

Don't forget to overcorrect and much more: The current finite element analysis publications related to clear-aligner treatments

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In the past year or so, the *American Journal of Orthodontics and Dentofacial Orthopedics* has published 7 articles focusing on clear aligners (CA) using finite element analysis (FEA).¹⁻⁷ Each article delves into clinical challenges using an almost 25-year-old CA system. The effectiveness of achieving fundamental or complicated tooth movements with CA remains low relative to fixed appliances (FA).^{8,9} The subjects explored in these 7 articles encompass torque control, intrusion, closing extraction spaces, anchorage preparations, overcorrections, and more. For many orthodontists, especially those of a more seasoned background, this might evoke a sense of déjà vu. Those who underwent orthodontic programs may recall the debates surrounding the above topics. Furthermore, it is essential to acknowledge that the advent of straight-wire systems largely resolved these so-called challenges or discussions. For example, overcorrection was deemed unnecessary (prolonged treatment time, needless back-and-forth movements), and anchorage preparation failed to yield any advantages in closing spaces (teeth are not tent pegs, and bone is not soil).

Over the years, a new, so-called language related to CA was developed. Unfortunately, this new language also contains several basic physical movements that, apparently, because of the CA's inability to perform them, the new language is recruited to solve it. In the CA language, what was previously considered

relative-intrusion/relative-extrusion stemming from tipping has been reclassified as true intrusion/extrusion, as both affect the overbite. Moreover, in CAs, tipping has morphed into torque. As mentioned by Gottlieb in the *Journal of Clinical Orthodontics* in 1970¹⁰:

There are ideas that achieve the status of a 'well-known facts' through repetition. Some of these have become a routine part of many orthodontists' treatment procedures without being proven. (One of these is overcorrection of teeth).

All inclinations' changes in the incisors' zone are currently considered torque changes. Why? Because of the endless repetition, it became the truth.

We do not have to go back to Archimedes, who said: "Give me a fulcrum, and I will move the world," to understand the importance of anchorage in moving teeth. It should be a common knowledge that the absence of anchorage, inherent in any removable appliance, including CA, coupled with the plastic material's inability to maintain planned vectors necessary for generating a sustainable couple—the distinctive a-vector rotational movement resulting in torque—cannot be incorporated into the repertoire of CA movements. Nevertheless, the new generation of orthodontists has embraced this concept, and the tip has transformed into torque as part of the new aligner vernacular. Furthermore, torque, a unique rotational movement with its center of rotation at the bracket's center and not at the center of resistance, can only be achieved within the minuscule bracket space, altering the tooth's inclination and angulation in the anteroposterior and mesiodistal dimensions, respectively.

Currently, a novel cohort of researchers is employing FEA to elucidate the reasons behind the lackluster treatment outcomes with aligners, as the average success rate of CAs hovers at a mere 50% effectiveness across all tooth movements (including tip, torque, intrusion, extrusion, rotations, and bodily movement). Each research group examines potential treatment attributes

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that could enhance the efficacy rate and achieve better results if incorporated into the treatment plan.

The sense of déjà vu we are experiencing is rooted in the chosen attributes scrutinized by the specialty years ago, such as overcorrections (overtreatment), anchorage preparations, and more. Over time, the hype surrounding these parameters waned as it was discovered that their contribution was negligible, if existent. The emergence of this fresh wave of studies (FEA) aimed at deciphering the enigma of the 50% efficacy does not catch us by surprise. However, it is baffling that the specialty seems to accept this 50% efficacy without acknowledging that aligners can offer an excellent solution for their original intended purpose: minor tooth movements, primarily tipping. As previously discussed, torque cannot be effectively achieved using aligners, which underscores the need for scientific exploration of other factors, such as overcorrections and more. It is akin to circling a core issue without genuinely addressing it.

In 2005, Turpin,¹¹ the former editor of the *American Journal of Orthodontics and Dentofacial Orthopedics*, published an influential editorial on CAs, wherein he emphasized: “the necessity for well-designed randomized clinical trials to garner extensive support within the orthodontic profession.” We concur with this notion and assert that rigorous clinical studies are essential to enhance the credibility and applicability of these research findings. In the spirit of Dr Turpin’s call for more robust clinical trials, we urge the authors of the 7 articles to take the lead and implement their recommendations in clinical practice on a sufficiently large patient cohort. Subsequently, reporting the outcomes to the journal would constitute an invaluable clinical contribution, propelling the advancement of orthodontic knowledge and patient care.

Please note it is important to remember that differences between laboratory-based FEA outcomes and biological reality might be more pronounced than anticipated.

REFERENCES

1. Liu L, Song Q, Zhou J, Kuang Q, Yan X, Zhang X, et al. The effects of aligner overtreatment on torque control and intrusion of incisors for anterior retraction with clear aligners: a finite-element study. *Am J Orthod Dentofacial Orthop* 2022;162:33-41.
2. Barros SE, Faria J, Jaramillo Cevallos K, Chiqueto K, Machado L, Noritomi P. Torqued and conventional cantilever for uprighting mesially impacted molars: a 3-dimensional finite element analysis. *Am J Orthod Dentofacial Orthop* 2022;162:e203-15.
3. Jia L, Wang C, Li L, He Y, Wang C, Song J, et al. The effects of lingual buttons, precision cuts, and patient-specific attachments during maxillary molar distalization with clear aligners: comparison of finite element analysis. *Am J Orthod Dentofacial Orthop* 2023;163:e1-12.
4. Zhu GY, Zhang B, Yao K, Lu WX, Peng JJ, Shen Y, et al. Finite element analysis of the biomechanical effect of clear aligners in extraction space closure under different anchorage controls. *Am J Orthod Dentofacial Orthop* 2023;163:628-44.e11.
5. Yang Y, Yang R, Liu L, Zhang X, Jiang Q, Fan Q, et al. The effects of aligner anchorage preparation on mandibular first molars during premolar-extraction space closure with clear aligners: a finite element study. *Am J Orthod Dentofacial Orthop* 2023;164:226-38.
6. Liu J-Q, Zhu GY, Wang YG, Zhang B, Yao K, Zhao ZH. Different biomechanical effects of clear aligners in closing maxillary and mandibular extraction spaces: finite element analysis. *Am J Orthod Dentofacial Orthop* 2023;163:811-24.e2.
7. Lyu X, Cao X, Yan J, Zeng R, Tan J. Biomechanical effects of clear aligners with different thicknesses and gingival-margin morphology for appliance design optimization. *Am J Orthod Dentofacial Orthop* 2023;164:239-52.
8. Kravitz ND, Kusnoto B, BeGole E, Obrez A, Agran B. How well does Invisalign work? A prospective clinical study evaluating the efficacy of tooth movement with Invisalign. *Am J Orthod Dentofacial Orthop* 2009;135:27-35.
9. Haouili N, Kravitz ND, Vaid NR, Ferguson DJ, Makki L. Has Invisalign improved? A prospective follow-up study on the efficacy of tooth movement with Invisalign. *Am J Orthod Dentofacial Orthop* 2020;158:420-5.
10. Gottlieb LG. Be careful about overcorrection. *J Clin Orthod* 1970;4:671-2.
11. Turpin DL. Clinical trials needed to answer questions about Invisalign. *Am J Orthod Dentofacial Orthop* 2005;127:157-8.