Aligner Techniques in Orthodontics

Susana Palma Moya
Javier Lozano Zafra

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Preface

I started to work with aligners in 2001 and immediatly I realized that they had a huge potential. It was easy for me to get familiar with the whole idea because I used to work with dental positioners at that time. In contrast, most of my colleagues were quite skeptical and did not consider aligners as a real orthodontic system.

Reviewing the literature we can see how the possibilities of the aligners have increased over the years. In 2001, there were limited tools available to solve mild crowded Class I malocclusions; however, several years after, we started to speak about extraction cases, Class II malocclusions, and open bites, which were treated more successfully each time. This situation was due to two factors: on the one hand, the continuous feedback the manufacturers use to make constant improvements, and on the other hand, the tremendous effort by many orthdontists who have been triyng to understand and explain what we call "*the plastic biomechanics*." Therefore, the perception of using the aligners as an effective orthodontic method is improving due to the irrefutable fact that the results are getting better and better and, in many cases, they overtake the outcomes achieved by conventional orthodontics.

We are only beginning to understand how the aligners move teeth, and the learning curve is slower than we thought. Those are the reasons why their effectiveness is indisputably attached to academic training and experience. The professionals with greater knowledge and greater number of treated cases will achieve better results. This is no surprise as this is what happens when a new technique is introduced.

For all these reasons, as professionals, we are the ones who still establish our treatment goals. Aesthetics and the patient's comfort should not conflict with the quality of the treatment results. This means that in quite a few situations, we need to use auxiliary techniques to complement the aligners deficiencies. It also means on the part of the practitioner a greater effort and dedication than usual to the occlusal and functional treatment finishing, and especially to training. I understand that leaving the comfort zone is not easy for those who have been treating patients the same way their *whole life*. This is where Dr. Palma and Dr. Lozano are absolutely exactly correct. This book fills a gap in our interpretation of the orthodontic movement with aligners. It offers a great number of essential keys to the understanding of the aligners biomechanics. It is the right publication at the right moment, with guides to treat different malocclusions with confidence, predictability, and quality. Following their solid biomechanics knowledge and experience-based advice, the reader will be introduced to the treatment of more and more difficult cases, always keeping the traditional occlusal standards.

The book covers all the different malocclusions from the easiest mild crowding cases to the complex pre-prosthetic treatments. It is written like an atlas, with specific cases fully explained step by step. The reader will also find an innovative and attractive video format of each treatment. For all these reasons, this book is a wonderful and easy tool for references suitable for beginners, but also for orthodontists well trained in aligners. Moreover, for the skeptical ones, the book, at least, will peak their curiosity. Is it really possible to perform a good quality orthodontics with aligners? This book will provide answers, and without doubt, many arguments for discussion.

We are at the beginning of a new technique. Previous and complete case planification through a powerful software has radically changed the way we work. This means we have to go back to school, but we have never had so many possibilities to train ourselves like today. In this way, the professional is able to become as competent as he or she wishes. However, it seems that some things never change; and I do not just mean the huge reluctance to accept new concepts or techniques (that is really frequent in our profession), I also mean the small percentage of people such as Dr. Palma and Dr. Lozano, whose great desire for self-improvement and progress gives as a result the finding of new knowledge. The knowledge that they generously share serves as an example and guide for many people.

Dr. Arturo Vela Hernandez

About the Authors

Dr Susana Palma Moya is an Orthodontist running a private practice in Ciudad Real, Spain. She obtained her postgraduate degree in Orthodontics and PhD in Dentofacial Orthopaedic and Orthodontics from the University of Madrid in 2002.

- Was among the first group of Spanish Invisalign Providers in 2001.
- International Invisalign Speaker since 2015.
- Assistant professor for the postgraduate's program in orthodontics at U.C.M University in Madrid from 2003 to 2007, and currently teaching orthodontics at Salamanca University.
- University degree in Orthodontics with Surfery from the International University of Cataluña UIC 2007
- University degree in lingual Orthodontics by Valencia University 2009- 2011
- Invisalign peer award 2015 (first international Award) and Invisalign peer award 2017(second European Award).
- Member of the EMEA teen global group and member of Ortodoncis group in Spain
- Invisalign Diamond II practitioner since 2015 and lectured in Invisalign treatment throughout Spain and Europe.

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- Member of the Invisalign TEEN global group and member of Ortodoncis group in Spain

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My thanks must go first to my husband Paco who has worked just as much as I on the preparation of this book. He has worked tirelessly in gathering together the evidence from videos and other photographic material required. I also want to thank him for his love and understanding which have given me the inspiration and strength to write it.

To my children Marta and Paco for the time I have stolen from them and the continuous inspiration and strength they provide to enable me to get the best from myself: thank you.

To my parents, Mercedes and Paco, whose love and effort encouraged me to become an orthodontist and who have been pillars of strength throughout my life.

To Align Technology for believing in me and giving me the opportunity to share my orthodontic experience with other practitioners from 2015 onwards.

I also want to thank all my orthodontics team, because without them we could not get the results we see today, which we are able to demonstrate in the book.

I want to thank my good friend and partner, Dr Javier Lozano, not only because it has been a pleasure sharing our time working on making the book (and ultimately helping many students master the aligner technique in Aligners Academy), but also because his friendship has led to a tipping point in my life.

And finally, my thanks go to the entire Wiley team for their help in producing this book.

Dr. Susana Palma Moya

To Susana and Paco,
You both take me to the 'next level' every day, inspire my work and my life.
I do not know where I will be in 10 or 20 years' time but, of this I am sure, our friendship will remain one of the most important pillars of life to me.

Thanks for trusting me, for taking care of me, for having me as a friend: I hope life brings you as much happiness as I think you deserve.

To Dani,
Your smile is the most important thing to me.

Dr. Javier Lozano Zafra

About the Companion Website

This book is accompanied by a companion website:

Companion website: www.wiley.com/go/lozano-zafra/aligner-techniques

The website includes:

- ClinCheck videos of every treatment in the book. Watch them simultaneously to every chapter, in order to fully understand biomechanics and staging used in every treatment.
- Patient Cases

1

History, Present and Future of Aligners

1.1 History of Clear Aligners

1.1.1 Early Beginning

Recent advances in technology have allowed many inventions that were previously only thought of to become a reality. Such is the case with clear aligners whose history began at the start of the 20th century.

These early retainers were developed by Hawley and others and made from Vulcanite and gold.

Rubber was first used in 1924, when Orrin Remensnyder developed the 'Flex-o-Tite',[1] a device that was meant to stimulate gums through home use combined with toothpaste, and was therefore convenient for periodontally compromised patients.

1 Remensnyder, O. A gum-massaging appliance in the treatment of pyorrhea. *Dent Cosmos*. 1926; **48**: 381–384.

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Companion website: www.wiley.com/go/lozano-zafra/aligner-techniques

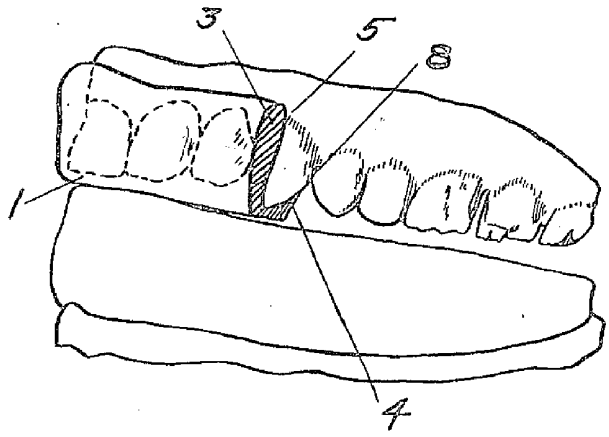
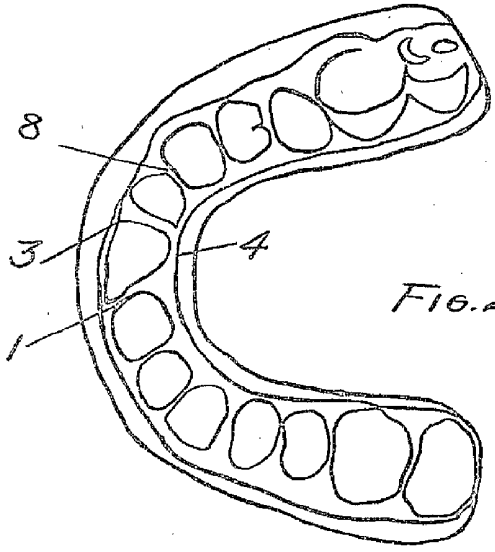


FIG. 1.



