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Chances and opportunities of lingual orthodontics in the era of aggressively marketed aligners – Excellence and evidence in care

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ABSTRACT

This review article discusses the current state of lingual orthodontics in the context of an increasingly superficial general perception of treatment outcome quality in orthodontics. Recent technological advances in bracket and archwire manufacturing, as well as in the processing of modern SE-NiTi-alloys, have contributed to defining a new "state of the art" in the lingual technique. Furthermore, the paper emphasizes the need for a more precise definition of key tooth movements within the orthodontic nomenclature, in order to enable especially younger colleagues to better assess the quality of contemporary orthodontic publications.

Introduction

Lingual orthodontic appliances - from the craft hour to a modern high Tech device

Few treatment modalities in orthodontics have evolved as significantly over the past years and decades as lingual orthodontics. Many of the often highly subjective statements made by colleagues who gained their experience with lingual appliances 20 years ago or even earlier no longer apply to the currently available Completely Customized Lingual Appliances (CCLAs),[1-4] Fig. 1.

Critical discussion points such as patient comfort, bracket loss, finishing, and general clinical handling have lost much of their former significance over the years and can now largely be classified as "problems solved".[1-5] In their recent review article Nandakumar et al.[5] have not only incorporated studies about conventional lingual appliances but also described the actual situation when using more sophisticated lingual systems. The extensive individualization of modern CCLAs, both in treatment planning and in the actual manufacturing process, has opened up new possibilities not only for lingual orthodontics, but for orthodontics as a whole.

Manufacturing of individual brackets and archwires

The production of bracket bodies using the Selective Laser Melting (SLM) process is different from other modern manufacturing techniques such as Metal Injection Moulding (MIM), as well as over older methods like investment casting or milling (Fig. 2).

In contrast to the MIM process, bracket production using the SLM technique offers far greater potential for optimization, further development, and even the complete redesign of individual bracket series. A key advantage is the rapid translation of design modifications into clinical application, a factor that truly makes the difference. Finally, bracket manufacturing is not based on standard values but on individual treatment planning with a target set-up. The clinical realization of this individualized planning has proven to be highly reliable, as numerous scientific studies have demonstrated, owing to the exceptional precision of CCLAs.[5-17] This precision is primarily achieved through the extremely accurate bracket slots, manufactured by high-speed milling with a maximum oversize tolerance of only 0.1%,[18] and through the custom-made archwires produced by CAM/CAM bending robots[19]. Furthermore, a meticulously refined indirect bonding protocol, optimized over many years, ensures the flawless transfer of the lingual brackets into the patient's mouth.[3]

The broadened therapeutic possibilities of lingual orthodontics, which have been demonstrated in several studies when compared with conventional labial fixed appliances, are also due to the innovative advancements in archwire manufacturing.[8,13,16,20-25] For instance, the ability to incorporate a scalable extra-torque in the anterior archwire segment and the introduction of expansion archwires in the maxilla combined with compression archwires in the mandible have, in selected cases, made previously uncommon tooth movements possible.[8,17,20-25]

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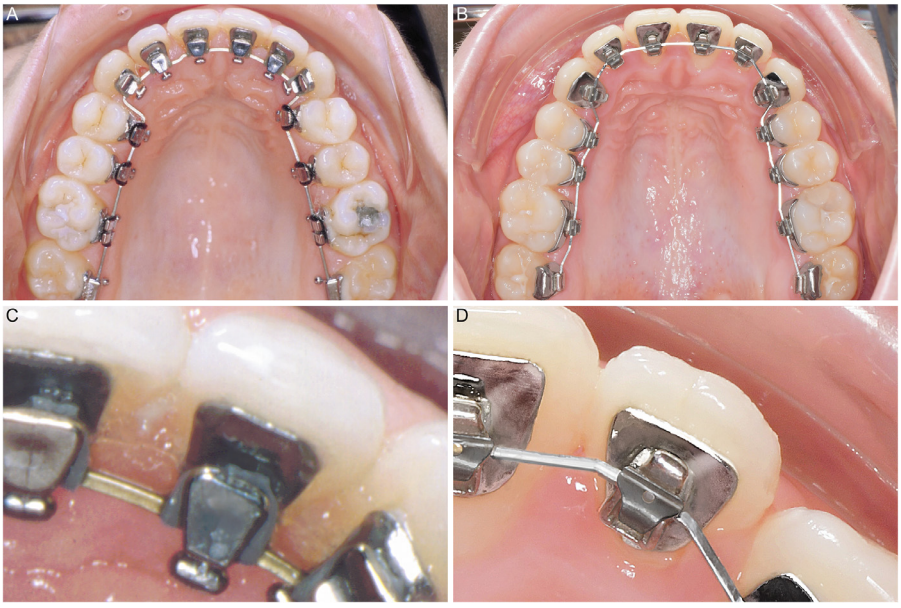

Fig 1. Lingual appliance from the last millennium: 7th generation Kurz brackets (Ormco, Glendorra, CA, USA) with standard, non-customized lingual archwire. A finishing bend was added manually between 12 and 11 (A). The 3rd generation of Completely Customized Lingual Appliances (CCLAS, WIN SL, DW Lingual Systems, Bad Essen, Germany) is a self-ligating lingual appliance (B). The customized 0.016" x 0.024" stainless steel ribbonwise archwire is very close to the tooth surfaces (B) and the appliance is only a little thicker than a fixed retainer.[1] Compared to older lingual appliances (C) current systems are much more comfortable for the patient and the orthodontist (D).

