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Customization in Lingual Orthodontics

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Review Article

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ABSTRACT

Lingual orthodontics is more difficult and complex than labial orthodontics for several reasons, such as difficulties in bracket positioning, patient comfort, maintenance of oral hygiene, and biomechanics. With the advent of newer materials and technologies, many of these problems have been overcome, and we are able to finish lingual orthodontic cases to the same standards as labial orthodontics. Customization along with the use of 3D treatment planning software in lingual orthodontics has enabled dentists to visualize the end result even before starting the treatment. Individualized brackets and wires can be realized by computer-aided design and computer-aided manufacturing on a target setup made at the outset of treatment so that post-treatment results mirror the pre-treatment setup. New technologies like CAD/CAM, intraoral and cast model scanning, 3D printing and robotics have all led to the emergence of several customized lingual appliance systems that have been instrumental in enhancing the reliability, precision, and feasibility of lingual orthodontics.

INTRODUCTION

The lingual orthodontic technique poses several challenges like difficulties in bracket positioning, patient comfort, maintenance of oral hygiene and biomechanics [1-4]. With the technological advances like CAD-CAM, robotics, 3D printing, many of these problems have been taken care of, and we are able to finish lingual orthodontic cases to the same standards as labial orthodontics [1,4-8]. Unlike labial orthodontics, customization in lingual orthodontics is a necessity. Since morphology of lingual surfaces is irregular and variable, it is important to achieve custom contouring and thickness standardization of bracket bases especially in anterior teeth. This helps in avoiding several first-order bends in the archwire [9-12].

Concept of customization is not new in lingual orthodontics [13]. Lingual brackets have always been customized to a certain extent with either metal or resin. Fontanelle in 1983, France, developed the customized lingual orthodontic appliance using individualized lingual attachments produced by metal casting method [14].

Manual laboratory procedures like CLASS [15], Hiro system [16], Lingual bracket jig [17], BEST [10] etc. have been able to individualize the brackets using resin. Resin is used to fill in the gaps between the bracket pads and the stone model of the teeth **(Figure 1)**. Manual methods of customization are prone to errors, and in order to enhance reliability, precision and feasibility of lingual orthodontics, use of advanced digital technology in customization of some or all of the following steps is desirable:

Bracket fabrication, bracket positioning, archwire fabrication and bracket-transfer methods

In late 1980's, Didier Fillion combined BEST system (Bonding with Equal Specific Thickness) with DALI (Dessin d'Arcs Lingual Informatise), a computer based program to design individualized archwire template [10]. Later he collaborated with Orapix (Orapix Co., Ltd., Seoul) to develop a lingual straight wire technique based on a digital setup [5]. In 1998, Dr. Wiechmann in collaboration with TOP-Service (Bad Essen, Germany) developed TOP (Transfer Optimized Positioning) system that uses a target setup in order to facilitate individualized positioning of brackets. Brackets are bonded directly on the malocclusion model with no bucco-lingual compensations. The compensations are made by an individualized lingual archwires, which are fabricated by a robot [18,19]. Dr. Wiechmann further refined the system and named it Incognito [20,21], which was later acquired by 3M Unitek in Monrovia, California. Dr. Alfredo Gilbert developed LAMDA (Lingual Archwire Manufacturing and Design Aid) system [22] to design and bend archwires with the help of LAMDA archwire-bending robot and LAMDA archwire designing software respectively. This in-office system is used to incorporate 1st order bends in the archwires either before or after the brackets are bonded. Some of the popular customized lingual orthodontic systems are discussed below.

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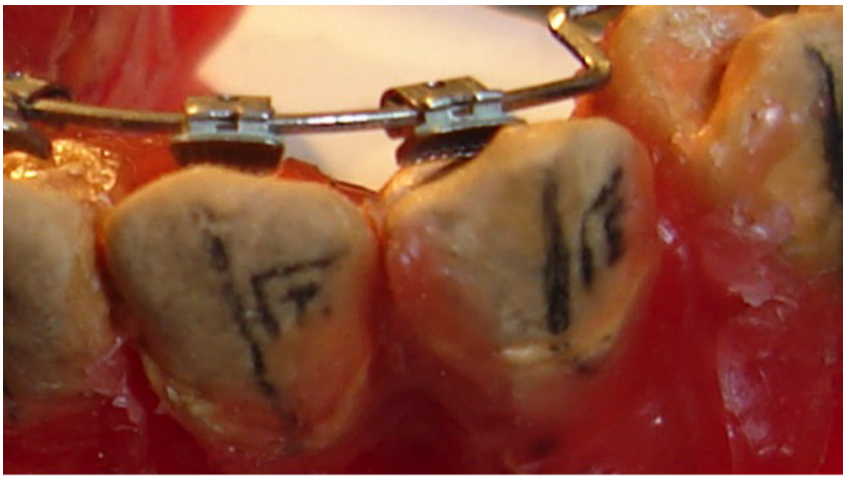

Figure 1. Hiro Technique: Uneven gaps between the bracket pads and lingual surfaces are clearly visible and this space will be filled with resin during customization of bracket bases.

