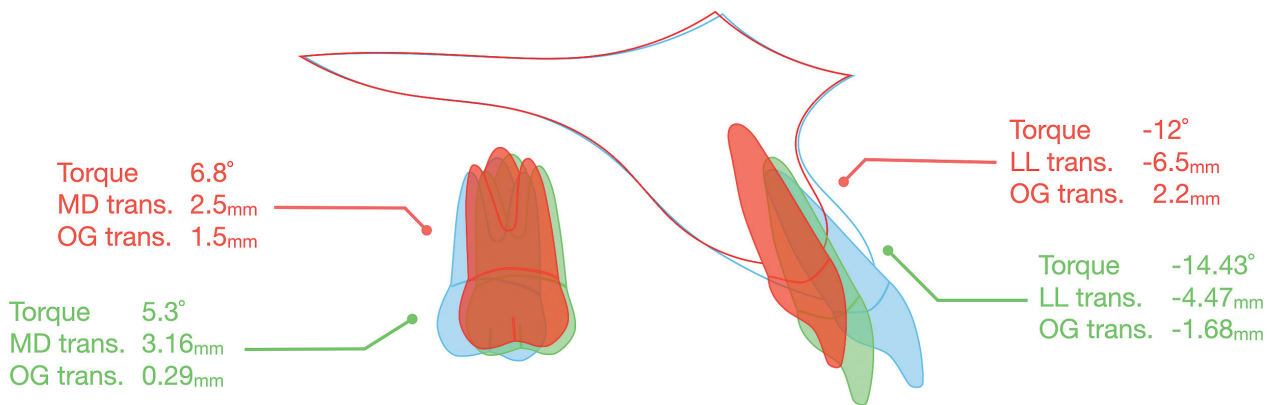


Mechanics and Clinical Significance for Mini-Screws in Four-Bicuspid Extraction Aligner Cases

Abstract

When treating extraction cases with clear aligner therapy, root paralleling during space closure has been inconsistently. Even the G6 (Align Technology, Inc., San Jose, CA, USA) solution does not guarantee highly predictable tooth movement. Anchorage loss and unwanted side effects are still encountered. The aim of the present article is to propose a mini-screw gold standard of care for patients who demand inconspicuous aligner therapy involving extraction of four first premolars. (*J Digital Orthod* 2020;58:94-98)

Despite the fact that Invisalign® G6 has been launched to improve the management in patients requiring extraction of four first premolars,^{1,2} the actual clinical outcome may be less than satisfactory in some circumstances. Dai et al.³ have reported the differences between predicted and achieved tooth movement (DPATM) of maxillary first molars and central incisors in first premolar extraction cases treated with Invisalign®. To be more specific, first molars on average tipped mesially by 5.3° and moved mesially 3.16mm even if they were specified to be stable. Because of posterior anchorage loss, the central incisors were tipped lingually, retracted less, and extruded more compared to predictions.³ The consequence was similar to the torque play between rectangular archwires and bracket slots, a phenomenon referred to as the bowing effect. Fig. 1 demonstrates the difference between one of our cases and Dai et al.'s³ study results. This



■ Fig. 1: A comparison of maxillary superimposed tracings of pre- and post-treatment (blue and orange, respectively) records a bimaxillary protrusion case that underwent four bicuspid extractions and clear aligner therapy. Dai et al.'s³ study results (green) tested G6 performance in extraction cases.

Dr. Lexie Y. Lin,
Resident, Beethoven Orthodontic Center (Left)