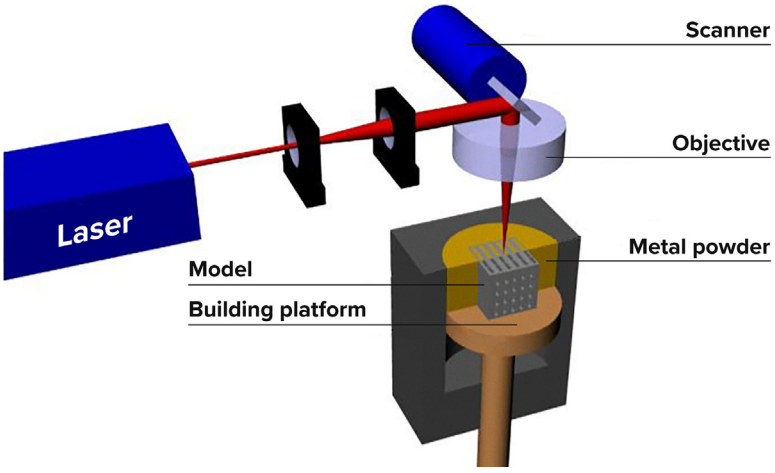

Fig. 2. Selective Laser Melting (SLM) is an edit manufacturing process in which the final piece is produced directly and an analogue in wax or resin is not necessary. The laser is controlled by the CAD/CAM software, which is extremely beneficial for further developments and innovations.

Postgraduate education in lingual orthodontics

Nevertheless, the successful integration of lingual orthodontics into daily clinical practice remains a considerable challenge even today. Particularly in France and Germany, however, the number of lingual treatments has continued to grow substantially in recent years despite the competitive yet stimulating presence of Clear Aligner (CA) systems. In this respect, the decisive factor appears to be the quality of university-based education, both within postgraduate programs and in subsequent professional training seminars. With professional teaching in lingual orthodontics, the final occlusal results obtained, even by beginners in the field of brackets bonded to the other side, can be of very high quality.[12]

Chances and opportunities – what lingual can do that clear aligners can`t

With removable clear aligners (CAs), only tipping tooth movements can generally be performed with relative reliability in compliant patients.[26] Consequently, experts recommend their primary use only for Class I malocclusions with mild to moderate crowding.[26] In an average orthodontic practice in Europe, this treatment modality would therefore not be optimal for all adult patients looking for orthodontic care. In contrast, the demonstrated efficacy and high degree of individual customization possible with a fixed CCLA allow for the achievement of an optimal individual treatment outcome in every single case. Recent clinical studies have demonstrated that when using CCLAs, orthodontic specialists can achieve reliable tooth movements in particular cases that were previously considered unusual.[8,17,20–25]

Non-surgical posterior crossbite correction in adults

In mild cases of posterior crossbite, intermaxillary elastics are often used to achieve correction. However, these auxiliaries exert their full therapeutic potential only when worn continuously, ideally 24 hours a day, 7 days a week. In daily clinical practice, such a high level of patient compliance is rarely achieved among adults, which often delays correction. In more pronounced cases, a Rapid Palatal Expansion (RPE) is typically used, which in adults generally requires surgical assistance, such as Surgically Assisted Rapid Palatal Expansion (SARPE) or Mini-Implant Assisted Rapid Palatal Expansion (MARPE). In this context, CCLAs have recently emerged as a true game changer in clinical orthodontics.[17,20–22,25] The first publication on this topic was, in fact, the most frequently accessed article in the Journal in 2024.[20] In that study, the possibility of crossbite correction through coordinated expansion and compression with CCLAs from both arches was discussed and implemented clinically for the first time even for more severe cases. A total of 64 consecutively treated patients (mean age 25.3 years) presenting with posterior

