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Quality in orthodontics: The role of customized appliances

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Abstract

Orthodontics as well as dentistry are undergoing a technological revolution with advances in medical imaging, 3D printing and customization of appliances and devices. Digital orthodontics can be defined as the process of manufacturing customized appliances based on a target setup which incorporates tooth positioning in six-degrees-of-freedom. Three-dimensional medical imaging provides better diagnostic tools and allows for fabrication of orthodontic appliances based on the coordinates system of the occlusal plane within the facial anatomy. This article describes the state-of-the-art in goal-driven orthodontic treatment, warns against the commercialization of our profession, and highlights the advantages of lingual orthodontics in terms of protection of the enamel.

KEYWORDS
peridontics/orthodontics

Currently the orthodontic specialty is facing many challenges. Some of these threats are external; some are due to our own decision as a dental community. External threats are easier to spot. A good example is the commercially fabricated perception that aligner therapy can be executed without an orthodontist, or even a dentist. Internal ones are not so easy to identify; a good example is treatment dictated by the appliance that was chosen as opposed to sound diagnosis and problem-oriented treatment planning. At this challenging time, it is important for orthodontists and dentists to think about the future role of the orthodontist and how we can use new technology to improve and maintain quality in orthodontic treatment outcomes.[1] Let us begin by assessing the achievement of goals during treatment.

1 | ARE WE ACHIEVING OUR GOALS?

A major goal of orthodontics is establishment and maintenance of an appropriate arch form for each patient. We have learned by research and experience through the years that the mandibular arch form should not be modified to a major extent, and that teeth should be positioned within the zone of equilibrium between the internal and external forces.[2] Although most clinicians aim to maintain the pre-treatment arch form, studies show that this is often not transferred to clinical practice.[3] The use of non-customized orthodontics with preformed arch wires does not allow for maintenance of the arch form, especially using the prefabricated NiTi wires. A solution to this problem can be the use of setup-driven manufactured orthodontic appliances where the initial arch shape is incorporated into the design of the brackets and wires.[4,5] This process needs supervision and approval by a qualified orthodontist (Figure 1).

A second area where goals are often under-achieved is the expression of torque or inclination of the upper incisors and canines. This is due to the use of undersized wires in slots that often are oversized. Inadequate, and usually deficient, torque has obvious esthetic consequences and less obvious functional consequences.[6] For example, the inclination of the upper incisors determines the antero-posterior position of their lingual surface, and this affects where tooth contacts occur in occlusion. Deficient torque leads to a smaller upper dental arch perimeter and a more palatally positioned lingual surface of the upper incisors.[7] In order to achieve Class I canine with under-torqued upper incisors, clinicians resort to interproximal reduction of the lower incisors, even in the absence of inter-arch tooth size discrepancy. In this example the lack of customization and or the lack of accuracy of traditional appliances have a cost in terms of interproximal enamel[8] (Figure 2).

2 | WHAT IS GOAL-DRIVEN ORTHODONTICS?

It seems that today there is a dissociation between diagnosis/treatment planning and treatment delivery. Treatment goals are defined during diagnosis and treatment planning process, but when treatment

