.	40
Retention to Small Clinical Crowns	47
Expansion Limits	48
Software Calibration for Eruption Compensation and Incisor Position.	48
Expanding Clinical Preferences	48
Post-Interceptive Treatment Retention	49
The Viability of Interceptive Treatment with Clear Aligners	50
References.	50
3 Mandibular Advancement: A Viable Alternative to Functional Appliances?	53
Class II Functional Correction in Clear Aligner Therapy.	53
The Mandibular Advancement Appliance: Current Features and Limitations	54
Mechanism of Bite Repositioning	54
Bite Jump Calibration	55
Case Selection.	58
Tooth Movement Beneath Precision Wings	59
Control of Mandibular Incisor Inclination	62
Vertical Elastics for Engagement of the Precision Wings.	62
Efficacy in Comparison to Class II Mechanics.	63

Maxillary Expansion in Conjunction to Mandibular Advancement	63
Solutions to Deficiencies in the Mandibular Advancement Appliance	63
Improving Engagement of Precision Wings and Mechanism of Bite Repositioning	63
Movement of Teeth Beneath the Precision Wings	64
Is Mandibular Advancement a Viable Alternative to Conventional Class II Correctors?	64
References	64
4 Problematic Complex Movements: Can Clear Aligners Treat Them Alone?	67
Have Clear Aligners Improved in Achieving Complex Movements?	67
The Challenges of Controlling Maxillary Lateral Incisors	68
Invisalign G4 and G7 Attachments	68
Alteration in Aligner Geometry for Enhancement of Tooth Movement	69
Combination Treatment with Fixed Appliances	70
Auxiliaries for Enhancement of Tooth Movement	70
Overcorrection for Improved Predictability of Maxillary Lateral Incisor Movement	70
Torque Control for Maxillary Lateral Incisors	71
Restorative Solutions for Maxillary Lateral Incisors	73
Bolton Discrepancies	74
Missing Maxillary Lateral Incisors	74
Root Uprighting	76
Elements of Successful Uprighting—The Virtual Gable Bend	76
Elements of Successful Uprighting—Attachment Design	77
Treatment Duration	79
Coverage of Aligner Material	79
Auxiliaries for Uprighting	79
Uprighting in Extraction Cases	79
Uprighting in Class II Treatment	84
Simplifying Complex Movements	85
References	87
5 Interproximal Reduction	89
Interproximal Reduction and Clear Aligner Therapy	89
The Indications of IPR	90
Decrowding	90
Treatment of Class II and Class III Malocclusions	90
Tooth Size Discrepancies	94
Incisor Uprighting	95
Midline Coordination	95
Gingival Black Triangles	95
Retention	96

IPR Technique	96
Considerations when Planning IPR	97
Round Tripping and IPR	97
Timing of IPR	97
Long Term Consequences of IPR	99
Reflections on IPR in Clear Aligner Therapy	99
References	99
6 Dilemmas in Bite Opening	101
The Challenge of Deep Bite Correction	101
Factors in Bite Opening	102
Leveling the Curve of Spee	102
Bite Ramps	102
G8 Modifications	103
Relative Intrusion	104
Short Clinical Crowns	104
Treatment Protocols	106
TAD-Supported Intrusion	106
Extraction Cases	106
Molar Extrusion	108
Improving the Accuracy of Bite Opening	112
References	112
7 Dilemmas in Open Bite Correction	113
Current Strategies for Open Bite Closure	113
Efficacy of Movements Associated with Bite Closure	114
Absolute Extrusion vs. Relative Extrusion	114
Molar Intrusion	115
Finishing after Anterior Open Bite Closure	118
Factors Affecting Bite Closure	118
The Reality of Molar Intrusion during Open Bite Closure	118
The Incorporation of Bite Jumps	120
TAD-Assisted Molar Intrusion for Bite Closure	120
The Reality of Open Bite Closure with Clear Aligner Therapy	122
References	124
8 Power Ridges: How Powerful Are They?	125
Torquing with Clear Aligners	125
The Indications of Power Ridges	126
Incisor Retraction	126
Posterior Protraction	126
Lingually Displaced Maxillary Lateral Incisors	126
Dental Decompensation for Orthognathic Surgery	130
Intermaxillary Forces	132
Distalization in Class II Treatment	132
The Efficacy of Power Ridges	132
Controlling Torque with Clear Aligners	134
References	134