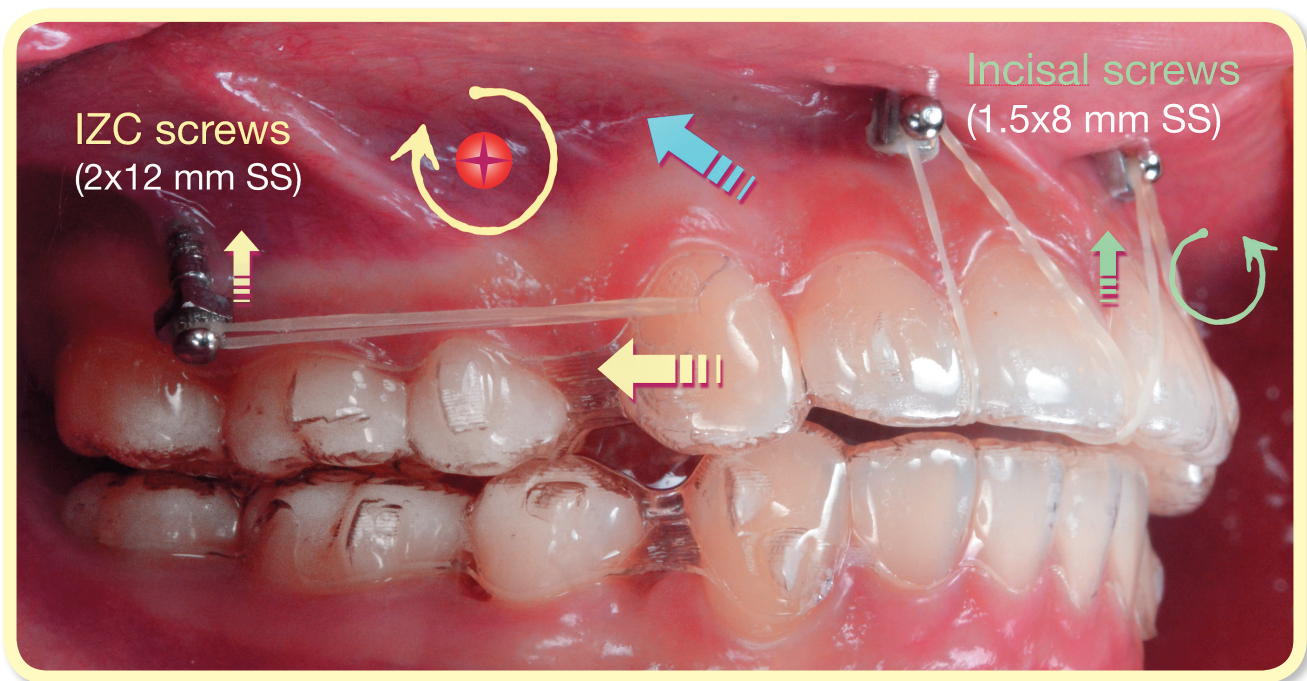
Dr. Chris H. Chang,
Founder, Beethoven Orthodontic Center
Publisher, Journal of Digital Orthodontics (Center)

Dr. W. Eugene Roberts,
Editor-in-chief, Journal of Digital Orthodontics (Right)



patient presented with bimaxillary protrusion, gummy smile tendency, and mild crowding in both arches. A treatment approach involving extraction of the four first premolars, followed by Invisalign® treatment in conjunction with OrthoBoneScrew® (OBS) (iNewton, Ltd., Hsinchu, Taiwan) anchorage system, was chosen (Fig. 2).

The post-treatment results show excessive mesial tipping of the first molar, rather than the expected and vertical movement (*intrusion*) that was expected due to the inherent intrusive mechanics of mini-screws.⁵ Initial crowding may explain the tilting molar, since it had been found to have an inverse correlation with



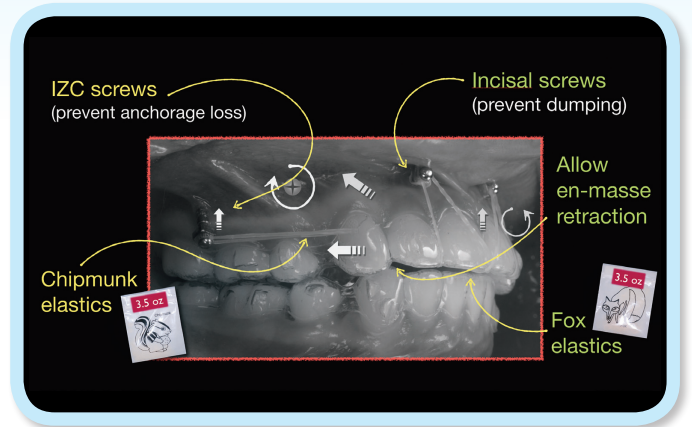
■ Fig. 2:

The force system is diagrammed for the IZC and incisal mini-screws. Based on the presumed center of resistance (C_R , red circle with a cross) for the maxillary arch, the elastics from the IZC screws to the cuspid precision cut has distal and vertical components (yellow arrows) that produce a clockwise moment around the C_R (curved yellow arrow). The incisal screws anchor an intrusive force (green arrow) that create a counterclockwise moment (curved green arrow) tending to flare the maxillary incisors. The presumed resultant for overall applied loads is the blue arrow.

DPATM relative to anchorage loss.^{3,6} As for the central incisor, the amount of retraction and intrusion was obvious, because it was a good use of the extraction spaces, but also prevented posterior open bite. Posterior open bite can be a common side effect in aligner treatment if there is premature contact in the anteriors.⁷ Furthermore, the angulation of the central incisor was better controlled in this case with the help of the mini-screws.