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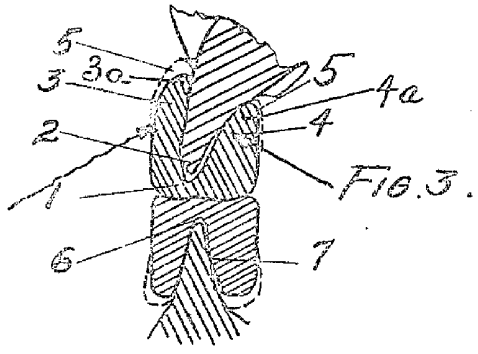

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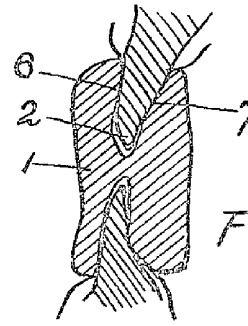

FIG. 4.

Fig. 1.1 Remensnyder patent file.

On approval the patent, Remensnyder described that the device might cause small teeth movements, using the expression 'orthodontic appliance' to describe it on his second patent for the device.[2]

Twenty years later, in 1946, Harold Kesling was responsible for developing what he called the 'Tooth Positioner', a device made from Vulcanite meant to prevent relapse after orthodontic treatment.

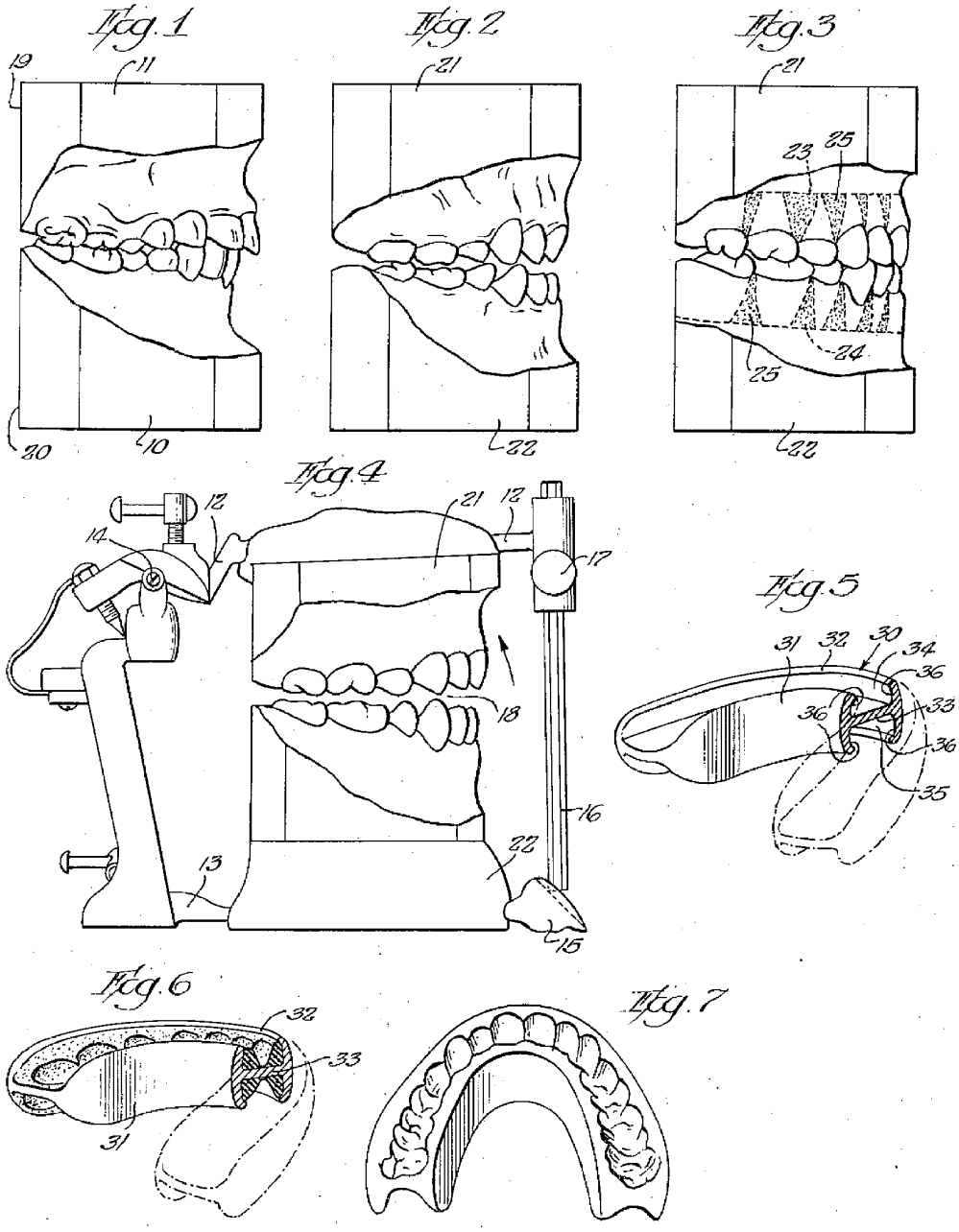

Fig. 1.2 Kesling patent file.

2 Remonsnyder, O. United States Patent 2,479,780, Orthodontic Appliance, Aug. 23, 1949.

This, alongside variations from other orthodontists, was considered a gold standard for several years, in which black vulcanite was the preferred option.

By using the tooth positioner, Kesling suggested 'major tooth movements could be accomplished with a series of positioners by changing the teeth on the setup slightly as treatment progresses. At present this type of treatment does not seem to be practical. It remains a possibility, however, and the technique for its practical application might be developed in the future'.

In 1963 when Shanks developed a technique for producing mouth guard style transparent retainers, with a machine capable of producing them. In 1964 Nahoum patented his 'vacuum formed dental contour appliance', while other orthodontists such as Ponitz[3] faced problems in different designs such as heating capability or plastic needs.

Up to this time these devices were used to stabilize the results of previous orthodontic treatment but were also used for minor corrections to the position of the teeth.

At the end of the 1980s, Elasto devices were developed that were made from highly flexible silicon that could be used for either one or two teeth quadrants.[4] Tooth movements were possible thanks to several set-ups that were built in different plastics, depending on the clinician's needs, after fixed appliances.

In 1994, Sheridan developed an aligner system,[5] which he called ESSIX, using clear, polymeric shell appliances with thermoplastic divots to reposition teeth, which was meant to solve minor anterior malpositions. In 1997, together with Schwartz, they standardized this by patenting a system that would be implemented in many dental offices until now, an 'in-office' vacuum system.

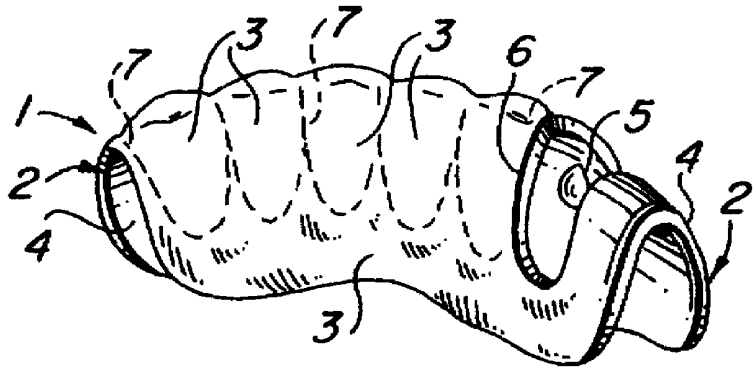

Fig. 1.3 Schwartz and Sheridan patent file.

3 Ponitz, R. Invisible retainers. *Am J Orthod*. 1971 59(3): 266–272.

4 Hinz R. Elasto-orthodontic system – a development of the positioner. *Prakt Kieferorthop*. 1991;5(3):179-88.

5 Sheridan JJ, McMinn R, LeDoux W. Essix thermosealed appliances: various orthodontic uses. *J Clin Orthod*. 1995;**29**(2):108–13.