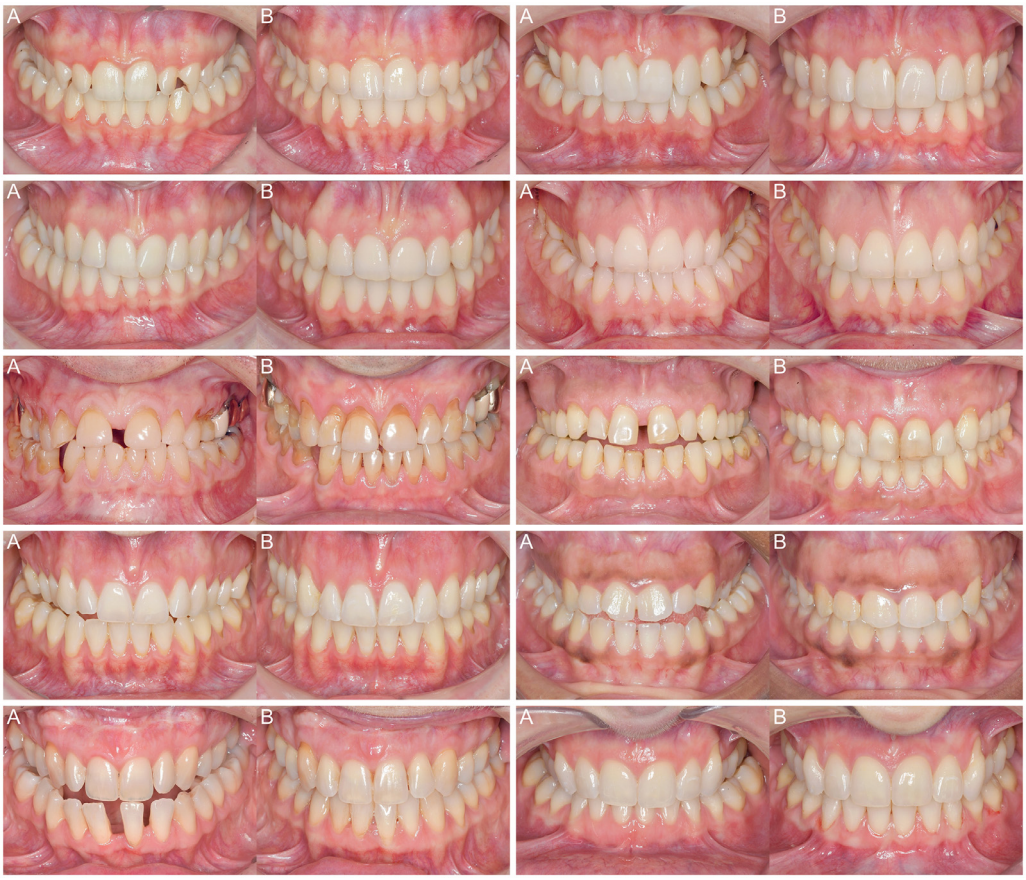

Fig. 3. 10 adult patients from the study of Janssens et al.[17] with posterior crossbite before (A) and after correction with CCLAs and CAD/CAM expansion and compression archwires (B).[17] The article which first presented this new method was frequently assessed.[20]

crossbites were studied. The treatment protocol consisted of individualized CAD/CAM designed expansion arches in the maxilla and compression arches in the mandible. The mean total transverse correction achieved was 6.9 mm, with a maximum correction of 12.8 mm in a patient with bilateral posterior crossbite. Notably, the transverse corrections achieved in both arches at the end of active treatment were equivalent to the planned corrections in the digital setup.[20] In a subsequent study, *Schmid et al.* compared the amount of posterior crossbite correction in 81 adult patients (43 SARPE + fixed labial appliances, 38 non-surgical CCLAs) presenting with moderate to severe posterior crossbites.[21] The extent of transverse correction at the end of orthodontic treatment was equivalent in both groups. The authors therefore concluded that "dentoalveolar compensation with CCLAs, as a combination of maxillary expansion and mandibular compression, appears to be a clinically effective approach to correct a transverse maxillomandibular discrepancy without the need for surgical assistance".[21] In a follow-up study on the same cohort based on digital measurements after 3D- superposition of the jaws, the same research group evaluated the amount of labial or lingual tooth tipping during crossbite correction and found no significant differences between groups. They reported that "translation, i.e., bodily tooth movements that cannot be explained by pure uncontrolled tipping, could be observed with SARPE in the maxilla and with DC-CCLA in both arches".[22] Looking at potential labial recessions in this similar patient cohort again, *Schmid et al.* reported that "there was no statistically significant difference in the incidence of gingival recessions between dentoalveolar compensation with CCLAs and SARPE after debonding…".[23] Recently, *Janssens et al.* looked at the quality of the occlusal outcome in 40 different adult patients treated with this approach and compared it to 40 Class I patients matched for gender and age. The authors used the ABO OGS for their evaluation. They found that no statistically significant difference was observed between the crossbite and non-crossbite groups regarding the total ABO score at the end of active treatment (20.7 vs. 18.8) and concluded that non-surgical crossbite correction did not lead to compromised occlusal results.[17] Figure 3 shows the initial and final situation of the 10 most severe cases in this non-surgical CCLA group. The final results do not look compensated.

Non-surgical class III correction after lower premolar extraction in adults

Unusual outcomes have recently been reported for the non-surgical correction of Class III malocclusion (Fig. 4). Following the observations of *Lossdörfer et al.*[8] regarding the torque control of the mandibular incisors during dentoalveolar compensation in Class III patients, *Thiem et al.*[23] were able to confirm this precise torque control in a cohort of 25 patients presenting with more pronounced Class III malocclusions (mean Wits = −6.7 mm) which were treated with lower premolar extractions.[8,23]

Figure 5 illustrates the clinical situation before and after the correction with CCLAs and the structural superimpositions of the 10 most severe cases (structural superimposition by Per Rank).[23] In a follow-up study conducted on the same patient cohort, it was demonstrated that despite the considerable bodily tooth movement in the mandibular anterior region, the entire alveolar process followed without any reduction in its transverse dimension.[24] Furthermore, *von Bremen et al.* reported that such extensive tooth movements do not lead to orthodontically induced apical root resorption (OIARR), as controlled biomechanics and the remodelling capacity of both cortical and cancellous bone can preserve root integrity even during substantial incisor bodily retraction in the mandible.[27]