9	Overcoming Limitations in Extraction Therapy	135
	How Predictable Is Extraction Therapy with Clear Aligners?	135
	Treatment Planning Considerations for Predictable Extraction Therapy	136
	Clincheck Development for Extraction Therapy	136
	Tipping During Space Closure	136
	Considerations for Posterior Protraction	141
	Controlling Posterior Torque	141
	Controlling Incisors During Retraction	141
	Clinical Management of Extraction Therapy	142
	Frequency of Aligner Changes	142
	Tipping During Therapy	142
	Combination Treatment	144
	Improving the Efficacy of Clear Aligner Extraction Therapy	146
	References	146
10	The Predictability of Bite Jumps	147
	What Are Bite Jumps?	147
	Indications for Bite Jumps	148
	Growing Patients	148
	Open Bite Closure	151
	Orthognathic Surgery	152
	Dental Functional Shift	152
	Principles of Bite Jump Use	152
	Predictability of the Bite Jump	152
	Timing	152
	Controversial Uses of the Bite Jump	154
	Excessive Overjet in Nongrowing Class II Patients	154
	TAD-Assisted Cases	155
	Extraction Cases	155
	Extensive Space Closure	156
	Mandibular Shifts	156
	Solutions for Discrepancies Between Clinical Outcomes and Outcomes Predicted by Bite Jumps	158
	Growing Patients	158
	Orthognathic Surgery Cases	158
	Open Bite Closure	160
	Dental Functional Shifts	160
	Optimal Planning of Bite Jumps in Clear Aligner Treatment	160
	References	161
11	Overcoming Limitations in Finishing	163
	Detailing with Clear Aligner Therapy	163
	Intra-arch Occlusal Discrepancies	164
	Discrepancies in the First Order	164
	Optimizing Tooth Movement	166
	Discrepancies in the Third Order	167
	Inter-arch Discrepancies	169
	Midline Discrepancies	169

Deep Bites	169
Anterior Open Bites	170
Posterior Open Bites	171
Finishing for Treatment Efficacy	173
References	174
12 When and How to Overcorrect?	175
The Various Roles of Overcorrection	175
Indications and Methods for Overcorrection	176
Unpredictable Tooth Movements	176
Unpredictable Jaw Movements	180
Occlusal Finishing	180
Residual Space Closure	181
Distalization	182
A Conservative Approach for Overcorrection	184
References	186
Index	187

Abbreviations

AAO	American Association of Orthodontists
ANB	A-point-nasion-B-point angle
BSSO	Bilateral sagittal split osteotomy
CBCT	Cone-beam computed tomography
IHA	In-house aligner
IMPA	Incisor mandibular plane angle
IPR	Interproximal reduction
MA	Mandibular advancement
PDL	Periodontal ligament
RME	Rapid maxillary expansion
RPFM	Reverse pull face mask
SNA	Sella-nasion-A-point angle
SNB	Sella-nasion-B-point angle
TAD	Temporary anchorage device
U1-SN	Upper incisor-sella-nasion angle
VCC	Virtual C-chain
VGB	Virtual gable bend

Optimizing Diagnosis and Treatment Planning with Clear Aligner Software

1

Contents

Clear Aligner Software: A Brief History	1
Major Deficiencies in the Invisalign Clincheck Software	2
The 3M Software	11
Dentsply Sirona Suresmile Software	14
uLab Software	16
The Ideal Clear Aligner Software	19
References	21

Clear Aligner Software: A Brief History

In orthodontic therapy with clear aligners, the judicious manipulation of the software constitutes a significant aspect of treatment planning and is critical for successful outcomes. The first software for clear aligner therapy was introduced by the founders of Align Technology and the inventors of the Invisalign appliance to the American Congress of Orthodontists in 1999 [1]. The technology adopted computer-aided design/computer-aided manufacturing (CAD/CAM) techniques to fabricate a series of aligners that gradually moved teeth into their desired positions. The first generation of the Invisalign software, known as the Clincheck, was primarily designed for the resolution of simple malocclusions, such as mild and moderate crowding, minor space closure, and minor root movements