U.S. Patent Dec. 2, 1997 Sheet 1 of 2 5,692,894

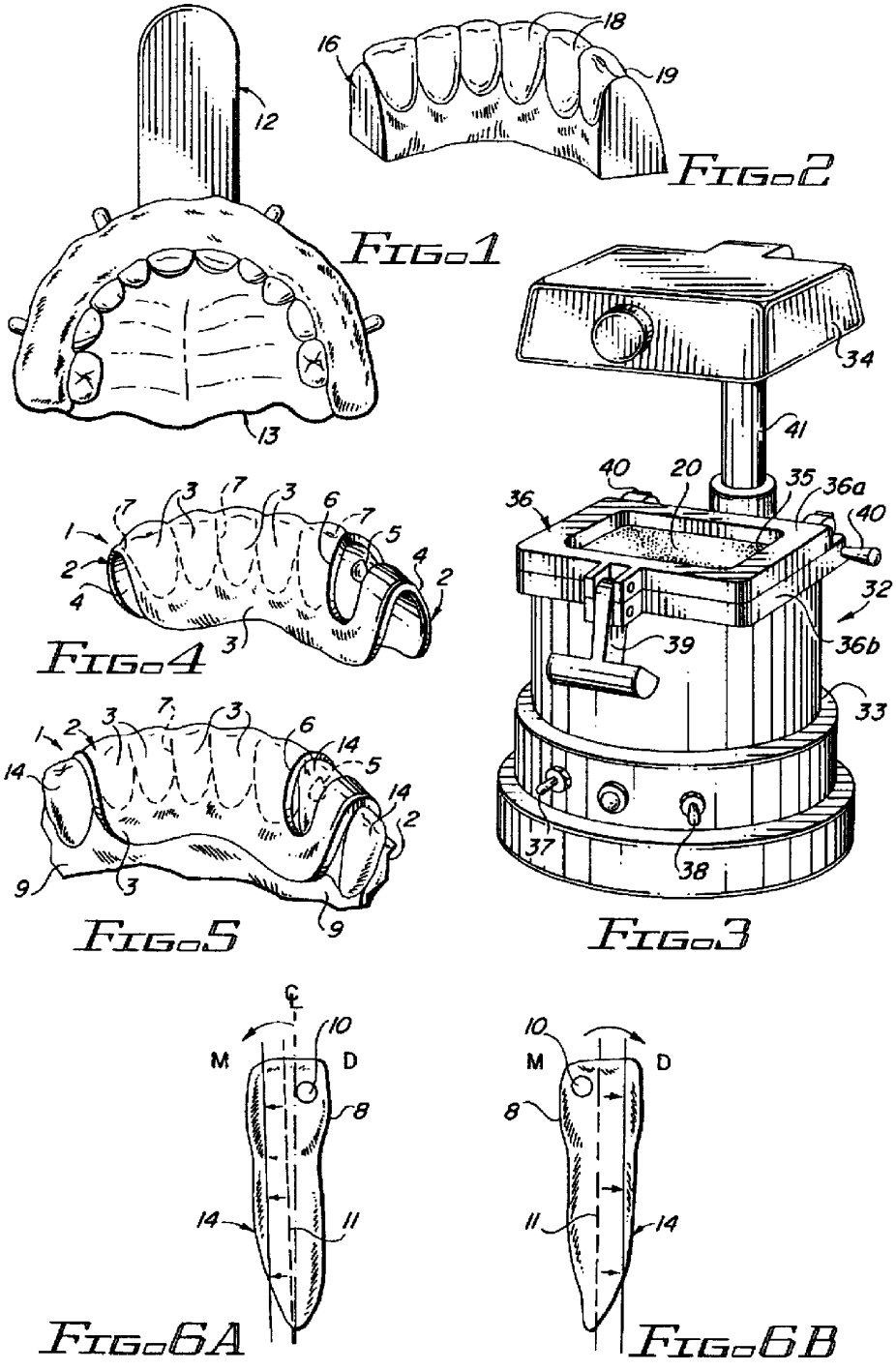

Fig. 1.3 (Cont'd)

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U.S. Patent Dec. 2, 1997 Sheet 2 of 2 5,692,894

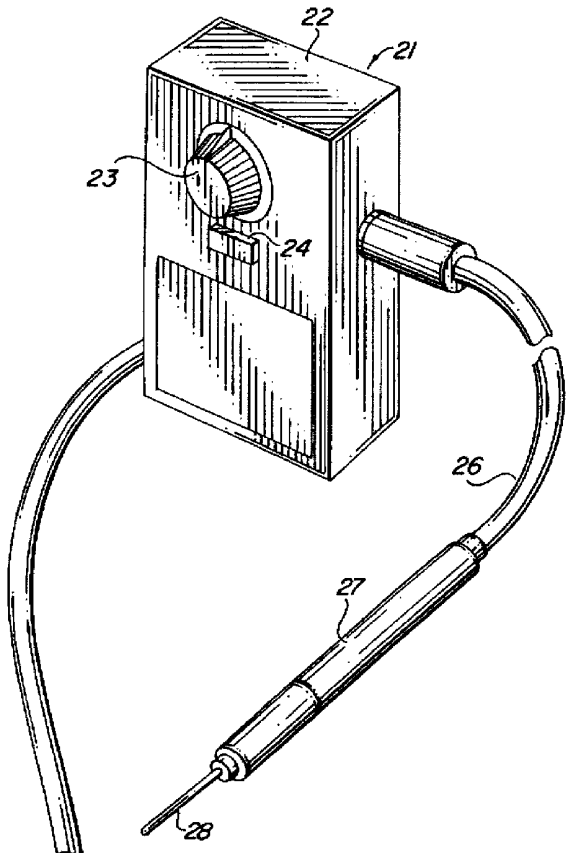


FIG. 8

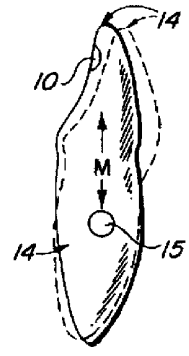


FIG. 7

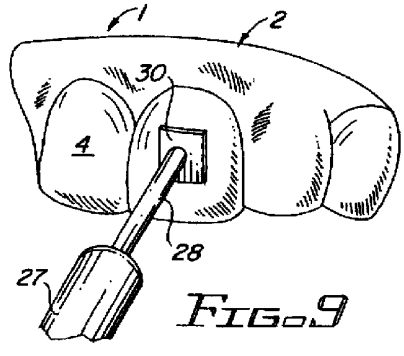


FIG. 9

Fig. 1.3 (Cont'd)

1.2 Origins of Align Technology

At the end of the 1990s a computerized aligner system was developed in the USA with promising features: namely, Invisalign, created by two Stanford students, Zia Chishti and Kelsey Wirth.

Zia Chishti was an orthodontic patient that found out that his own clear retainer might be applicable to the whole orthodontic treatment, as it might be able also to move teeth and avoid metal braces. This reasoning led to why they both started the Company, partnered with some other students in their campus, Apostolos Lerios and Brian Freyburger, who were responsible for the Computer Aid Design part of this start-up.

They then developed a software to design incremental stages of retainers to straighten teeth in a campus laboratory. In 1998, they got Food and Drug Administration (FDA) approval, and were then able to sell their product to the orthodontic community, which was resistant to this radical change, mostly owing to the lack of orthodontic experience of its founders.

In 2000, they raised $140M from venture capital companies and this allowed them to start a $31 million TV campaign that same year. In 2001, the Company went public, raising an additional $128M on NASDAQ.[6]

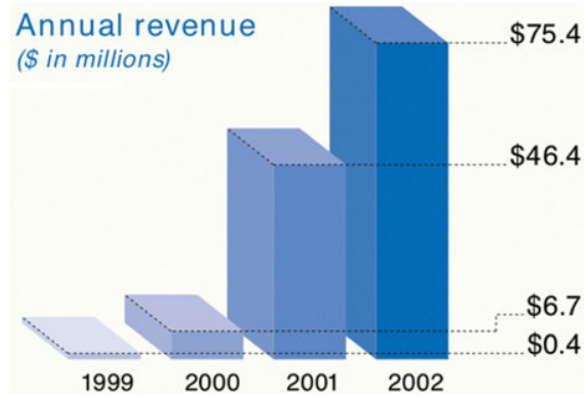
During this time, consumers drove more than 70% of the American Orthodontists to be trained in the system.[7] That same year, Align Technology made Invisalign available to general dental practitioners, arguing that offering it only to orthodontists would be considered unfair competition by dentists.

ALIGN
ALIGN TECHNOLOGY, INC.

Fig. 1.4 Align Technology logo.

By then, Align Technology was spending most of its revenues on advertising, and losing about $18 million per year,[8] which led cofounders Wirth and Chishti to resign from Align Technology before 2003.

Fig. 1.5 Align Technology annual revenue.



6 Feder, BJ. 'Orthodontics Via Silicon Valley; A Start-Up Uses Computer Modeling And Venture Capital to Reach Patients'. The New York Times, 18 August 2000: p. 1.
7 Bush, J. 'Stealth Braces'. YT Regional Newspapers (August 14, 2001). Retrieved January 9, 2013.
8 Lau, G. 'It has a bracing impact on patients; Align Technology' May 3; 2004.

After a cut in advertising to one-third of the original, the company grew from 80,000 patients treated in 2002 to 175,000 in 2004, while receiving awards for its stereolithography techniques, medical design and fast growth. In addition, the company finally achieved a profit for the first time in 2003.