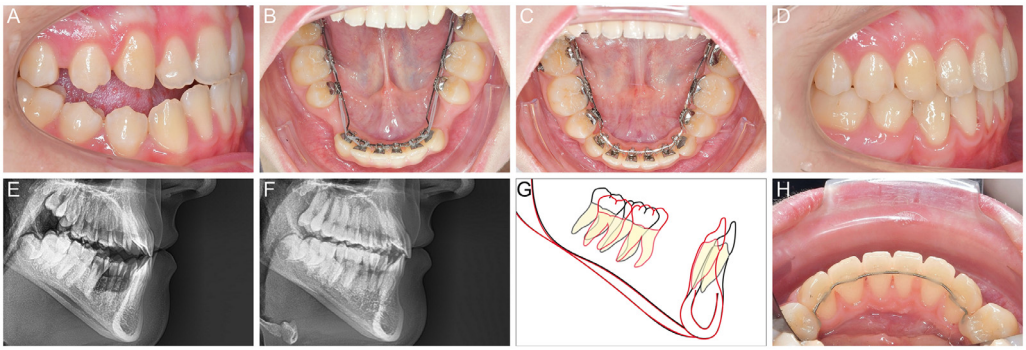

Fig. 4. Adult patient with Class III molar relationship and lateral open bite (A). The correction was achieved following the method proposed by Thiem et al.[23] (B-D). The radiographs and the structural superimposition show a bodily retraction of the lower incisors (E-G). More than 2 years after the end of active orthodontic treatment the periodontal situation in the lower anterior segment is unremarkable (H).

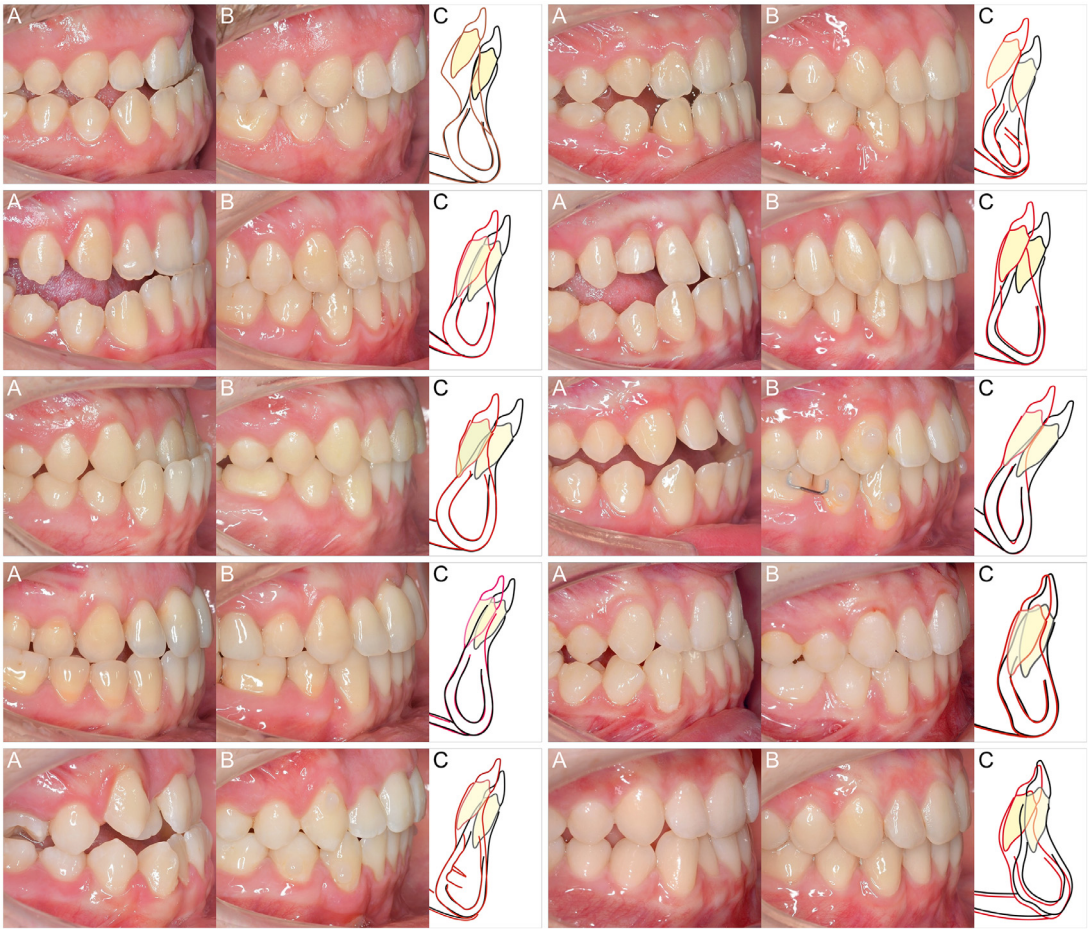

Fig. 5. All patients in the study of Thiem et al.[23] have been treated with lower premolar extractions for correction of their Class III malocclusion (A before and B after treatment). The structural superimpositions (C, by Per Rank) show either lower incisor retraction or lower incisor decompensation together with alveolar process remodelling.

The least invasive correction of the most frequent malocclusion is a lingual domain - Class II, can do

Orthodontic correction of a Class II malocclusion remains one of the most frequent challenges in orthodontic treatment, even among adult patients. The most favourable approach for patients is undoubtedly the least invasive one. Consequently, non-extraction treatments without surgical assistance are preferred by the majority of our patients. As major preconditions for successful correction of the sagittal discrepancy, the successful orthodontic appliance accomplishes the following three key objectives:

1. Levelling of the mandibular curve of Spee, primarily through bodily intrusion of the lower anterior teeth.
2. Maxillary expansion.
3. Palatal root torque and/or bodily retraction of the maxillary incisors (see chapter 4).

