บทความปริทัศน์
Review Article

ภาพรวมของการจัดฟันโดยใช้อินวิสไลน์

ปริยากร ชัยมงคล* บัญชา สำรวจเบญจกุล**

บทคัดย่อ

อินวิสไลน์เป็นการจัดฟันโดยใช้เครื่องมือจัดฟันแบบถอดได้แบบใส โดยเครื่องมือมีหลายชิ้น และต้องเปลี่ยนตามลำดับ ในปัจจุบันอินวิสไลน์ถูกนำมาใช้ในการรักษากันอย่างแพร่หลาย โดยเครื่องมือชนิดนี้ เป็นทางเลือกในการรักษาคนไข้ที่ต้องการความสวยงาม การพัฒนาของเทคโนโลยีในปัจจุบันส่งผลให้การผลิตเครื่องมือนั้นทำได้มากและมีความแม่นยำสูง ส่งผลให้การจัดฟันโดยใช้อินวิสไลน์ทำได้ง่ายและสะดวกสบายขึ้น แม้ว่าในอดีตอินวิสไลน์ถูกแนะนำให้ใช้รักษาในผู้ป่วยที่มีการเรียงตัวของฟันผิดปกติในระดับเล็กน้อยเนื่องจากเครื่องมือยังมีข้อจำกัด แต่ปัจจุบันเครื่องมือได้ถูกพัฒนาอย่างต่อเนื่องและสามารถใช้ในการรักษาผู้ป่วยที่มีการสบฟันผิดปกติแบบยากมากขึ้น บทความปริทัศน์นี้มีวัตถุประสงค์เพื่อนำเสนอข้อบ่งชี้ ข้อดี ข้อเสีย การนำเครื่องมือไปใช้ในทางคลินิก รวมถึงการพัฒนาของเครื่องมือเพื่อนำมาใช้ในการรักษา

คำสำคัญ : อินวิสไลน์, เครื่องมือจัดฟันแบบถอดได้แบบใส, เครื่องมือจัดฟัน

An Overview of Invisalign®

Priyakorn Chaimongkol* Bancha Samruajbenjakun**

Abstract

Invisalign® is a sequential aligner therapy, which is widely available and popular nowadays. This technique represents a new orthodontic treatment option for patients who care of esthetics. With the advance of computer and technology, Invisalign® can be fabricated in a large number and has high accuracy. Thus, this appliance is practical for everyday treatment for orthodontists. Although this appliance was recommended to use with mildly malaligned occlusion because of the limitations of appliance, nowadays this appliance has been developed for the more complex malocclusion. This review is intended to present the overview of Invisalign®, such as indications, advantages, disadvantages, clinical application and also the development of the appliance.

Keywords: Invisalign, Clear aligner, Orthodontic appliance

* นักศึกษาหลักสูตรปรัชญาดุษฎีบัณฑิต สาขาวิทยาศาสตร์สุขภาพช่องปาก คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์
** ผู้ช่วยศาสตราจารย์ ภาควิชาทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ อำเภอหาดใหญ่ จังหวัดสงขลา
* Ph.D. Candidate in Oral health Sciences, Orthodontic section, Department of Preventive Dentistry, Faculty of Dentistry, Prince of Songkla University, Hat Yai District, Songkhla
** Assistant Professor, Department of Preventive Dentistry, Faculty of Dentistry, Prince of Songkla University, Hat Yai District, Songkhla

Introduction

Invisalign® is a modern technology developed from positioner appliances. Kesling[1] introduced the tooth positioning appliance for refining during orthodontic finishing stage in 1945. After basic treatment with fixed appliance was completed, a positioner, which was a flexible rubber appliance, was fabricated on wax set-up. Since this appliance could produce minor tooth movement, the advantages were reducing the space left after debanding, artistically setting and also retaining dental position. Moreover, Kesling predicted that it would be possible to obtain major tooth movement by using positioners that were fabricated on sequential models of progressed tooth movement. In 1971, Ponitz[2] invented invisible retainer fabricated from prepositioned teeth on dental model and found that it produced limited tooth movement. After that, Sheridan et al[3] developed Essix appliance in 1993. This technique was accomplished with interproximal tooth reduction and sequential alignment with clear retainer. However, a disadvantage of this technique was time-consuming because new set of impression and model were required every visit for sequential tooth movement. Nowadays, prediction of Kesling came true because of computer technology. Align technology has been developed for orthodontic treatment practically.[4] Nowadays, Invisalign® has become alternative treatment options for adult patients.[5]

Indications

Invisalign® appliance was indicated to treat patients with mild non-skeletal malocclusions.[5] Joffe[6] suggested that the most successful treatment was obtained when treating mildly malaligned malocclusions including

- Mild crowding and malaligning (1 to 5 mm)
- Mild spacing (1 to 5 mm)
- Deep overbite (when deepbite can be corrected by intrusion and proclination)
- Non-skeletal constricted arch (expansion with limited teeth tipping)

Moreover, Invisalign® was suggested to treat malocclusion which need to be corrected by slight tooth movement in antero-posterior and lateral direction, minor interproximal reduction, or by lower incisor extraction.