Fig. 2 demonstrates the proper mini-screw positioning and mechanics plan for aligners. Two 2mm x 12mm stainless steel (SS) mini-screws were installed bilaterally in the infra-zygomatic crest (IZC) extra-alveolar (E-A) area, and two 1.5mm x 8mm SS mini-screws were inserted in the maxillary anterior inter-radicular region. These mini-screws were placed when the tenth aligner was delivered. 3.5oz elastics (*Chipmunk and Fox, Ormco, Glendora, CA*) were specified to activate the aligners (Fig. 3).

This four-mini-screw setup appears to be similar to the strategy for gummy smile in fixed appliances.⁸ However, the IZC and incisal mini-screws serve different purposes. The aligners themselves can provide advantages with regard to the efficiency in mild-to-moderate cases,⁹ but cannot offer an ideal force system for all types of tooth movement. When treating extraction cases, root paralleling during space closure after extraction has been found to be challenging.¹⁰ Even the G6 protocol along with SmartStage^{®2} does not guarantee highly predictable



■ **Fig. 3:** The illustration of the combined use of application with clear aligner therapy, mini-screws and elastics. The incisal screws and IZC screws served different purposes for preventing unwanted movements.

tooth movement. Anchorage loss and unwanted side effects are still encountered.

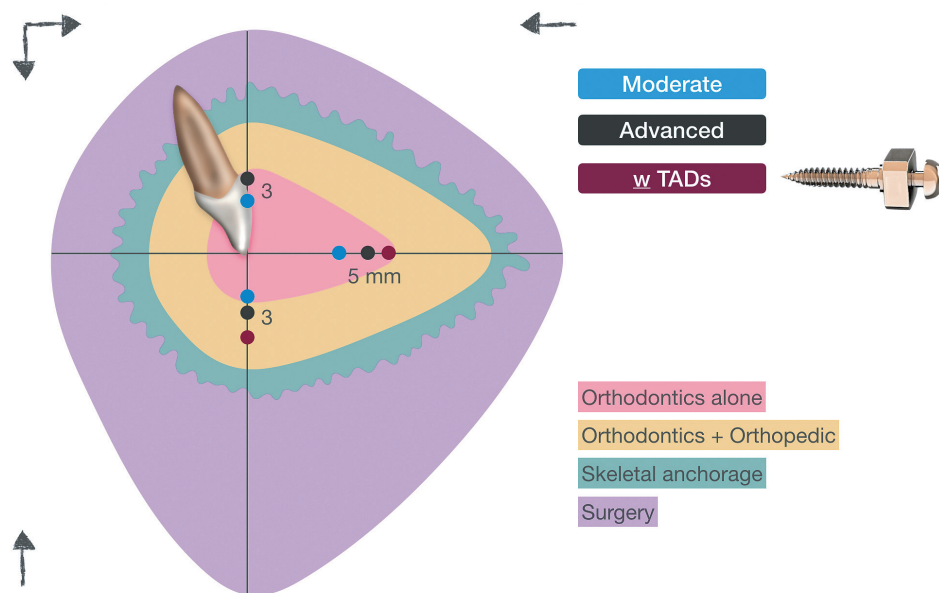
Thus, prevention is better than cure. On the one hand, the IZC E-A mini-screws literally maximize the posterior anchorage, allowing practitioners to design simultaneous retraction from canine to canine. On the other hand, the incisal mini-screws aim to compensate the anterior dumping tendency, minimizing the side effect and encouraging bodily movement during retraction. Furthermore, the presumed resultant for all applied loads is likely to impact the entire maxillary arch with backward and upward movement. This mechanotherapy can change the occlusal plane, leading to counterclockwise rotation of the chin point. Thus, the OBS anchorage¹¹ system is of the utmost importance in expressing the full potential of aligners.

Mini-screws are a stable anchorage system that can withstand approximately 400g of orthodontic force,¹² which is more than adequate for clear aligner therapy. The failure rates for IZC E-A screws and incisal screws to support fixed appliances are 6.3%¹³ and 7.2%,¹⁴ respectively, and failure may be less frequent with aligners because the force applied is lower and intermittent. Further studies on this issue are expected.

With regard to the envelope of discrepancy,¹⁵ Invisalign® has its own tooth movement assessment

overview which provides guidance for programming substantial tooth movement into the ClinCheck® (Align Technology, Inc., San Jose, CA, USA) treatment plan, along with the skills that may be needed for the treatment (Fig. 4).¹⁶

Fixed appliances and clear aligners are simply tools. When and how to use them properly is left to the practitioners' discretion. In the meantime, mini-screws have the ability to expand the envelope of discrepancy for both appliances.