All three treatment objectives can be effectively achieved using CCLAs,[11,14,15,17,18,20–22,25,27–33] whereas removable devices such as clear aligners (CAs) are often pushed to their biomechanical limitations.[27,34,35] Due to the high degree of versatility offered by CCLAs, the search for the ideal treatment concept can be further differentiated. Class II corrections

can be achieved either with greater or lesser levels of patient compliance. Moreover, the correction may be accomplished mainly through maxillary distalization or mandibular mesialization. The following section discusses the three most common least invasive concepts for Class II correction with CCLAs in adult patients.

Class II correction with Class II elastics

Even in adult patients, a Class II malocclusion of half a unit or more can be corrected with a fixed appliance and intermaxillary elastics, provided that patient compliance is good. Remarkably, *Janssens et al.* were only recently the first to evaluate the efficacy of this concept in adult patients.[15] Earlier studies had primarily investigated the efficacy of Class II correction with fixed appliances and intermaxillary elastics in considerably younger patient groups.[36] Until then, a comprehensive evaluation of this approach with sufficient statistical power had not been available.

In their study *Janssens et al.* copied the method described by *Petterson et al.*[34] who evaluated the efficacy of clear aligners (CAs) in combination with intermaxillary elastics for Class II correction. The study showed that CAs were not effective in correcting Class II malocclusions with intermaxillary elastics without refinements even in cooperative patients.[34] In a follow-up study on the same patient cohort, *Leavitt* reported that even after 3.6 refinements on average and 76 aligners, the mean anterior-posterior correction was only 1.1 mm.[35] The authors of both studies compared the quality of the final occlusal outcome to a control group of Class I patients and found significant differences in the overall ABO OGS score with the occlusal results in the Class II group being substantially worse.[34,35] In contrast to that, *Janssens et al.* was able to show that CCLAs in combination with Class II elastics could correct a Class II malocclusion successfully in adult patients and that the final treatment outcome was of a similar high quality in Class I and Class II patients (Table 1).[15] As patient compliance was reported to be good in all three studies, CAs obviously failed to fulfil the three key objectives mentioned above (see also chapter 4). Figure 6 shows an adult Class II patient from the study of *Janssens et al.*[15] before and after CCLA treatment in combination with intermaxillary elastics. For successful Class II correction, all three key objectives were fulfilled.

Table 1
Outcome comparison of three investigations on Class II correction in adults with intermaxillary elastics. Patterson et al. evaluated the result after the first set of clear aligners.[34] Leavitt documented the results after 76 aligners and 3.6 refinements on average.[35] Janssens et al. looked at the situation before and after CCLA-treatment with intermaxillary Class II elastics.[15] The results highlight the superior efficiency of fixed appliance treatment compared to removable clear aligners.

	Patterson at al.[32] Clear Aligner		Leavitt[33] Clear Aligner		Janssens et al.[14] CCLA	
	initial	final	initial	final	initial	final
Total ABO	55.98	48.78	60.55	36.77	56.33	17.88
Alignment	21.35	7.13	23.91	6.41	23.25	4.53
Marginal ridges	4.65	5.15	5.68	4.14	4.08	2.73
Buccolingual inclination	2.93	2.50	4.82	3.09	6.20	4.68
Overjet	8.40	9.35	8.50	6.27	6.65	1.60
Occlusal contacts	2.58	12.03	1.77	5.73	2.50	1.50
Occlusal relationship	14.28	13.35	15.41	10.45	12.55	2.85
Interproximal contacts	1.55	0.38	0.68	0.14	1.10	0.00
AP correction achieved	0.25 mm		1.01 mm		3.22 mm	
AP correction achieved versus plan	7%		33%		91%	
ABO exam passed/n	0/40 (0%)		3/22 (13.6%)		38/40 (95%)	

Class II correction with maxillary miniscrews

For less cooperative patients or those presenting with more pronounced Class II relationships, CCLAs can be combined with miniscrews. In these cases, the complete implementation of the three key objectives is crucial to avoid undesirable premature contacts in the anterior segments during maxillary total arch distalization.

In 2021, *Beyling et al.*[33] introduced a novel concept for Maxillary Total Arch Distalization (MTAD) using interradicular miniscrews in combination with CCLAs. The authors evaluated the efficiency of Class II correction in 35 clinical situations (70 miniscrews). A total of 97% (3.6 mm) of the planned bite correction was achieved, and at the end of treatment, there was no statistically significant difference in the final