In 2004 the FDA cleared expanded labelling for Invisalign and removed the permanent dentition requirement, making possible the launching of Invisalign TEEN and widening clinical applicability to include more complex cases and increase the age band for treatment.

Fig. 1.6 Align Technology stereolithographic has been heavily awarded.

In 2005, the Harvard School of Dental Medicine required for the first time that its orthodontic graduate students complete Invisalign certification before they graduated.[9]

1.3 Early Clear Aligner Manufacturers

Although most patented innovations have been developed by Align Technology, other companies have been working on new functionalities since the beginning of the century.

Orthoclear

- Founded in 2005 by Zia Chishti, one of the Invisalign system founders, based in Pakistan, ended its operations in 2006 after a corporate agreement with Align Technology that followed litigations related to trademark.

ClearCorrect

- Founded in 2006 in Texas, it was developed by one of the practitioners using Orthoclear, after it ended its operations, to be able to finish his patient treatments not using the Invisalign system, offered to old Orthoclear customers.
- This was made in collaboration with a technician working with plaster models. In 2008 they digitalized the process and were able to produce larger series of aligners, which they sent to the orthodontists together with the plastic models made for every movement.
- The Company was acquired in 2008 by Straumann group, together with some other companies with previous experience in the field to build an aligner system driven by this international holding.

9 Antelman G. *International Directory of Company Histories*. St James Press. 2008; **94**: pp. 15–18.

Fig. 1.7 Models and aligners by Clear Correct.

Orthocaps

- Founded in 2006 in Germany by Khan, this system has a 'method of combining two different soft aligners for day and night time use'. These two types differ from one another in both their composition and the amount of pressure they exert. This innovation is called the TwinAligner system.

Inman aligner

- Developed by a dental technician, Donal P. Inman in 2000 in Florida, it was initially for minor alignments and finally widely used by general practitioners for veneer preparation in a simple and more affordable way than other aligner brands.

1.4 Align Technology Development

Align Technology claims an investment over $1000M, which has made them a leader the clear aligner market over 20 last years, with more than 900 patents currently issued at the time of writing.

This progress has been possible thanks to an increasing clinical and engineering team that has been involved with many innovations over the years, such as:

- Invisalign 1.5: this included initial SmartForces and attachments, which are attachments combined with three dimensional (3D) activations on the aligner material (by then, EX30) that help creating counterforces to achieve desired movement.
- Invisalign G3: this included passive aligners on the arch with less movement to allow class II and III elastics on patients with A-P correction needed, as well as laser cut precision cuts or hooks.
- Invisalign G4: Optimized attachments for root control movements, open bite, and pressure points on aligners on teeth with small clinical crowns that could not accommodate double attachments.

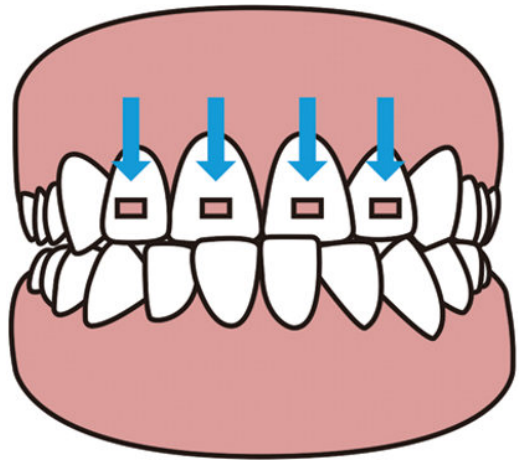


Fig. 1.8 Optimized attachments for anterior open bite.

- SmartTrack: Align Technology's proprietary material for aligners, launched for its increased fitting and elasticity.
- Invisalign G5: mostly for vertical malocclusions treatment, including specific protocols for Spee curve intrusion, passive attachments or precision ramps to help disoccluding posterior sectors.

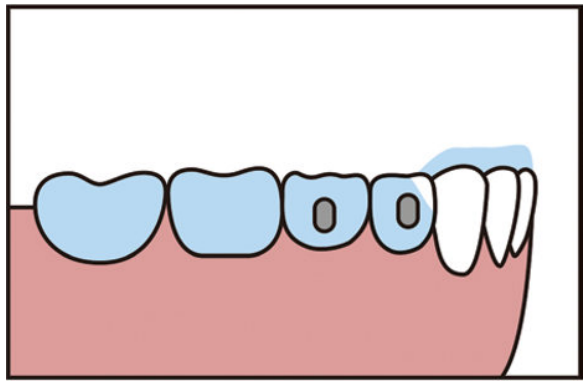


Fig. 1.9 Passive attachments for anterior intrusion.

- Invisalign G6: specific movement protocol for premolars extraction as well as exclusive attachments group designed to fulfil the best outcome in these cases.
- Invisalign G7: designed for improved finishing with functionalities such as specific lateral incisors attachments.
- One week wear: an aspect that helped to reduce the treatment length resulting from changing the aligners every 7 days instead of 14, as had previously been the case (after an internal clinical study).
- Mandibular advancement: this is one of the features that has further increased the range of cases treated, as it includes not just orthodontic treatments, but functional ones, substituting classical twin blocks or mandibular advancements for power wings.

Fig. 2.7 While second molars are moving, the rest of the teeth are considered as anchorage.

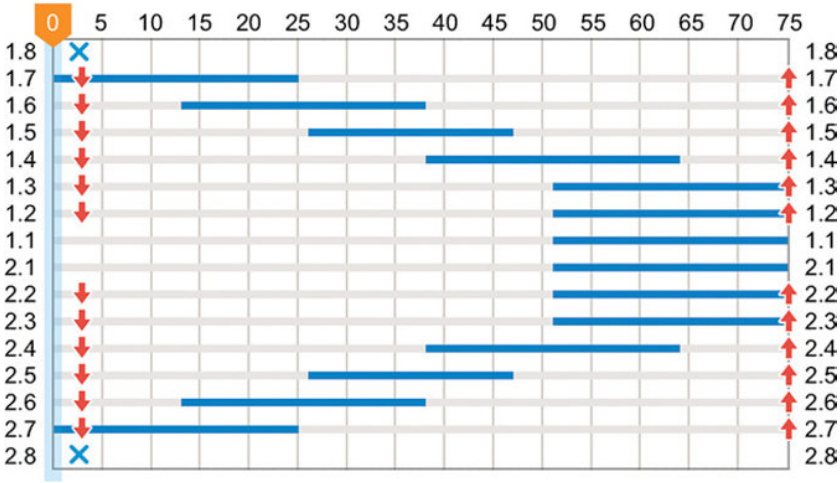


Fig. 2.8 This figure shows a horizontal 'V' movement pattern.

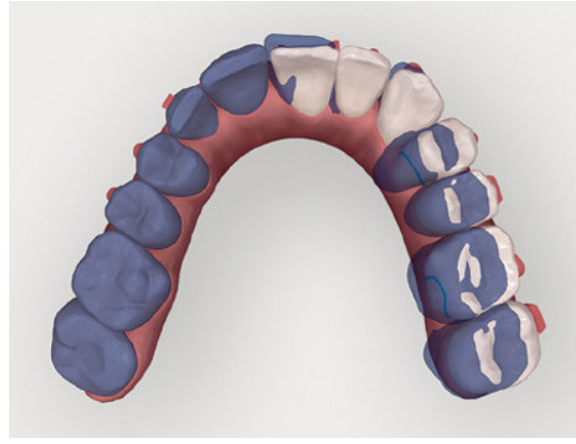


Fig. 2.9 The second quadrant is being expanded using the first quadrant as anchorage.

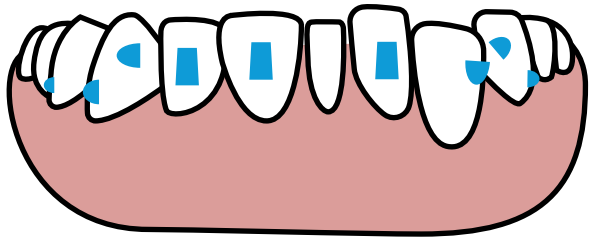


Fig. 10.3 Conventional attachments are selected whenever there are no optimized ones available.