[2]. Subsequent generations of the Invisalign clear aligner appliance improved both the aligner material and its capabilities as well as the functionality of the software. Typically, software innovations allowed for finer control during the virtual setup through the addition of more features for tooth positioning, the addition of auxiliaries, and treatment planning. The technological development of Invisalign's clear aligner appliance has expanded its range to the potential treatment of more complex malocclusions. However, many of Invisalign's claims regarding the efficacy of its appliance, such as the resolution of significant rotations, extrusions and intrusions of 2.5 mm in anterior teeth, and root movements of up to 4 mm in posterior teeth, have not been properly substantiated [2].

Importantly, in 2015, Invisalign introduced a number of innovations, including the Clincheck Pro, alongside alterations in aligner material and

the addition of a number of features for the management of cases involving first premolar extractions [3]. At the time of writing, the current version of the Clincheck software is the Clincheck Pro 5.0, which is essentially the original Clincheck Pro with a number of modifications. Since its first iteration, Clincheck has not been web-based but needs to be downloaded as an application. As a result, it remains prone to discontinuities from server disruptions. The Clincheck Pro 5.0 remained unavailable as web-based software. Notably, the 2015 update incorporated into the software the 3D toolbar, which allows for the positioning of individual teeth in all dimensions, updated its SmartTrack polymer aligner material, increased functionality for the placement, orientation, and sizing of attachments and cuts, widened capabilities for expansion and contraction of either the maxillary or the mandibular arch, and allowed the addition and removal of sites of interproximal reduction for space management [3, 4]. The update also added a number of features to assist in treatment planning, including an automatic Bolton analysis, the visualization of occlusal contacts, and a “dual view,” which compares the clinician’s modifications to Invisalign’s initial setup.

In recent years, a variety of dental suppliers have created competing clear aligner appliances along with their respective software. In 2018, 3M launched its Clarity clear aligner system and its web-based software for treatment planning. Also in 2018, Dentsply Sirona introduced its SureSmile aligners and Elementrix software as another clear aligner alternative. Both 3M and Dentsply Sirona’s software differ significantly from that of Clincheck and offer distinct advantages for the clinician.

Despite Invisalign’s continued innovations, its Clincheck Pro software remains limited by a number of deficiencies, which potentially compromise ideal treatment outcomes. These limitations range from lack of optimization for single tooth movement to a failure in correcting skeletal discrepancies to unrealistic modeling of soft tissue changes. For instance, the Clincheck software currently lacks proper integration of soft and hard tissues. As a result, the treatment

simulation fails to realistically model soft tissue changes produced by orthodontic movements. It is important that the clinician is mindful of these deficiencies so that they can anticipate the effects of their mechanotherapy and minimize any unfavorable outcomes.

In the following chapter, we discuss the major limitations of Invisalign’s Clincheck software, which range from a lack of functionality for optimizing single tooth movement to improper modeling of soft tissues. In our discussion of single tooth movement, we will focus on the judicious manipulation of attachments. When viable, we will propose solutions for overcoming these limitations in the software. Thereafter, we will survey the lesser-known alternative software and discuss how their differing features might be used to the clinician’s advantage for delivering successful orthodontic treatment.

Major Deficiencies in the Invisalign Clincheck Software

Single Tooth Movement: Incompatibilities in Attachment Design

Studies have shown that the addition of attachments onto teeth improves the accuracy of specific types of orthodontic tooth movements [5]. Simon et al. reported the best accuracy in the bodily distalization of upper molars of at least 1.5 mm when movements were supported by attachments on the tooth surfaces [6]. Clinically, we have observed that the use of attachments prevents excessive tipping of molars during distalization. However, we note that though the difference in accuracy for distalization between teeth with attachments was greater than that of teeth without attachments, it was not by a statistically significant margin [6].