■ Fig. 4:

The anteroposterior and vertical millimetric range of treatment possibilities in orthodontics can be expressed as an envelope of discrepancy. The different colored zones describe the range of potential tooth movement with fixed appliances. The arrows indicate the direction of movement in the diagram. The reason the green zone is shown in “fuzzy” fashion is that there is only sufficiently reliable data to make estimates at this point.¹⁵ The blue dots indicate moderate treatment with variable predictability in clear aligner therapy, while black dots indicate more complex treatment with less predictability which often requires additional orthodontic techniques as they are more challenging to achieve with the use of aligners alone. Very close monitoring is recommended.¹⁶ The burgundy dots are estimated points, representing the expansion of the envelope of discrepancy for aligners.

Conclusions

Without mini-screws, it is hard to deliver ideal mechanics for patients who demand inconspicuous aligner therapy for treatment involving extraction of four first premolars. This article explains the characteristics of mechanism, and emphasizes the clinical significance of mini-screws in conjunction with Invisalign®. Further studies will result in robust clinical recommendations.

References

1. Align Technology I. Invisalign G6. Available from: <http://www.invisalign-g6.com/en-XA>.
2. Chang MJ, Chen CH, Chang CY, Lin J, Chang CH, Roberts WE. Introduction to Invisalign® Smart technology: attachment design, and re-call checks. *J Digital Orthod* 2019;54:80–95.
3. Dai FF, Xu TM, Shu G. Comparison of achieved and predicted tooth movement of maxillary first molars and central incisors: First premolar extraction treatment with Invisalign. *Angle Orthod* 2019;89:679–687.
4. Archambault A, Lacoursiere R, Badawi H, Major P, Carey J, Flores-Mir C. Torque expression in stainless steel orthodontic brackets: a systematic review. *Angle Orthod* 2010;80:201–210.
5. Lee JS, Kim JK, Park YC. Biomechanical considerations with temporary anchorage devices. In: Graber LW, Vanarsdall RL, Vig KW, Huang GJ. *Orthodontics: current principles and techniques*. 6th ed. St. Louis: Mosby; 2017. p. 511–568.
6. Geron S, Shpack N, Davidovitch M, Kandos S, Davidovitch M, Vardimon AD. Anchorage loss—a multifactorial response. *Angle Orthod* 2003;73:730–737.
7. Lagravère MO, Flores-Mir C. The treatment effects of Invisalign orthodontic aligners: a systematic review. *J Am Dent Assoc* 2005;136:1724–1729.
8. Wang A, Chang CH, Roberts WE. Conservative management of skeletal Class II malocclusion with gummy smile, deep bite, and a palatally impacted maxillary canine. *Int J Orthod Implantol* 2017;48:24–46.
9. Zheng M, Liu R, Ni Z, Yu Z. Efficiency, effectiveness and treatment stability of clear aligners: a systematic review and meta-analysis. *Orthod Craniofac Res* 2017;20(3):127–133.
10. Phan X, Ling PH. Clinical limitations of Invisalign. *J Can Dent Assoc* 2007;73:263–266.
11. Chang CH, Lin JS, Yeh H. Extra-alveolar bone screws for conservative correction of severe malocclusion without extractions or orthognathic surgery. *Curr Osteoporos Rep* 2018;16:387–394.
12. Liou JW, Pai CJ, Lin CY. Do miniscrews remain stationary under orthodontic forces? *Am J Orthod Dentofacial Orthop* 2004;126:42–47.
13. Hsu E, Lin JS, Yeh H, Chang CH, Roberts WE. Comparison of the failure rate for infrazygomatic bone screws placed in movable mucosa or attached gingiva. *Int J Orthod Implantol* 2017;47:96–106.
14. Chang CH, Huang C, Lee WH, Roberts WE. Failure rates for SS and Ti-alloy incisal anchorage screws: single-center, double-blind, randomized clinical trial. *J Digital Orthod* 2018;52:70–79.
15. Nguyen T, Proffit W. The decision-making process in orthodontics. In: Graber LW, Vanarsdall RL, Vig KW, Huang GJ. *Orthodontics: current principles and techniques*. 6th ed. St. Louis: Mosby; 2017. p. 208–244.
16. Align Technology. Invisalign® tooth movement assessment overview. 2011. Available from: <https://s3.amazonaws.com/learn-invisalign/docs/us/ToothAssessment.pdf>.