INCOGNITO

There are some important biomechanical considerations in lingual orthodontics that play an important role in finishing an orthodontic case to the same standards as labial orthodontics. One such consideration is the line of application of force. If the line of application of force is closer to the centre of resistance of the tooth, then the magnitude of moment will decrease resulting in less side effects, better operator control, and accurate finishing. The other important consideration is torque play. Correct expression of torque is essential for three dimensional control and successful orthodontic treatment [23]. Wire edge beveling [24] and oversized slots can lead to torque play, which ultimately affects orthodontic control in both bucco-lingual and vertical dimensions. Proper bucco-lingual inclination of teeth is important to achieve ideal occlusion and esthetics [23]. Because of the longer lever arm in lingual orthodontics, these side effects in B-L and vertical planes are more pronounced in lingual orthodontics than in labial orthodontics [23,25].

For instance, with a torque slop of 15 degrees **(Figure 2)**, if the point of force is placed on the labial side as in labial orthodontic technique, it only effects the incisal edge position to a minimal extent. However, when the point of force is placed on the lingual side as in lingual orthodontic technique, the discrepancy in the incisal edge position can be clinically significant depending on the length of the lever arm [7,23].

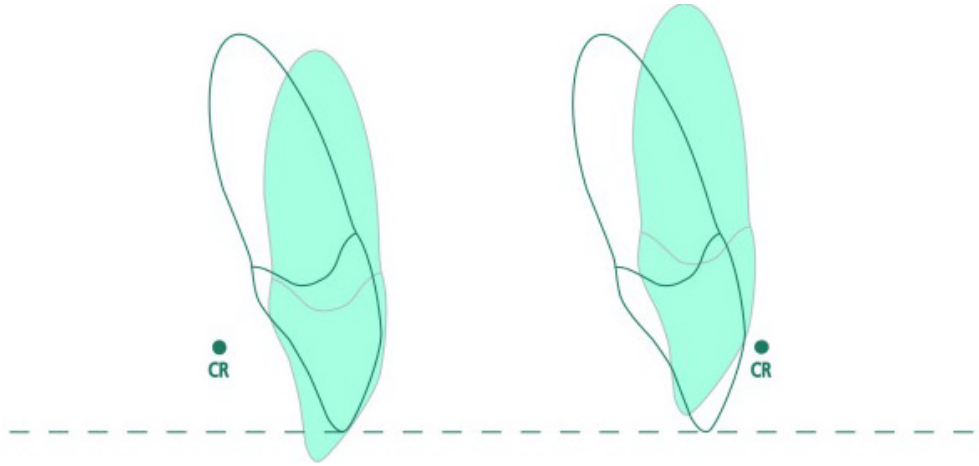

Figure 2. Effects of torque loss. Comparison of torque loss (-15 degrees) in lingual and buccal technique with respect to vertical side effects (CR = Centre of Rotation). Copyright ©2009 Demling et al. licensee BioMed Central Ltd.

In incognito appliance, **(Figure 3)** the brackets, their slots along with the archwires are customized thereby reducing the torque play [23]. Also, the brackets are not customized to accommodate for the difference in thickness of individual teeth rather archwire is robotically bent to compensate for such differences thereby avoiding the need for thick resin pads **(Figure 4)**. This results in brackets and their slots being positioned as close as possible to the lingual surfaces of teeth, causing the levers to have shorter arms, better operator control, and improved patient comfort [7,25,26]. Additionally, the benefit of this is that it increases the interbracket distance.

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Figure 3. Incognito appliance.

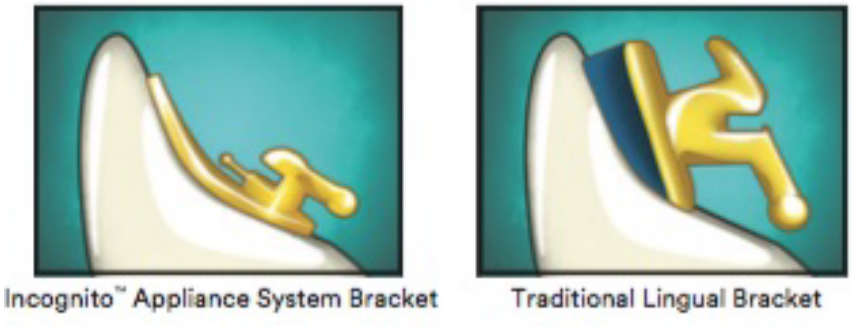

Figure 4. No resin pad is needed in customized Incognito bracket.

After 3M lab receives the patient's PVS impressions and wax bite, a manual setup in wax or a virtual setup based on doctor's prescription is created. After doctor approves the setup, a 3D digital model is created with the help of optical scanner.