Contraindications

Joffe[6] also instructed about the case that should not be treated with Invisalign® :

- Severe crowding over 5 mm
- Severe spacing over 5 mm
- Skeletal discrepancy over 2 mm
- Severe tooth rotation over 20 degrees
- Centric relation and centric occlusion discrepancy
- Anterior or posterior openbite that need to be closed by extrusion
- Teeth extrusion
- Severe teeth tipping over 45 degrees
- Teeth with short clinical crown
- Partial erupted permament teeth
- Arched with multiple missing teeth

However, nowadays, many studies reported that complex malocclusion could be successfully treated with Invisalign®.[7-9] Invisalign® could correct crowding with mandibular incisor or premolar extraction, deep overbite, ectopically positioned teeth and rotation. Moreover, it could distalize molars and extrude incisors, which has proven to be one of the most difficult movements to achieve by using clear aligner.[7]

Advantages

Invisalign® provides ideal esthetics for the patients who seek for orthodontic treatment with invisible appliance, however, good compliance and cooperation must be evaluated. Moreover, the appliances are comfortable to use because they are easy to insert and remove.[6, 10] It is much less bulky

and obtrusive compared with conventional fixed and removable appliance.[11] Since teeth were moved around 0.2 mm, subjective evaluation of patients showed that less discomfort was found in patients treated with aligners compared with fixed appliances.[12] Speech has rarely become the problem, although it is usually affected for 24 hours to one week of treatment.[6, 12] Removing aligner during eating and cleaning, patients can continue eating without restriction.[13] It can also provide better oral hygiene because the appliance does not impede oral hygiene procedures. Thus, the risk of decalcification, gingivitis and periodontal problems could be reduced. [4, 10, 13] Moreover, special care of aligner is not needed, brushing with toothbrush and toothpaste is sufficient and aligner have to be changed every two weeks period. For orthodontist, this technique can reduce chair time[10] because only minor procedure is needed such as bonding attachment or interproximal reduction. Comparing with conventional appliance, less frequent visits is needed with 6 to 8 weeks instead of 4 to 6 week intervals.[11]

Disadvantages

Although, Invisalign® can be used with many types of malocclusions, Invisalign® alone is not suggested for severe skeletal discrepancies treatment. Orthognathic surgery and fixed appliance could be used combined with Invisalign® to correct severe skeletal discrepancies.[6] Moreover, previous article showed that Invisalign® was only about 59 percent effective. The accuracy of certain tooth movements, such as the upper incisor torque and the premolar derotation, were less than 50 percent effective. Kravitz described just a 41% mean accuracy of tooth movement.[14] In addition, posterior openbite was reported after the use of aligner due to lacking of occlusal corrections that was not fully incorporated into the virtual treatment plan. Another reasons was related to unfinished corrections, which was a primary factor in developing anterior interference.[15]

Previous study reported that Invisalign® showed inferior outcome than fixed appliance. Using ABO-OGS score, Invisalign® did not treat malocclusions as well as conventional braces. Invisalign® was especially deficient in its ability to correct large antero-posterior discrepancies and occlusal contacts. The strengths of Invisalign® were its ability to close spaces and correct anterior rotations and marginal ridge heights. The Invisalign® group lost 13 OGS points more than the braces group on average, and the OGS passing rate for Invisalign® was 27% lower than that for braces.[16] However, the overall improvement in OGS scores indicate that both Invisalign® and fixed appliances were successful in treating Class I adult extraction cases in this sample.[17]

Previous study compared post-retention dental change after treated with Invisalign® and traditional orthodontic treatment using fixed appliances. The result showed that the change in the total alignment score in the Invisalign® group was significantly larger than fixed appliances group and found significant changes in maxillary anterior alignment in Invisalign® group only.[18]

To obtain the greatest result, patients have to wear aligner around 20-22 hours a day. Good compliance of patients is needed when using Invisalign® for orthodontic treatment.[5] This appliance is not suitable for patient who has teeth with severe undercut[11] and partial eruption of permanent teeth because short clinical crowns could not provide enough retention.[12] After set of aligners was made, orthodontist has no ability to modify the aligner. If treatment plan has to be changed, new impressions will be needed for new aligners and that can be costly. The lag time for plan formulation and new aligners fabrication could take 2 months and this can lengthen treatment time.[6] During treatment procedure, anatomy of teeth cannot change thus restoration should be performed before treatment.[12] Consequently, well treatment plan is needed before appliances fabrication. Furthermore, these appliances

are transparent thus they are prone to be misplaced easily.[5, 10]