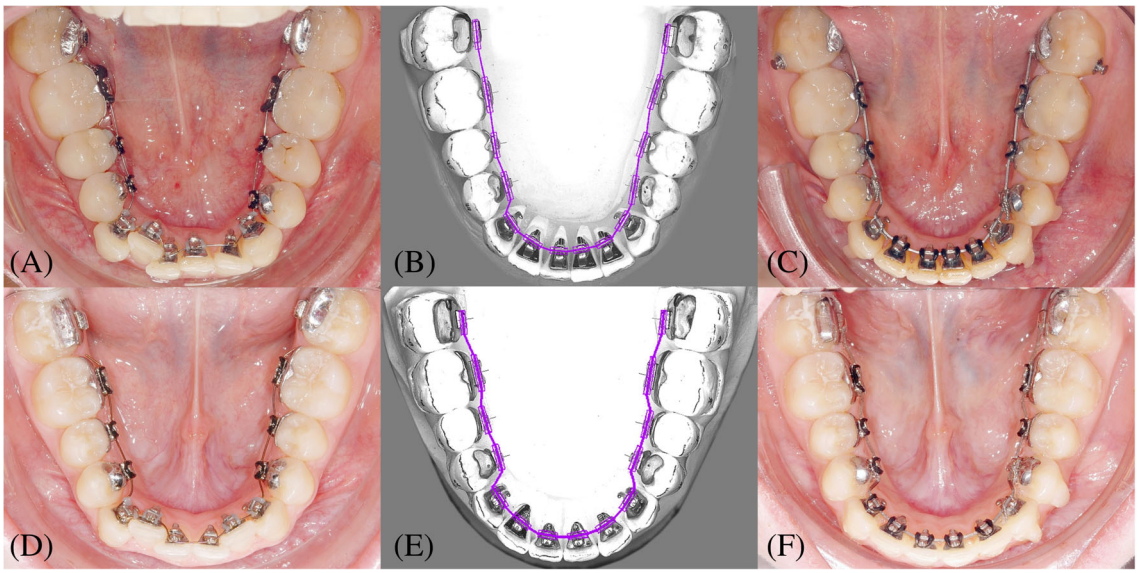

FIGURE 1 These two patients (A),(C) and (D),(F) with similar crowding pattern and different initial arch form were treated with WIN lingual system WIN; (DW Lingual Systems, Bad Essen, Germany) (A) and (D). The original arch form was incorporated into the setup in order to be maintained during orthodontic treatment (B) and (E). At the last appointment before debonding the crowding was resolved and the original arch form was preserved. This level of customization is not possible with preformed arch wires

FIGURE 2 Large antero-posterior discrepancies can only be corrected if ideal inclination (torque) of the anterior teeth is established. Deficient upper anterior inclination often occurs in labial technique due to the use of undersized wires and oversized slots. These images correspond to: (A) initial malocclusion prior to bonding. (B) after leveling and aligning and (C) final result. Please note the excellent inclination control of the anterior teeth which allow for correction of a full-cusp dental Class II relationship

FIGURE 3 The individual treatment goals are incorporated into a setup which will be the blueprint for appliance fabrication (A). Based on the desired positions of the teeth brackets and wires are customized (B); these brackets are then transferred to the malocclusion model in order to be bonded in the patient's mouth (C)

execution relies on the same average-driven preadjusted appliance for everyone, the realization of these treatment goals is not always easy. Human error, anatomical differences and secondary effects due to an average prescription appliance applied to a specific patient result in lengthy treatment times.[9] The orthodontist is forced to have a constant reactive approach to compensate for the lack of customization of the orthodontic appliance. Orthodontic treatment delivery becomes a trial and error exercise where the orthodontist must have

FIGURE 4 Small changes in angulation as seen in the lower right first molar can have a significant adverse effect on occlusion in all three planes of space—especially in the vertical dimension. In crowded situations the angulation discrepancy may not be perceptible until late in treatment. The use of customized and indirectly bonded braces minimizes errors in bracket positioning

FIGURE 5 Based on the patient's smile and facial esthetics the desired change in incisor exposure, angulation and alignment of the incisors is incorporated into the setup that will be the blueprint for appliance design and fabrication. Note the correction of the angulation of the midline and the relative extrusion of the upper incisors relative to the back teeth

a reactive approach to compensate for the secondary effects produced by non-customized appliances.[10]

Goal-driven orthodontics is achieved most effectively by a proactive process of design and manufacturing of orthodontic appliances where the target tooth positions are planned on a dental setup.[11] The setup includes both intra-arch and inter-arch tooth positioning. In other words, the position of each individual tooth in relation to its neighbors is defined in the three-dimensional space; then it is refined based on the desired occlusion. The key to achieving the defined treatment goals is that the individual setup be the blueprint for manufacturing the appliances (Figure 3). The amount of tooth displacement, rotation and overall expansion can be quantified and adjusted during appliance fabrication.[12] Advantages of this approach include accurate tooth positioning,[13] less human error during indirect bracket bonding,[14] and the possibility of maintaining the pre-treatment arch form (Figure 4). Secondary advantages can be faster treatment, with less secondary effects that are time-dependent[15] and better accurate and precise outcomes. Goal-driven orthodontics applies to both labial and lingual appliances[16-18] (Figure 5).

3 | WHY LINGUAL ORTHODONTICS?