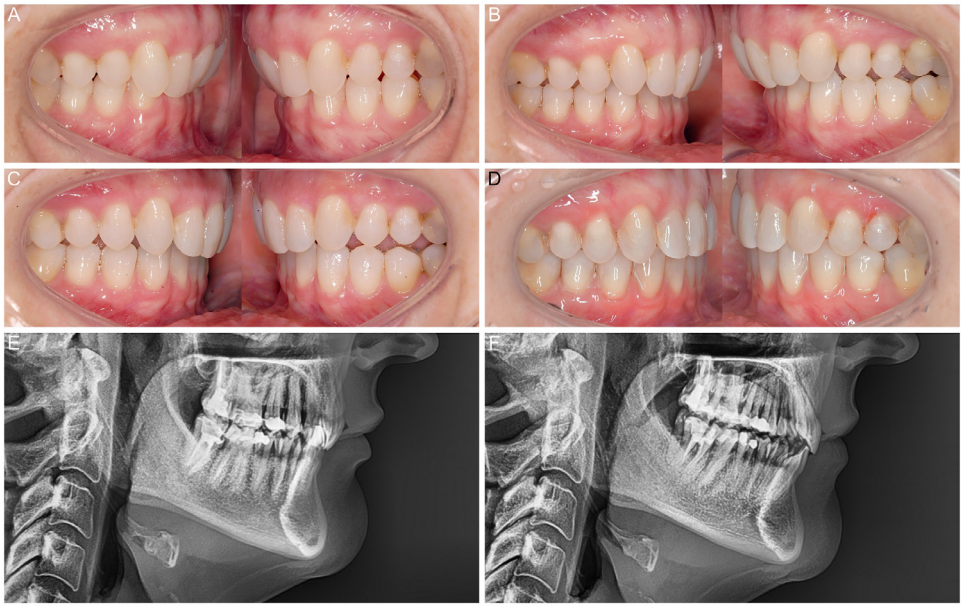

Fig. 6. Adult patient from the study of Janssens et al.[15] with Class II division 1, severe deep bite and anterior crowding (A). After complete alignment of the upper incisors their inclination was still almost negative and the lower curve of Spee was too deep. Stainless steel archwires (with extra-torque in the upper jaw) were used to torque the upper anterior teeth (palatal root torque) and level the lower curve of Spee (B). With further levelling and torquing the preconditions for successful Class II correction with intermaxillary elastics were fulfilled (C). At the end of CCLA treatment, the very cooperative adult patient achieved a high-quality occlusal outcome (D-F).

Fig. 7. Adult Class II patients from the study of Janssens et al. before (A) and after (B) treatment.[14] Due to the excellent torque control, all patients had a similar inter-incisor angle at the end of CCLA treatment. In most cases efficient levelling with lower incisor intrusion is mandatory for the bite correction. The average quality of the final occlusion at the day of debonding was high (ABO OGS 17.1).

canine relationship compared with the planned outcome. Due to the favourable situation (all three key objectives fulfilled) at the onset of MTAD, the bite correction went well and only two of the 70 miniscrews were over-loaded and failed prematurely; in both cases, reinsertion was not necessary.[33]

More recently, *Janssens et al.*[14] evaluated the occlusal outcome of 40 adult patients using the methodology described by *Patterson*.[34] These patients presented with moderate to severe Class II relationships (> ½ unit), which were also corrected using CCLAs in combination with inter-radicular miniscrews for MTAD. The planned bite correction of 4.5 mm in the first molar region was achieved in 99%, with a maximum of 8.6 mm. The average ABO OGS score improved from 55.8 to 17.1, and 38 out of 40 patients finally met the ABO standards. 3 of the 144 miniscrews were overloaded and failed before schedule, indicating a survival rate of over 97%.[14] Figure 7 illustrates the 10 patients in this study who initially exhibited the most severe malocclusions.

Despite the frequently claimed effectiveness of clear aligners in combination with miniscrews for Class II correction in adults, the author is not aware of any clinical investigations to date that may substantiate these claims, neither regarding the efficacy nor the efficiency of an aligner-based concept.

Class II correction with the Herbst appliance

Ruf and Pancherz demonstrated favourable dentoalveolar effects of Herbst appliance therapy in combination with labial multi-bracket systems in young adults presenting with more severe malocclusions.[37] In the proposed treatment protocols, the active Herbst phase generally preceded the subsequent labial multi-bracket phase. However, when combined with CCLAs, both phases can be carried out simultaneously.[38] Beyond the efficiency of this combination, particularly in challenging Class II division 2 cases with minimal residual growth, the torque control in the lower anterior segment is noteworthy.[31,39] Both *Mujagic et al.* and *Vu et al.* reported high efficiency in achieving a high-quality final occlusion in their clinical studies.[11,32]

When the desired dentoalveolar correction is primarily mandibular in nature, and the patient has chosen lingual brackets, the combination of a CCLA with the Herbst appliance can be the method of choice for moderate to severe Class II malocclusions. Figures 8 and 9 illustrate the various stages of CCLA–Herbst treatment in two severe Class II cases.

When marketing meets reality – the torque story

In recent years, less visible treatment modalities have gained increasing acceptance in adult orthodontic care. Stimulated by the extensive marketing campaigns of major aligner manufacturers, a growing number of potential patients have come to recognize that tooth movement remains possible well into adulthood. The entire field of orthodontics worldwide has benefited from these substantial—primarily financial—investments by the industry and the consequently more informed public.

In addition to diagnosis-based treatment planning, it is the orthodontist's responsibility to select the appropriate appliance for the respective case. As previously mentioned, one of the most frequently encountered malocclusions, the Class II, requires excellent torque control in the maxillary anterior region for a high quality final occlusal