Clinical application

Patient preparation and orthodontic records of Invisalign® appliances are similar to treatment with conventional fixed appliances. Pretreatment records comprise of panoramic and lateral cephalometric radiography, oral impression, bite registration and photos.[5] Precision of impressions is important thus the impression materials should be polyvinyl silicone material or polyether material. Maximum intercuspation position should be recorded by using silicone bite. The innovation of Invisalign® is scanning and imaging the high precision casts made from high quality and accurate impressions. Then, 3-dimensional models will be duplicated form patient's teeth and will be used for treatment plan developed by orthodontist and translated by Invisalign® technology.[6] Nowadays, direct intra-oral scan is used to eliminate error from impression step and to obtain greater accuracy.[11] All data must be sent to Align technology in California to create virtual models from malocclusion and correct with proprietary 3-dimensional CAD-CAM technology. After that, orthodontists can download virtual treatment models through a program called ClinCheck® and re-evaluate the treatment plan by tooth movement from initial until obtain final dental position. Orthodontists can request for plan modification, aligner design, selection of attachment and other items, such as precision cuts for using elastic and button cutouts for using bondable attachments to teeth surface, until obtaining precise and satisfying treatment plan.[5, 6, 11] Computer images are converted to series of physical models and these models will be used for aligners fabrication using Biostar pressure molding machine (Great Lakes Orthodontic Products, Tonawanda, NY).[19] After series of aligners are made, plan could not be changed. If the plan must be modified during the treatment process, auxiliary appliances can be used combined with aligners or contact Align technology for modification and construction new set of aligners.[5, 6]

Around 4-6 weeks, Invisalign® appliances are delivered to clinicians. In the first visit, orthodontist must check for fit and comfort after aligner insertion. The fit of aligner can indicate that the appliance is working effectively. Since the initial visit, patients should be informed about the attachment and auxiliary appliances thus they would not be disappointed when they were placed. Some orthodontists delay the bonding of attachments to allow patients getiing used to aligner first. Inter-proximal reduction is performed depending on schedule recommended by Align Technology. Patient must be informed about wearing instruction.[6, 11] Invisalign® can produce minor tooth movement by creating divots, which produce force for individual tooth movement, and windows, which prepare space for teeth to move into.[19] After aligner therapy was completed, treatment result must be evaluated and patient satisfaction must be obtained. In case that objective is not fully achieved, refinement course is indicated. Course of refinement comprises of additional set of aligners, which can continue the treatment until the endpoint. Many orthodontists compare this stage as final detailing stage.[11]

Patient instruction

After the treatment was begun, present aligner has to be changed to the next one every two weeks to advance to the next stage of tooth movement.[6] Each aligner is designed to move teeth for 0.25 to 0.3 mm in 2 weeks and these aligners have to be worn in a specific sequence. Aligners should be worn for 20 to 22 hours a day to obtain effective result, except when eating, drinking hot beverages, brushing and flossing. Thus, Invisalign® appliances should be used in adult and adolescents who have acceptable compliance.[5] To monitor the treatment progression, check up with orthodontist every 6-8 weeks is required.[11]

Development technique treating with Invisalign®

In the past, previous study reported that Invisalign® appliance was not suitable to treat patient with premolar extraction because Invisalign® had limited capability to control tooth angulation during space closure. Although bonding restorative attachment on buccal surface of tooth could provide greater angulation control, it helped partially.[6] Space closures of extraction were the result of crown tipping of the adjacent teeth rather than bodily movement.[5] Bollen and others[4] found severe tipping around extraction site in premolar extraction case. Moreover, Miller and others[20] found tipping around lower incisors extraction site. Consequently, recent study used Invisalign® combined with fixed appliance to treat patient who had severe crowding with four first premolars extraction. During the treatment, distal tipping of canines and mesial tipping of second premolars and first molars were found and caused bowing effect, then fixed appliances and power arms were used to eliminate tipping movement.[21] Another study suggested that if the teeth tipped exceeds 10-15 degree during space closure, segmental or full-fixed appliances were recommended after treatment with aligners. Moreover, fixed appliance should be performed before using aligners in case of severe localized crowding. Previous study reported the case of 30-year-old patient who had class II molars with severe crowding and ectopically erupted upper right canine. Upper first premolars were extracted and upper canines were distalized with segmental fixed appliances before treatment with aligners. Brackets from canines to first molars and T-loops in segmented 0.017" x 0.025" TMA wires were used for canine distalization.[22] Nowadays, Invisalign® has developed the methods including attachments to enhance the effectiveness of root control during tooth movement in extraction case. For first premolars extraction case, optimized root control attachments are suggested to bond on canines and second premolars to control roots. For second premolars extraction, optimized root control attachments are recommended to bond on first premolars and bonded molars with 1 mm thick vertical rectangular attachments.