- Bevelled attachments: both horizontal and rectangular vertical attachments can be bevelled
  - Horizontal attachments can be bevelled to the occlusal (HBO) or to gingival (HBG) to help with intrusion or extrusion movements:
    - For extrusive tooth movements on posterior molars, a horizontal attachment bevelled to gingival can be used
    - For intrusion, use the horizontal attachment bevelled on the occlusal on the teeth adjacent to the one that has to be intruded

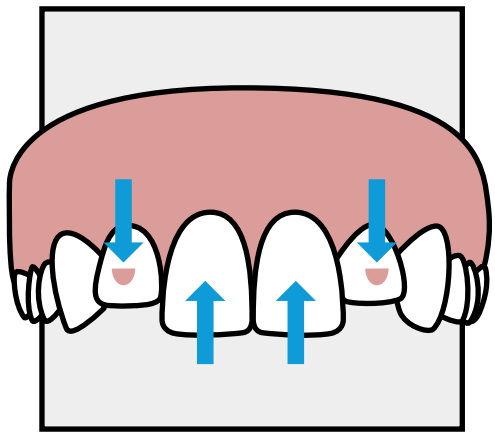


Fig. 10.4 Extrusion attachments are placed on teeth adjacent to the ones to be intruded, so as to create a counter-movement that will lead to a force couple. This is a great example of how biomechanics are applied on aligners.

  - Vertical attachments can be bevelled to mesial (VBM) or to distal (VBD): for rotation movements when the software has not placed optimised rotation attachments, for example when correcting first molar rotation. The bevelled surface is the active one, as the bevel provides a flat surface for the aligner to push against to achieve the desired tooth movement.

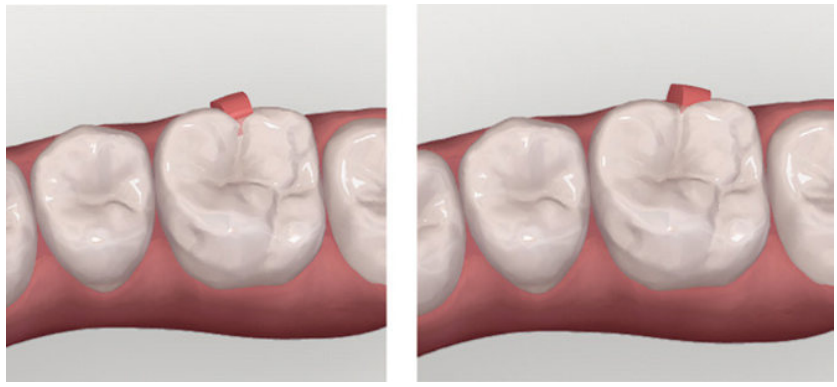


Fig. 10.5 Vertical attachments bevelled to mesial (left) and distal (right).

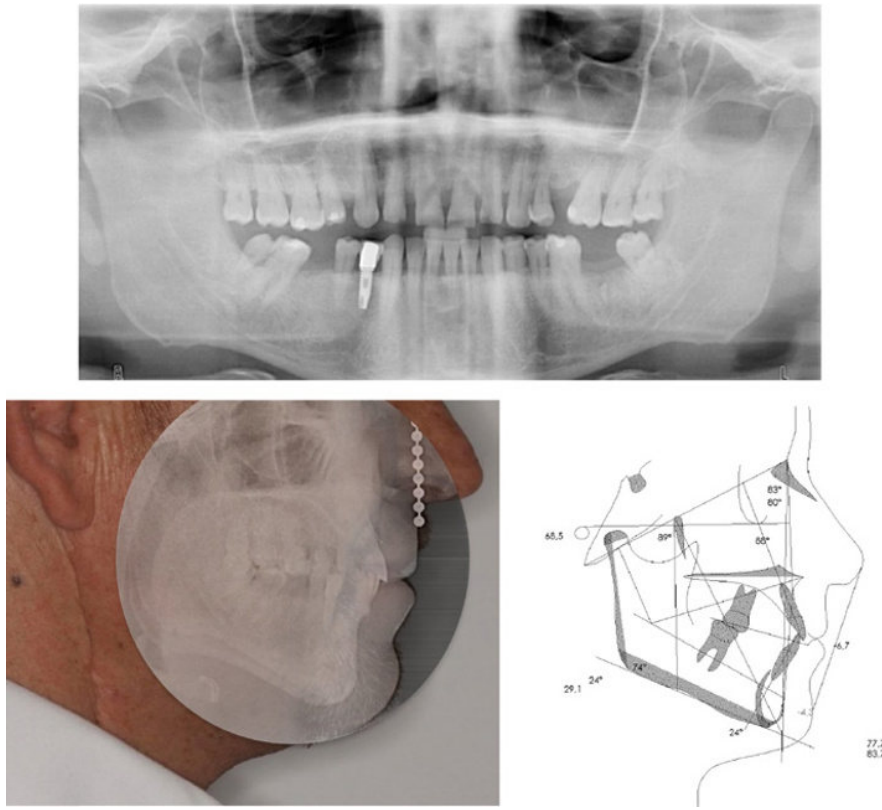


Fig. 17.8 Pretreatment panoramic X- ray, teleradiograph and cephalometry.

Staging Maxilla
- First expansion and then do not move molars to use them as anchorage to retrude upper incisors.
- Open space for implants of 14 and 25
- **Staging mandible:**
- Do not move molars to have posterior anchorage

Fig. 17.9 Upper CC superimposition and instructions to CAD designer.

- Anchorage AT HBG U4 and U6
- Optimized attachments on canines
- Implants of 14/25/37 and 46

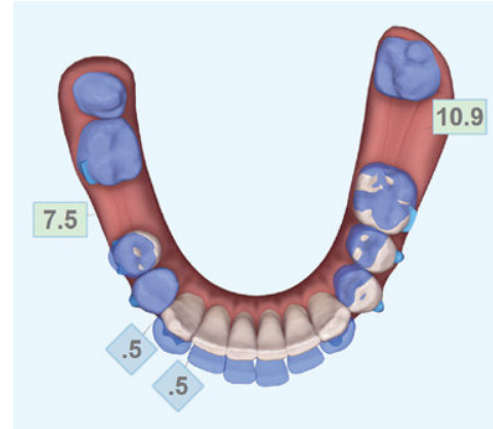


Fig. 17.10 Lower CC superimposition and instructions to CAD designer.

IPR in lower arch to create overjet to close upper diastemas

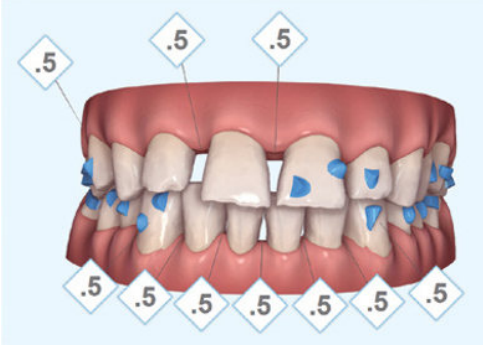


Fig. 17.11 Front CC view.

- Many anchorage attachments in posterior zone.
- IPR + TRL at the same time to lower incisors (final position of lower incisors –1 degree)

Fig. 17.12 Front intraoral picture.

Communication with the Technician

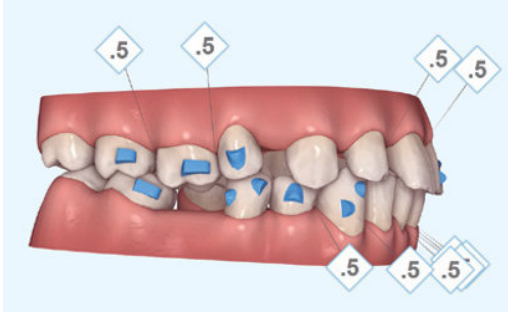


Fig. 17.13 Right ClinCheck view, initial situation.

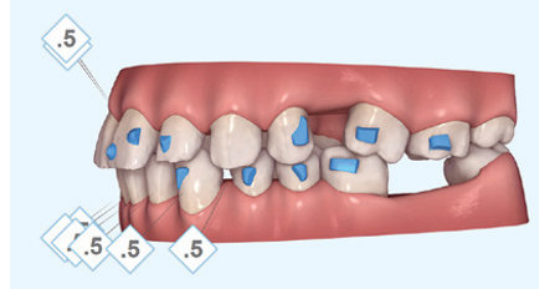


Fig. 17.14 Left ClinCheck view, initial situation.

Fig. 17.15 Post-treatment views.

Fig. 17.16 Pretreatment and final smile.

Fig. 17.17 Post-treatment panoramic and lateral X-rays.

17.1.2 Spacing with Frenulectomy

Fig. 17.18 Skeletal class I with spacing.

Diagnosis

A 20-year-old, symmetric patient who presented with a dental class I and a gummy smile. The patient had a large upper diastema. Short clinical crowns on upper incisors were also found.