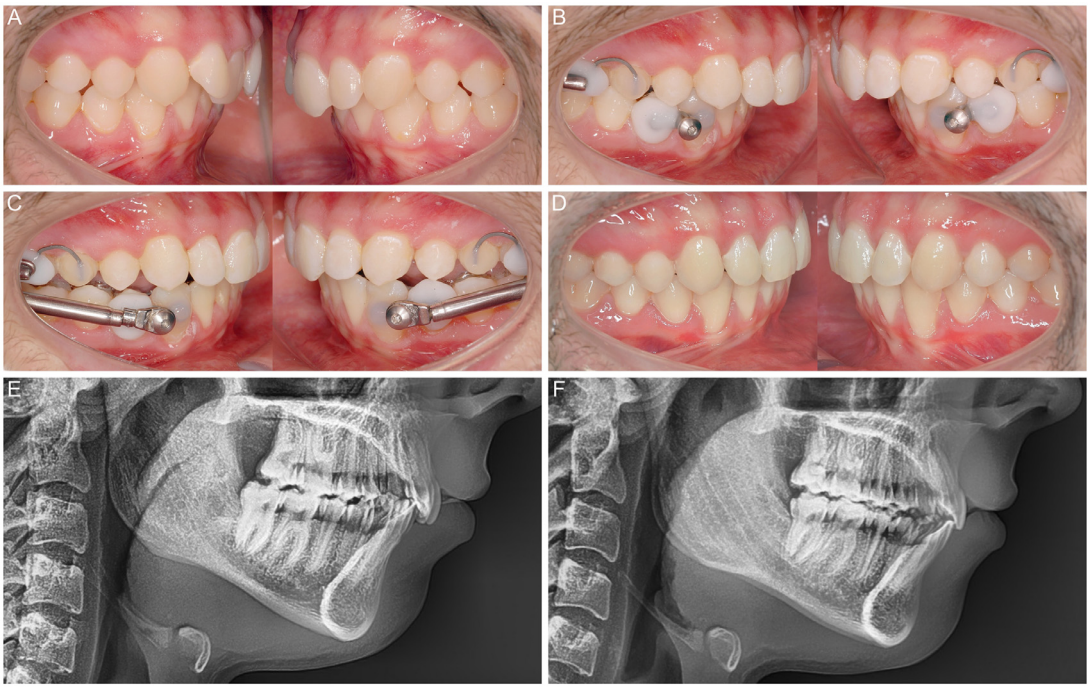

Fig. 8. 17-year-old patient from the study of Mujagic et al.[11] with full Class II molar relationship on both sides (A). After levelling and aligning the Herbst-appliance was bonded to the labial tooth surfaces (B). Stepwise activation of the Herbst Telescopes for improved patient comfort during the adaptation phase (C). The final occlusal result is of a high quality. The lateral head films show an acceptable inclination control of the incisors in both jaws (E, F).

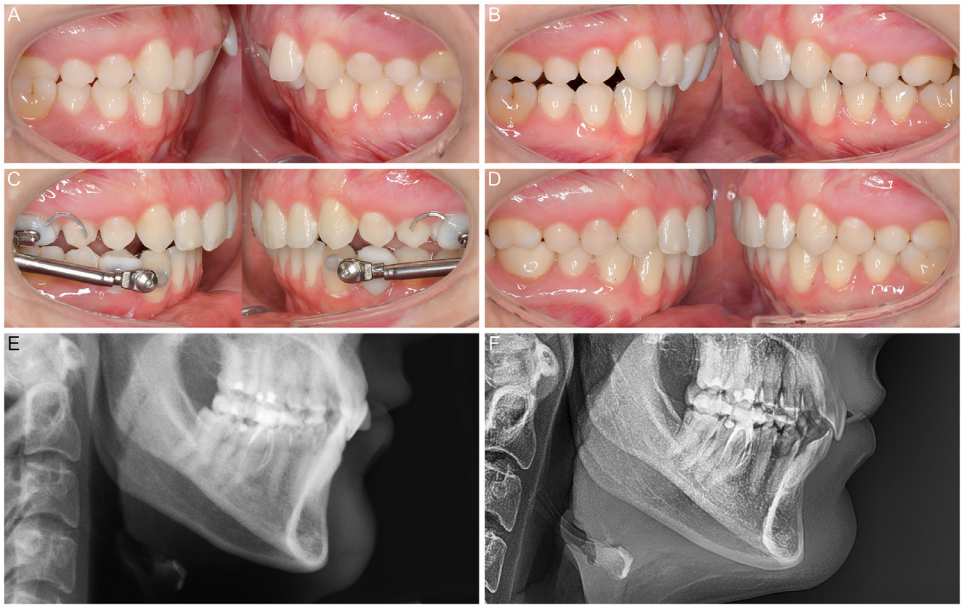

Fig. 9. 34-year-old female patient with Class II division 2 and deep bite. The Class II was more severe on the patients left side as the 36 was missing (A). After the aligning phase, upper incisors were still retroclined and needed palatal root torque. Also, the lower curve of Spee had to be levelled a bit more (B). The upper stainless steel archwire with extra-torque did continuously improve the upper incisor inclination during the Herbst-phase (C). The final inter-incisor angle is acceptable (D). The lateral head films show successful levelling of the curve of Spee and palatal root torque in the upper front (E, F).

outcome[33] In this context, controlled positioning of the maxillary incisors, particularly in the apical third of the roots is essential.[30] The necessity of such a substantial control of the root position is evident in the treatment of Class II Division 2 cases but is equally indispensable in patients presenting with a Class II Division 1 malocclusion.[11,14,15,30,33,39] Without it, achieving a prognostically favourable Class I intercuspation in the posterior segments is largely impossible. Therefore, precise control of the position of the maxillary incisor roots, and especially of their apices, represents a crucial element in orthodontic mechanotherapy.