For lingual root torque of upper and lower incisors, power ridge was recommended by Align technology to place on buccal surface of incisors. For lingual root torque and lingual translation of upper incisors, power ridge will be placed on both buccal and lingual sides. However, power ridge is designed for upper and lower incisors but not available for other teeth. To torque root of other teeth in lingual direction, conventional attachments are required.

Previous study reported that anterior openbite correction treatment with Invisalign® has limited success and ideal occlusion is difficult to obtain.[5] However, Schupp et al[23] treated 15-year-old female with anterior openbite and tongue dyskinesia, and sigmatism during speech. Patient underwent myofuntional therapy before orthodontic treatment. During Invisalign® treatment, vertical rectangular attachments were bonded on upper incisors, canines and first premolar and lower canines and premolars. After 20 months, functional overjet and overbite were obtained. Relapse was not found after 12 months Invisalign® treatment.

To correct rotation, Invisalign® appliance is not suitable for severe tooth rotation.[5] Vlaskalic et al[12] suggested that rotation of tooth with round anatomy such as premolar is challenging and tooth rotation exceeds 45 degree should be derotated and reduced the magnitude of rotation with fixed appliance before treated with aligners.

Regarding inter-arch mechanics, previous study reported about the limitation of the appliance thus it had imperfection of buccal malocclusion correction.[5, 24] It was shown that conventional fixed appliance was more successful to correct bucco-lingual crown inclinations, occlusal contacts, occlusal relationships, and overjet compared with Invisalign® [16] and could produce better occlusal relationship.[25] Moreover, clear

sequential orthodontic aligners, which is similar to Invisalign® was used in another study and found that buccal occlusion correction was minimal successful.[24] In addition, Kamatovic[26] concluded that Invisalign® could not correct antero-posterior and transverse relationships. However, some clinicians recommended to bond buttons on buccal surface to assist tooth movement but this technique could affect retention of the appliance.[6] Nowadays, plastic buttons were suggested to bond directly on aligners combined with the use of interarch elastics. The retention of aligner was gained by adding the attachments on teeth. It showed that this technique could improve inter-arch relationship and suggested that it can provide better treatment results for broader variety of cases using Invisalign® treatment.[27] Moreover, prescribing precision cuts were recommended to facilitate the use of buttons and elastics.[28] Class II and III elastics were recommended to used with precision cuts to correct antero-posterior dental relationship. Midline deviation was suggested to correct by using class II elastic on one side and class III elastic on opposite side.[28]

For patient who has erupting teeth, eruption compensation will be designed by orthodontists to prescribe the room to accommodate the natural eruption while wearing aligner. To prevent supra-eruption of terminal molar, eruption tab is suggested by Align technology. It extends over the mesial cusp of terminal molar thus it helps prevent supra-eruption of terminal molar and keep it from exceeding the height of adjacent teeth.

After completion of initial aligning, some case may need to detail the treatment with detailing pliers to correct minor dental malalignment such as minor rotation, antero-posterior of anterior teeth and tighten interproximal contacts. Since aligners were pre-built, little extra pressure-generating dimples are needed to create using pliers to move teeth into desired position. The purpose of detailing is to encourage fully expression of tooth movement in pre-programmed aligner thus the desired movement must already be present in the aligner. Moreover, pressure points can be flatted and repositioned by using Invisalign® eraser plier. Detailing method can reduce the need of refinement aligners in finishing stage.

Invisalign® combined with corticotomy

Aside from esthetics, treatment time is challenging for adult orthodontic treatment.[29] Corticotomy is safe and effective technique to accelerate orthodontic tooth movement by producing regional accerelatory phenomena (R.A.P.).[30] Cassetta et al[31] reported clear aligner with corticotomy case. Patient's chief complaint was dental crowding and required short treatment time and esthetic appliance. After corticotomy, orthodontic force was applied immediately using clear aligner and each aligner was used for 5 days. Treatment was completed in 2 months and it was one-third of usual time treating with clear aligners.

Retention strategies

Retention can be obtained from fixed or removable retainer or combination depending on experience of orthodontists. For clear retainer, there are many factors that can shorten lifetime of this appliance such as wear, crack, discoloration and staining. Thus patients should have been checked up regularly to re-evaluate dental position, abnormality of retainer and fabricate new retainer if needed.[11, 32]

Conclusion

Treatment with Invisalign® is another option for orthodontic treatment, especially for patients who concern about esthetics. With the advance of computer and technology, Invisalign® has been developed and limitations of treatment were gradually eliminated. However, additional researches and case reports are still needed to improve the effectiveness of these clear aligners in the near future.

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