Treatment Plan

- Closing spaces and maintain anterior torque by adding extra lingual root torque
- Perform a frenulectomy at the initial stage so as to increase clinical crown size; however patient refused and postponed it to the end of treatment, together with a frenulectomy to prevent space relapse

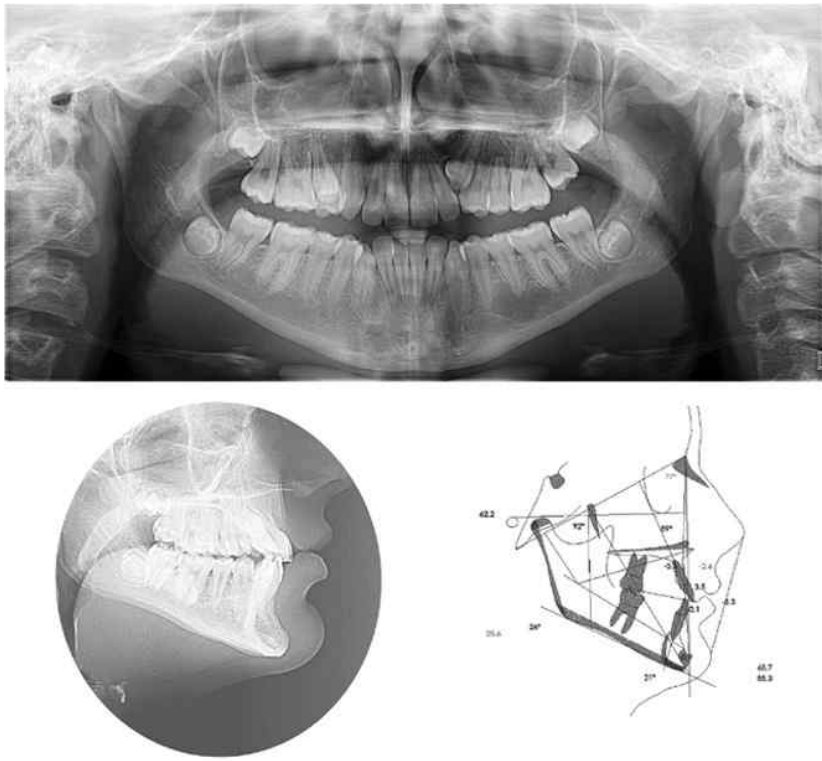


Fig. 18.68 Panoramic X-ray, teleradiograph, cephalometry.

Maxillary staging:
EXPANSION simultaneously to premolar rotation and distalization of 1.7 and 1.6
- Round tripping of 2.2 and 2.4 to open space for 2.3

Mandibular staging:
- Expansion and simultaneous proclination
- IPR + retraction + Lingual root torque to lower incisors

- Upper expansion with torque control + crisscross elastics
- Anchorage gingival bevelled attachment
- HBG U4 and U6
- Optimized attachments in canines
- Lower IPR
- Locatelli to open space for 2.3 and 1.5
- Lingual sectional wire to pull 1.5 to labial

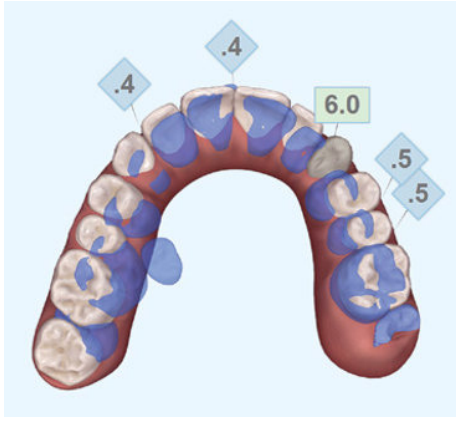


Fig. 18.69 Upper CC superimposition and instructions to CAD designer.

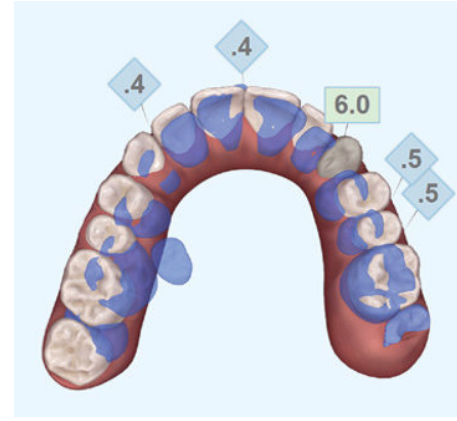


Fig. 18.70 Lower CC superimposition and instructions to CAD designer.

Fig. 18.76 Locatelli to open space for 15 and 23.

Fig. 18.77 Situation at the end of first set of aligners.

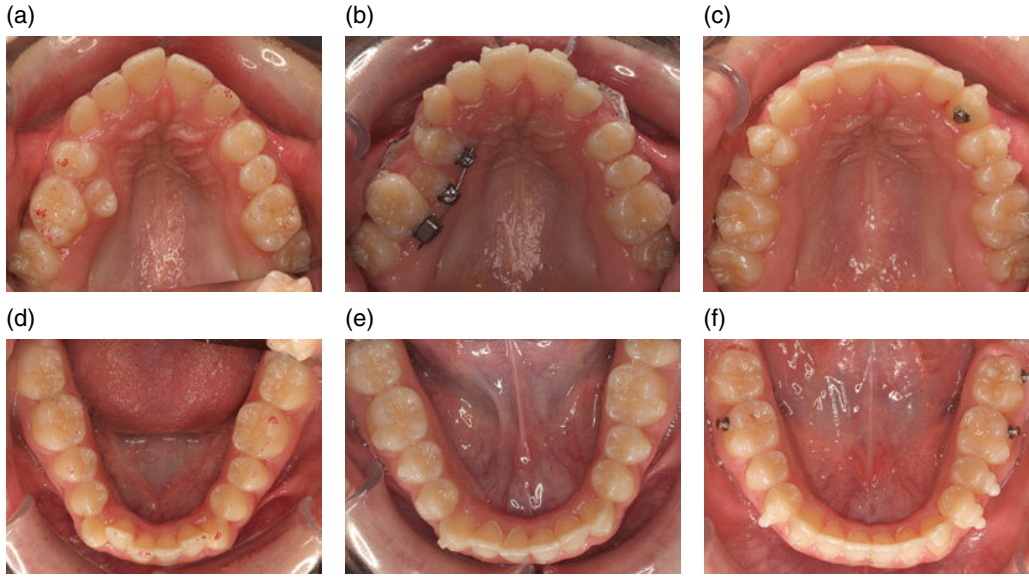


Fig. 18.78 (a–f) Transversal development of the arches.

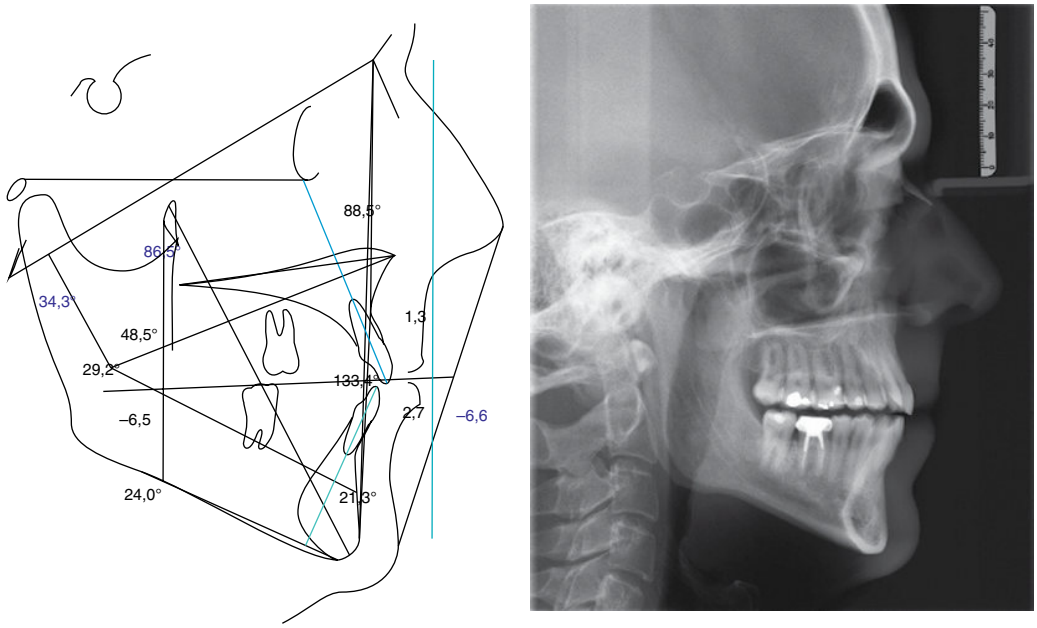


Fig. 20.246 Final cephalometric examination.

Fig. 20.247 Final panoramic X-ray.

20.3.7 Anterior Crossbite, Skeletal Class III

Fig. 20.248 Initial frontal intraoral view.