Studies have also investigated the effects of attachment use on the efficacy of other types of movements. A clinical trial in 2005 supported the use of attachments to improve the accuracy of rotational movements [7]. Simon et al. observed that in premolar rotations of $>10^\circ$, the use of

attachments and the degree of movement per aligner both had a great impact on predictability [6]. A systematic review in 2015 also recommended the use of attachments to improve the predictability of rotational movements [5]. Nevertheless, other studies have shown conflicting results and claimed that the use of attachments does not aid in stimulating derotation for canines [8]. A 2019 systematic review also concluded there is a lack of evidence to support the use of attachments for derotation [2]. Despite the lack of consensus in the current evidence, it is still recommended to place attachments on teeth for derotation, especially exceeding 15°, for treatment predictability [5].

There is a greater consensus for the use of attachments in improving the predictability of extrusive movements. The treatment of vertical problems, especially deep overbite, is especially challenging for clear aligners. In a clinical trial, extrusion was found to be the least accurate tooth movement [9]. Therefore, it is recommended that attachments be placed on teeth requiring extrusion for predictability [2].

It is evident that the use of attachments is able to stimulate certain orthodontic movements [10]. In its most recent generations, Invisalign’s Clincheck Pro has incorporated a number of features that expanded the clinician’s control over attachments as well as their capabilities for controlling tooth movement. Specifically, when the clinician decides to place an attachment, they are able to choose its shape, whether an ellipsoid, mesial or distally beveled vertical attachment, or a gingival or incisally beveled horizontal attachment (Fig. 1.1). Secondly, the clinician is also able to determine the size of the attachment—3, 4, or 5 mm in length (Fig. 1.2). Thirdly, the clinician is able to position the attachment both in terms of its location on the tooth surface and the orientation of its bevel (Fig. 1.3).

Despite these capabilities, there remain shortcomings in the Clincheck software’s attachment design that compromise treatment predictability. Notably, because of the limited configurations available, the attachment cannot properly adapt to the full range of tooth surfaces. For instance, the software limits the minimum size of attach-

ments so that they cannot be incorporated onto tooth surfaces that are deficient in crown length. This situation arises when attachments are required for distalizing maxillary molars with short clinical crowns (Fig. 1.4). In such cases, the vertical beveled attachment would most ideally support the distalizing movements. However, because of the short clinical crowns in the maxillary molars, the Clincheck software will automatically trigger the placement of horizontal beveled attachments instead of the desired vertical beveled attachments (Fig. 1.5). As a result, the predictability of the distalizing movement is

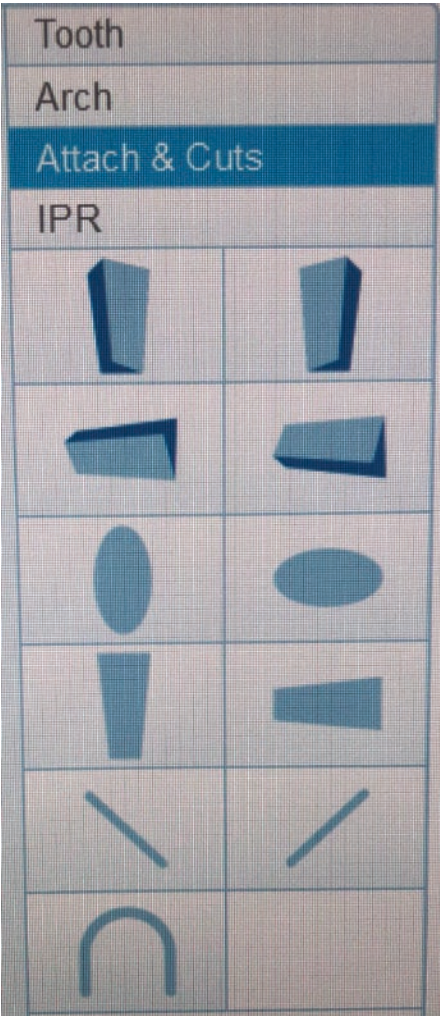


Fig. 1.1 Invisalign allows for a wide range of attachments, including the horizontal bevel, vertical bevel, and ellipsoid