With the advent of completely customized lingual appliances, the delivery of lingual orthodontic treatment is more user-friendly from the clinician's and patients' point of view.[19] Precise slot dimensions, ribbon-wise slot orientation, individualized arch wires, large bracket bases, flat design and high standards in lingual orthodontic education allow for high performance that surpass the possibilities of traditional orthodontic treatment. Some advantages include:

- Reduction of the incidence of decalcification with its inherent savings in terms of enamel and financial burden (see discussion below),[20]
- Individualized treatment plans that can be predictably transferred to the patients' mouth,[21]

- Better torque control because of precise slot and arch wires dimensions,[22]
- Biomechanical advantages in terms of vertical control thanks to ribbon-arch wires,[23] and
- Avoidance of secondary effects due to conventional non-customized orthodontic treatment
  - Human-error present in direct bonding techniques,[14]
  - Inter-patient variability not accounted for with non-customized appliances,[24] and
  - No preservation of arch form.

In competitive orthodontic markets, lingual appliances offer a great marketing tool and a way for orthodontists to differentiate themselves from their competitors. These appliances expand the potential patient pool to include these patients that reject labial appliances. Lingual appliances are the only non-visible appliances on the market and are mainly compliance-free. Patients can perceive and enjoy every improvement immediately without affecting their social life. Dentists and orthodontists can visualize and detect small changes without labial appliances in the visual field as often it is difficult to evaluate smile esthetics and tooth position when labial appliances are present. And overall, patients accept lingual orthodontics with great enthusiasm which creates a happy practice.[25]

4 | ENAMEL DECALCIFICATION AS A PROBLEM

One of the most frequent negative effects of orthodontic treatment is decalcification of the enamel.[20] Lingual appliances proved to be much less hazardous for the enamel where the frequency of decalcifications in comparison with labial appliances is five times less, and when present are 10 times smaller (Figure 6). The self-cleansing effect of the tongue, better exposure to cariostatic saliva, and the close adaptation of the bracket base are factors in the reduction of this unwanted effect. A more obvious difference between the lingual and other orthodontic techniques is the fact that there is no need to remove labial composite bonding material when braces are placed on the lingual surface, which is the case for both labial braces and attachments bonded to the labial surface of the teeth. Lingual debonding procedures maintain the natural gloss of the untouched labial enamel surface. Even with excellent debonding protocols in labial orthodontics a change in the labial enamel surface can be detected without magnification.[26]

5 | WHY IS LINGUAL TREATMENT MORE POPULAR IN EUROPE THAN IN THE UNITED STATES?

Lingual orthodontics is not only more popular in Europe than in the United States, but is also more popular in Asia and around the world. American orthodontists over the age of 55 are still resentful from the bad experiences they had with early lingual appliances in the last

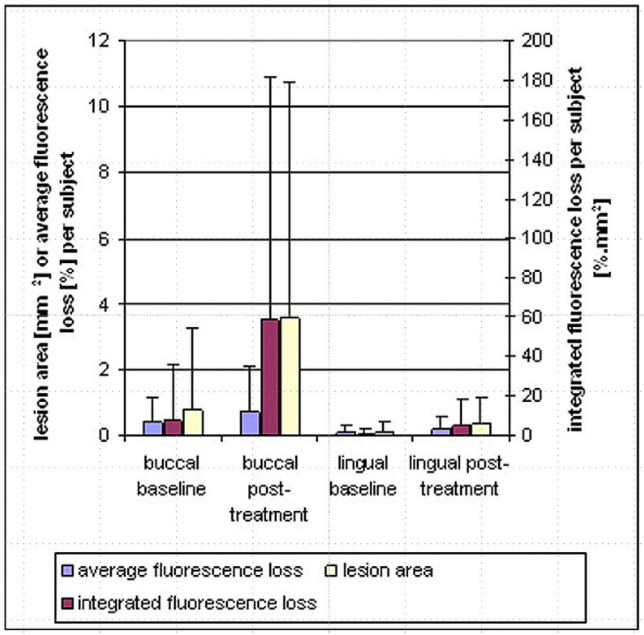

FIGURE 6 Not only the incidence of White-Spot lesions is lower in lingual orthodontics, but also the size and severity of the lesions is much lower compared to labial braces. In this graph (from van der Veen MH, Attin R, Schwestka-Polly R, Wiechmann D. Caries outcomes after orthodontic treatment with fixed appliances: do lingual brackets make a difference? Eur J Oral Sci. 2010 Jun;118[3]:298–303) it can be observed that the fluorescence loss and the area of the white-spot lesions post lingual orthodontic treatment is much smaller than the ones in labial treatment

century. When German-produced completely customized lingual appliances were introduced in the United States, the number of users increased considerably, but only for a short period of time until the appliance production was attempted in a different country with unsuccessful outcomes. A completely customized lingual appliance is made out of 40 unique and individualized components—28 brackets, 10 archwires and 2 bonding trays—which require a high level of precision and accuracy. If one of these components is compromised the customized lingual system will not perform as intended. The European orthodontic market is highly competitive and the lingual market is growing fast. Many young orthodontists want to offer an esthetic treatment option with full three-dimensional tooth control in order to differentiate themselves from the competition. Before building their practices they learn lingual orthodontics.[27]