In one of the first aligner studies in this field, *Simon et al.* (2014) reported that planned torque movements in the maxilla could be achieved with aligners to an average extent of approximately 50%.[40] Despite a considerable inclusion bias and an obvious conflict of interest by one of the authors - that was explicitly denied but is well known at least in Germany - this study remains among the most frequently cited

sources used to emphasize the efficacy of aligners in this context.[40] This is particularly remarkable given that the cited investigation did not, in fact, examine any torque movements of the maxillary incisor roots, but only changes in crown inclination. The measurement method employed, based on digital dental models and crowns, does not permit differentiation between uncontrolled tipping and controlled root movement (palatal or buccal root torque, or buccolingual translation). It is self-evident that the positional change of any structure (in this case the roots) can only be evaluated on an object that actually contains that structure, which is not the case for dental models which only contain the crowns, whether physical or digital. Nevertheless, even recent studies in this area often fail to consider these fundamental methodological limitations.[41]

It is becoming increasingly evident that there exists a considerable degree of conceptual ambiguity worldwide regarding the definition of the term *torque* in orthodontics. As mentioned above, the success of a Class II correction largely depends on the performance of the appliance used, particularly its ability to produce a palatally directed movement of the root apex in the maxillary anterior region while maintaining a relatively stable incisal edge position. The term *palatal root torque* refers specifically to this type of tooth movement. In contrast, the terms *root torque*, crown torque, or simply torque may either refer to a movement of a tooth or describe its actual inclination (*root torque = root inclination, crown torque = crown inclination, torque = inclination*). The frequently, but erroneously, attributed ability of aligners to achieve a clinically relevant (and statistically significant) movement like a palatal root torque in the maxillary anterior region can be fully explained by this conceptual imprecision in the orthodontic nomenclature.

Only against this background can the findings of a recently published "Modified Delphi Consensus Study" in the field of clear aligner therapy be properly evaluated.[41] In the section on tipping, the authors state: "The reason for this high predictability of movement is due to the simple biomechanics of the uncontrolled tipping movement, which does not require any torque, just a single force exerted on the tooth crown." Later in the same article, however, after classifying torque as one of the most challenging movements to achieve with aligners, the authors report that torque expression for mandibular incisors ranges from 40−60% of the planned value, and for maxillary incisors, "the predictability of torque is approximately 50%." The movements classified as torque in this section of the article were uncontrolled tipping movements.[41] Unfortunately, these very figures are what even the attentive reader ultimately takes home from the study.

The references concerning the torque movements cited in the before mentioned "Modified Delphi Consensus Study"[41] are exclusively based on studies using digital dental models on which only the tooth inclination is evaluated and not the root movement.[42-44] Furthermore, in the only study referenced regarding torque control of the maxillary incisors, only mandibular incisors were examined.[43] This combination of contradictory and opaque nomenclature makes it difficult even for the interested and biomechanically well-trained reader of this article to find out what is finally the truth and what is not. As a result, the reader is left with the simple, but nonetheless incorrect message that aligners can achieve approximately half of the planned torque movement, and that overcorrections could further improve this outcome.

It should be noted that a more differentiated evaluation of root movements is only possible radiologically. A high-quality CBCT scan can be considered the gold standard for assessing controlled root movement of individual incisors, yet due to radiation protection concerns, it is rarely available. *Hong et al.* investigated the movement of 120 maxillary incisors of adult patients using CBCT scans before and after treatment, with an intended mean inclination correction of 13° by a palatal root torque.[45] Although they found that 47% of the intended inclination change was achieved, the actual movement consisted solely of uncontrolled tipping, with comparable displacement of the incisal edge in one direction and the root apex in the opposite direction. Unfortunately, this study again illustrates the dilemma of inconsistent nomenclature, as the authors state that "the achieved torque movement with clear aligners was significantly lower than predicted, with a mean efficacy of 46.81±33.95%," even though, on average, there was no greater movement in the root region compared to the crown region. Therefore, this study clearly shows that effectively 0% of the planned torque movement was achieved.[45,46]

The road ahead − teaming up ethics and economics

If you ask a postgraduate student whether they would prefer to learn how to tip teeth or how to achieve controlled bodily tooth movement, the answer today remains undisputed. As teachers and mentors of these highly talented young professionals, we should avoid the misconception that industry has somehow outpaced nature. Concepts based on removable appliances - both now and in the future − can only achieve limited, primarily tipping movements of teeth, and even those depend heavily on patient compliance.

A solid understanding of orthodontic biomechanics, combined with extensive clinical experience in the use of completely customized lingual bracket systems, remains the essential prerequisite for achieving optimal results in the shortest possible time, and consequently, for economic success with higher priced appliances. Any deliberate compromise in treatment quality must be regarded as self-deception within a medical context,[47,48] particularly if it is money-driven. And, as we all know, self-deception never lasts until the final hour.

Conclusion

Numerous recent studies underline the fact that lingual orthodontic techniques have significantly changed and evolved in recent years. The combination of modern lingual systems and comprehensive lingual, preferably university-based education enables the well-trained orthodontic specialist to achieve high-quality orthodontic treatment outcomes with very aesthetic fixed appliances.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dirk Wiechmann reports a relationship with DW Lingual Systems GmbH that includes: equity or stocks. Dirk Wiechmann has patent licensed to DW Lingual Systems GmbH. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Dirk Wiechmann: Writing − review & editing, Writing − original draft, Validation, Supervision, Methodology, Data curation, Conceptualization.

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