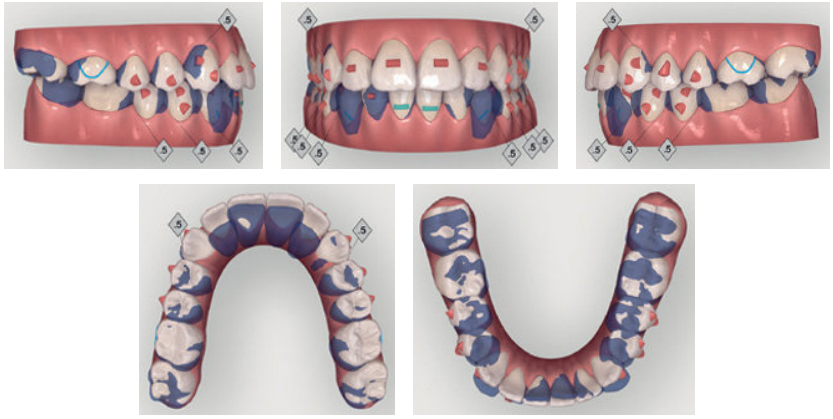


Fig. 20.252 Initial Clinchecks.

Fig. 20.253 Refinement: intraoral views.

ClinCheck 2: Requirements for the Technician

- Class III elastics button cutouts on right side
- Left button cutouts to close posterior open bite
- Final occlusal adjustments with 3-D controls to improve occlusion

Fig. 20.254 Refinement ClinChecks.

Requirements for the Technician

- Simultaneous distalization of the upper and lower molars once both molars distalized 2 mm start moving simultaneously to distal 5 to 5 together in the upper and in the lower arch.
  - Vertical attachments were requested to control the tipping of the canines and premolars during the distalization
  - Maintain the torque of the upper and lower incisor during the retrusion as they would lose torque during the retraction

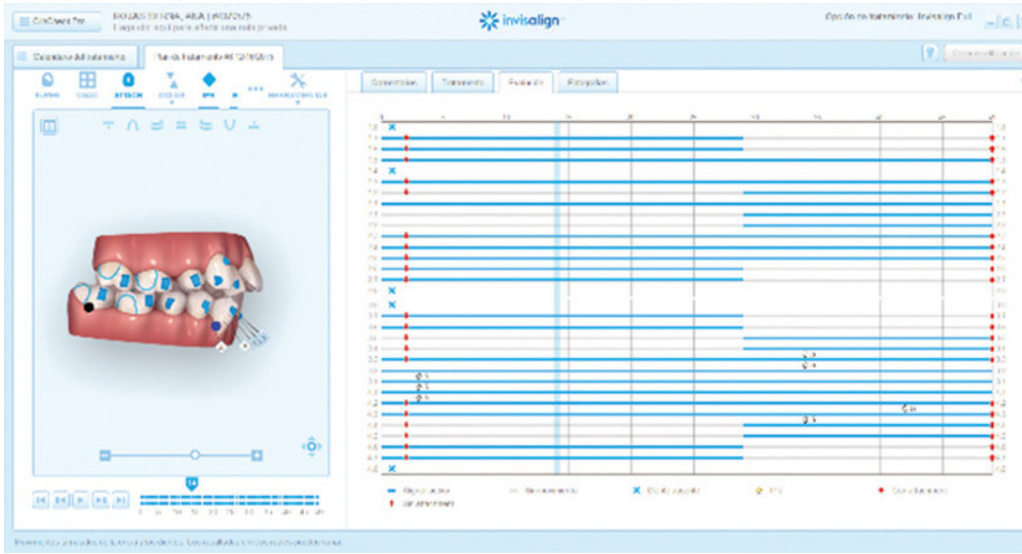


Fig. 20.262 Simultaneous distalization pattern in upper and lower arches.

Upper simultaneous distalization assisted by

- TAD in tuberosity
- Extraction of 18, 28 and 48

Lower simultaneous distalization assisted by TAD in retromolar trigone.

- IPR 3 to 3 and class II elastics

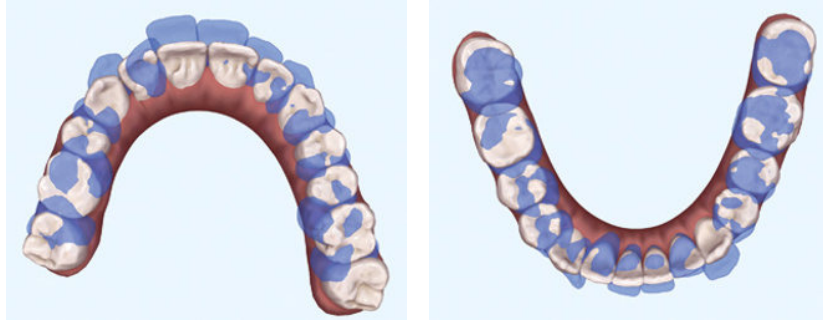


Fig. 20.263 Upper and lower ClinCheck views.

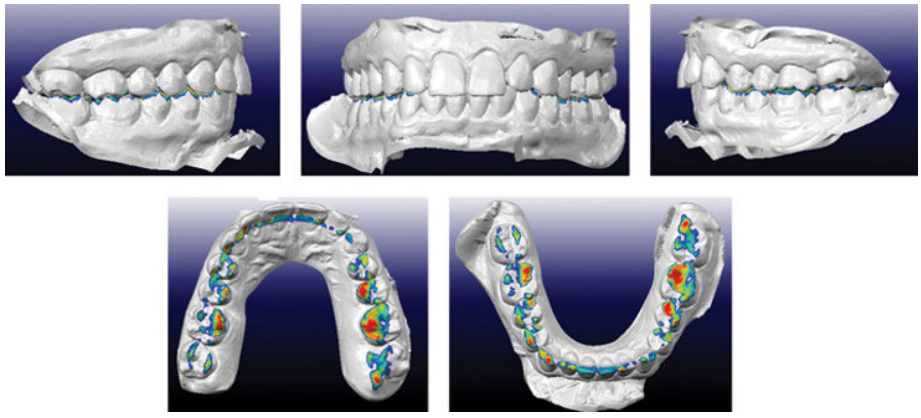


Fig. 21.140 Occlusal contact point at the end of the treatment.

Fig. 21.141 Initial and final smile.

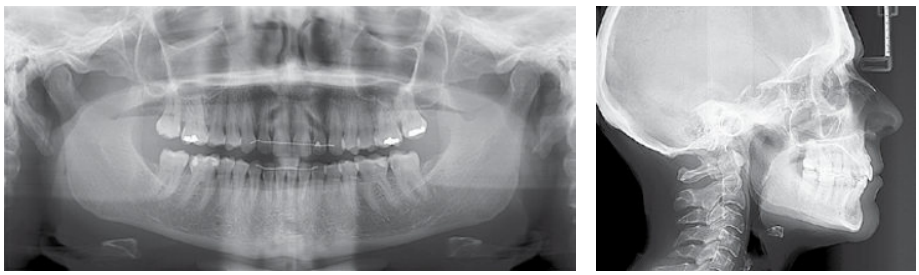
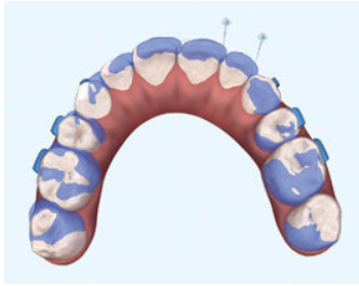


Fig. 21.142 Final panoramic and lateral X-rays.

21.2.4 Deep Bite: Skeletal Class II with TADs

Fig. 21.143 Initial intraoral view.



- ***Staging Maxillary:*** Expansion + rotation mesial-out 1.6 and 2.6
- Lingual-root torque of upper incisors + labial crown torque of upper incisors

Fig. 21.147 Initial upper occlusal superimposition ClinCheck view.

- ***Staging Mandible:*** 1) Expansion
  2) Relative intrusion through proclination
  3) Lower incisors intrusion

Fig. 21.148 Initial lower occlusal superimposition ClinCheck view.

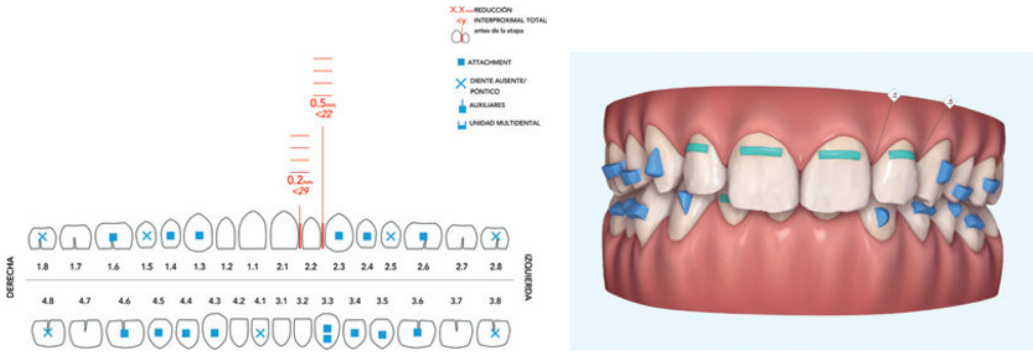


Fig. 21.149 Interproximal reduction is only needed mesial and distal to 22 to make the shape equal to that of 12.