Many recent American orthodontic graduates start their career with a great amount of debt and end up working as associates at a corporate office. While in the corporate world their capabilities in terms of making decisions are limited, and until they are able to become independent their interest in lingual orthodontics is non-existent.[28] This phenomenon is combined with a movement toward clear removable appliances mainly pushed by the manufacturers and not by scientific research, neglecting completely the limitations in tooth movements one can expect when using only removable appliances.[29] Unfortunately, many US orthodontic specialists have supported this

approach, to the point that companies are starting to obviate the orthodontist in the process and developing do-it- yourself orthodontic products.[30]

6 | WILL THE USE OF TECHNOLOGY ALLOW DENTISTS TO PERFORM THOUGHTLESS ORTHODONTICS?

A well-executed but wrong strategy is very dangerous. The commercialization of the orthodontic profession has changed the perception of the importance of orthodontic diagnosis, treatment planning and appliance customization among orthodontic professionals. Today clinical research in orthodontics is barely present in meetings and conferences. Company organized meetings are full of entertainment showing that case" that luckily worked". It seems that the figure of the orthodontist is no longer making decisions and therefore not necessary. But excellence in orthodontics depends mainly on the orthodontist's skills and education and not in the appliance of choice.

The only solution to this imminent threat comes from within the profession where there should be an emphasis on quality in orthodontic education at the postgraduate level, where the future of the profession is shaped into high skilled and thoughtful professionals. After all we do really need orthodontists particularly in lingual treatment.

In summary, quality orthodontics requires evidence-based diagnosis and treatment planning, customized appliances with good performance and reduced secondary effects, and a good team led by a skilled orthodontist to gather the records, customize, deliver and monitor the treatment. This knowledge and education should be the purpose of graduate programs in orthodontics. It will depend on us—dentists—to commit to quality in order to protect our patients. The future is promising, advances in appliance customization—both in the lingual side and labial side of the teeth—three-dimensional technology applied to facial and dental diagnosis and treatment planning and companies devoted solely to dental printing (for instance: SprintRay, Los Angeles CA) enable clinicians to achieve excellence in orthodontics.

REFERENCES

1. Grauer D, Wiechmann D, Heymann GC, Swift EJ Jr. Computer-aided design/computer-aided manufacturing technology in customized orthodontic appliances. *J Esthet Restor Dent*. 2012 Feb;24 (1):3-9.
2. McNamara C, Sandy JR, Ireland AJ. Effect of archform on the fabrication of working archwires. *Am J Orthod Dentofacial Orthop*. 2010;138: 257.e1-257.e8.
3. Ronay V, Miner RM, Will LA, Arai K. Mandibular arch form: the relationship between dental and basal anatomy. *Am J Orthod Dentofacial Orthop*. 2008 Sep;134(3):430-438.
4. Wiechmann D, Rummel V, Thalheim A, Simon VS, Wiechmann L. Customized bracket and archwires for lingual orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 2003;124:593-99.5.
5. Beers AC, Choi W, Pavlovskaia E. Computer-assisted treatment planning and analysis. *Orthod Craniofac Res*. 2003;6(Suppl 1): 117-25.5.
6. Schlosser JB, Preston CB, Lampasso J. The effects of computer-aided anteroposterior maxillary incisor movement on ratings of facial attractiveness. *Am J Orthod Dentofacial Orthop*. 2005;127(1):17-24.
7. Cao L, Zhang K, Bai D, Tian Y, Guo Y. Effect of maxillary incisor labiolingual inclination and anteroposterior position on smiling profile esthetics. *Angle Orthod*. 2011;81(1):121-129.
8. Grauer D, Heymann GC, Swift EJ Jr. Clinical management of tooth size discrepancies. *J Esthet Restor Dent*. 2012;24(3):155-159.
9. Grauer D, Proffit WR. Accuracy in tooth posi-oning with a fully customized lingual orthodon-c appliance. *Am J Orthod Dentofacial Orthop*. 2011;140:433-443.
10. Weber DJ 2nd, Koroluk LD, Phillips C, Nguyen T, Proffit WR. Clinical effectiveness and efficiency of customized vs. conventional preadjusted bracket systems. *J Clin Orthod*. 2013;47(4):261-266. quiz 268.
11. Ormco. Increasing Clinical Performance with 3D Interactive Treatment Planning and Patient-Specific Appliances. Orange, CA: Ormco; 2008.
12. Jheon AH, Oberoi S, Solem RC, Kapila S. Moving towards precision orthodontics: an evolving paradigm shift in the planning and delivery of customized orthodontic therapy. *Orthod Craniofac Res*. 2017;20 (suppl 1):106-113.
13. Koo BC, Chung CH, Vanarsdall RL. Comparison of the accuracy of bracket placement between direct and indirect bonding techniques. *Am J Orthod Dentofacial Orthop*. 1999;116:346-345.
14. Joiner M. In-house precision bracket placement with the indirect bonding technique. *Am J Orthod Dentofacial Orthop*. 2010;137:850-854.
15. Knösel M, Klang E, Helms HJ, Wiechmann D. Lingual orthodontic treatment duration: performance of two different completely customized multi-bracket appliances (incognito and WIN) in groups with different treatment complexities. *Head Face Med*. 2014;10:46.
16. Scholz RP, Sarver DM. Interview with an insignia doctor: David M Sarver. *Am J Orthod Dentofacial Orthop*. 2009;136:853-856.
17. Wiechmann D. A new bracket system for lingual orthodontic treatment. Part 1: theoretical background and development. *J Orofac Orthop*. 2002;63:234-245.
18. Wiechmann D. A new bracket system for lingual orthodontic treatment. Part 2: first clinical experiences and further development. *J Orofac Orthop*. 2003;64:372.
19. Wiechmann D, Gerss J, Stamm T, Hohoff A. Prediction of oral discomfort and dysfunction in lingual orthodontics: a preliminary report. *Am J Orthod Dentofacial Orthop*. 2008;133:359-364.
20. Heymann GC, Grauer D. A contemporary review of white spot lesions in orthodontics. *J Esthet Restor Dent*. 2013;25(2):85-95.
21. Pauls A, Nienkemper M, Schwestka-Polly R, Wiechmann D. Therapeutic accuracy of the completely customized lingual appliance WIN: a retrospective cohort study. *J Orofac Orthop*. 2017;78(1):52-61.
22. Lossdörfer S, Bieber C, Schwestka-Polly R, Wiechmann D. Analysis of the torque capacity of a completely customized lingual appliance of the next generation. *Head Face Med*. 2014;10:4.
23. Inami T, Ito G, Miyazawa K, Tabuchi M, Goto S. Ribbon-wise customized lingual appliance and orthodontic anchor screw for the treatment of skeletal high-angle maxillary protrusion without bowing effect. *Angle Orthod*. 2018;88(6):830-840.
24. Canales C, Larson M, Grauer D, Sheats R, Stevens C, Ko CC. A novel biomechanical model assessing continuous orthodontic archwire activation. *Am J Orthod Dentofacial Orthop*. 2013;143(2):281-290.
25. Fritz U, Diedrich P, Wiechmann D. Lingual technique—patients' characteristics, motivation and acceptance. Interpretation of a retrospective survey. *J Orofac Orthop*. 2002;63(3):227-233. English, German.
26. Wiechmann D, Klang E, Helms HJ, Knösel M. Lingual appliances reduce the incidence of white spot lesions during orthodontic

multibracket treatment. *Am J Orthod Dentofacial Orthop*. 2015 Sep; 148(3):414-422.
27. George RD, Hirani S. Fully-customized lingual appliances: how lingual orthodontics became a viable treatment option. *J Orthod*. 2013;40 (suppl 1):S8-S13.
28. Pruzansky DP, Ellis B, Park JH. Influence of student-loan debt on orthodontic residents and recent graduates. *J Clin Orthod*. 2016;50(1): 24-32.
29. 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.
30. Wexler A, Nagappan A, Beswerchij A, Choi R. Direct-to-consumer orthodontics: surveying the user experience. *J Am Dent Assoc*. 2020; 151(8):625-636.e4.

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