Fig. 23.30 Initial and final smile and overjet.

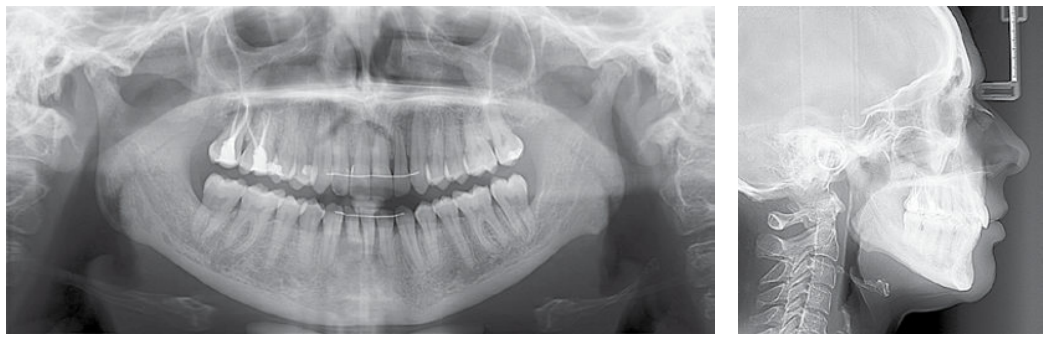


Fig. 23.31 Final panoramic and lateral X-rays.

Tips for Incisor Extraction Treatment

- Check before extracting the incisor, for a favourable root position of adjacent incisors toward the extraction site
- Vertical attachments in the other three incisors for tip control during the space closure. Optimized root control attachment might be used in the canines
- Ask the technician to do a simultaneous intrusion + tipping movement of lower incisors to help parallelism of the roots
- 'Speed of root movement must be half of the maximum permitted' gable bend movement starting by movement of the root. Ask for 10 degrees of virtual gable bends when closing extraction sites

Fig. 24.75 Initial intraoral views.

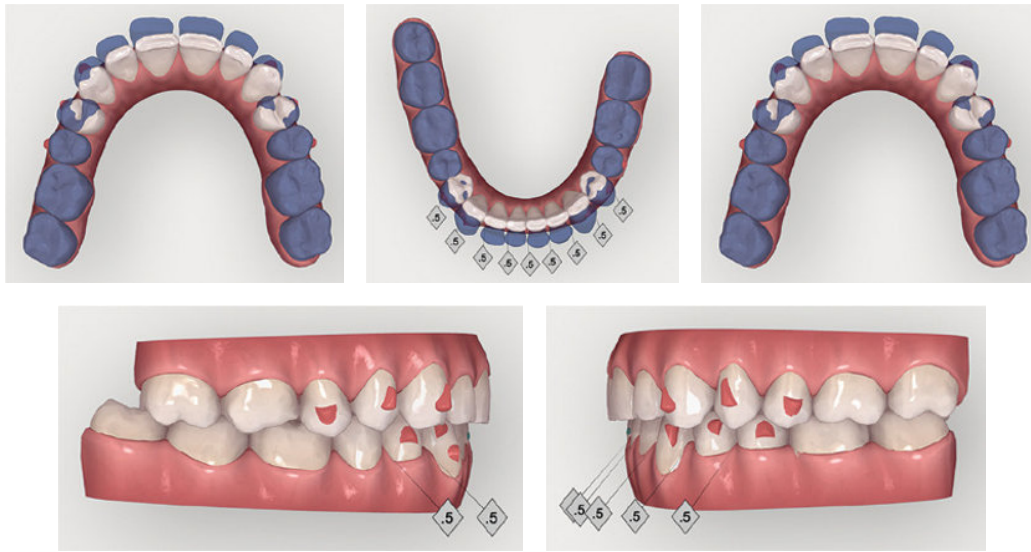


Fig. 24.76 Initial Clinchecks.

Clincheck 1: Communication with Technician

- Set molars as unmovable on both upper and lower arch
- Add extra LRT to 12–22 and 32–32. Solve rotations of premolars at the same time as retrusion, creating a reciprocal movement
- Use optimized deep bite attachments on premolars to help with anterior intrusion and avoid deep bite causing interferences

Fig. 25.29 Intraoral and extraoral views of smile before and after treatment.

At the end of the treatment patient's smile had improved together with the occlusion, using a simple procedure of composite bonding distal to upper laterals. MARPE helped but this planning is the one we like least of the three described earlier (compared with cases in chapters 19 and 20)because:

- As can be seen, anterior anchorage is missed as a result of aligner trimming
- They might exert an opposed force for palatal suture opening, leading treatment to failure

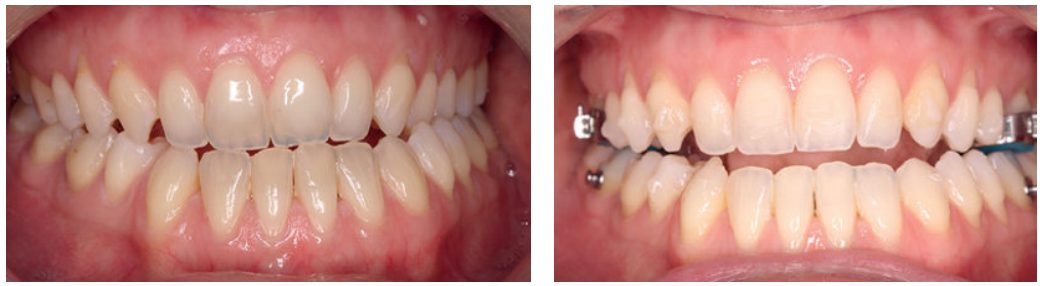


Fig. 25.30 Intraoral views before and after treatment.

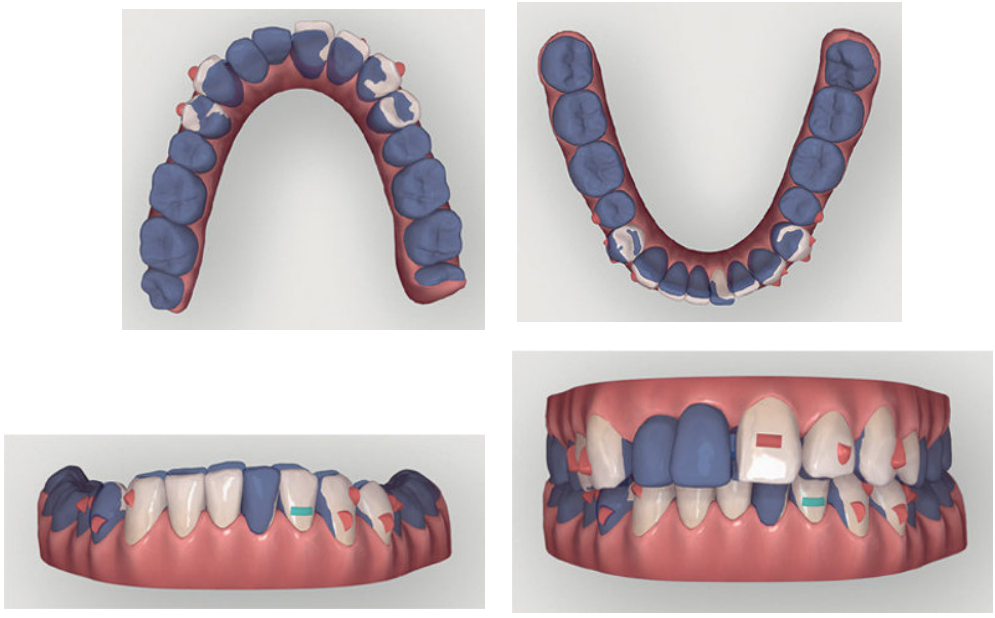


Fig. 25.37 Initial Clinchecks.

Fig. 25.38 Initial smile.

Fig. 25.39 Refinement: intraoral views.

Fig. 25.42 Final X-ray views.

Fig. 25.43 Change in smile after ceramic restoration (Dr Ignacio Vázquez Natividad).

25.4 Anterior Intrusion for Two Central Incisor Veneers

Fig. 25.44 Tooth wear on anterior teeth led to severe attrition of 11–21.