Customized virtual brackets with large custom bracket bases are created and then positioned on the digital setup. Large bracket pads aid in achieving increased bond strength and are also helpful in re-bonding procedures. At this stage, bracket tie-wings, hooks, slots and profile are customized to enhance patient comfort and to optimize tooth movement. Wax patterns of brackets are printed using a Stereolithography apparatus and then cast in gold. The brackets are then placed on the original malocclusion model. Brackets are transferred from the model to the patient's mouth using indirect bonding trays. Customized archwires are designed and fabricated matching the target setup using a computer program and robotic technology respectively [26,27].

ORAPIX SYSTEM

In 2001, Dr. Scuzzo et al. introduced the Lingual Straight Wire concept with the goal to eliminate compensating bends in the archwire in the horizontal and vertical planes [28]. In their study, they found out that by changing the height and position of placement of brackets more towards the cervical region of the teeth, the difference of thickness between canine and premolar decreased allowing for the use of lingual straight wire. With this use of cervical lingual arch form, use of mushroom shaped archwire may be eliminated. As this technique required a manual set-up, Dr. Fillion used Orapix system (Orapix Co., Ltd., Seoul) to develop a Lingual Straight Wire technique [5,29,30] based on a digital set-up.

When mushroom archwires are used in conventional ways as in Hiro Technique, the brackets bases' are customized with thicker resin pads in comparison to customized Lingual Straight Wire technique. This is because thickness standardization of bracket bases in anterior teeth depends upon the thickness of canine teeth, so brackets get further away from the incisors requiring thicker resin pads when Hiro Technique of indirect bonding is used. However, in Lingual Straight Wire technique, canine thickness doesn't govern the position of incisor brackets, so this result in thinner bracket pads as incisor brackets could be placed in close contact with the lingual surfaces [29].

The models are scanned with proprietary 3D scanner, and with the help of 3TXer software, an ideal virtual numeric setup is built as per the prescription. Upon doctor's approval of the setup, a set of chosen virtual brackets are positioned to be as close as possible to the lingual surfaces of teeth. During the virtual bracket positioning, canine brackets and 2nd bicuspid brackets may be positioned with distal offset to eliminate the need for bends in these areas so that straight wires could be used [29]. During the virtual setup, over corrections, if needed, may be incorporated in the virtual set up by changing the bracket position. Once the virtual setup is finalized, straight archwire is then designed making sure that it passes through the centre of virtual bracket slots. Customized jigs are designed with the help of 3TXer software on the virtual brackets. These jigs, containing all the virtual information, are fabricated with the help of CAD/CAM technology [30]. Actual brackets are transferred to the malocclusion model with the help of jigs and customized using the resin. Resin helps to customize the bracket pads by closing the gaps between them and the

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stone model of the teeth. These customized bracket pads are extended over most of the lingual surfaces using the KommonBase [31]. Indirect bonding of brackets is carried out in patient's mouth with silicone trays or resin custom trays.

SURESMILE

Sure Smile (OraMetrix, Inc., Richardson, TX, USA) carries the option to integrate CBCT images to create a precise virtual target setup and it utilizes individualized robotically bent archwires in the final stages of orthodontic treatment to create a customized lingual appliance [27,32]. With Sure smile, the operator may use any conventional lingual brackets with their fully customized archwires **(Figure 5)**. First, optical or CBCT scan is submitted to the lab to create a digital model followed by creating a diagnostic setup as per the doctor's prescription. After stock lingual brackets are bonded, the case is levelled and aligned as usual. Second intra oral scan or CBCT is taken to record the position of teeth and brackets to create a therapeutic set-up based on doctor's prescription. Once the doctor approves it, customized archwires are robotically bent in all the three planes to accomplish the desired end result.

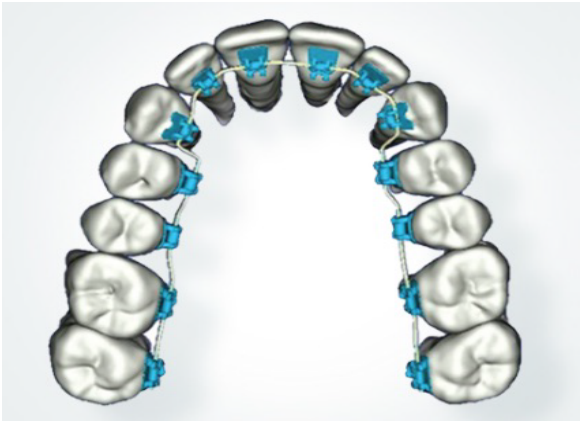

Figure 5. Suresmile system: Customized archwire.

Other Commercial Appliances [13,26,29,30]

Currently there are several other customized lingual appliance systems available like, Lingual Liberty by Dr. Fillion, WIN appliance by Dr. Wiechmann, Harmony (American Orthodontics), a self-ligating lingual appliance system designed by Dr. Patric Curiel, E-Brace produced by Guangzhou Riton Biomaterial Co., Ltd. etc. These appliances are customized more or less the same way as other customized lingual appliance systems discussed earlier. Digital models along with the use of advanced digital technology help create a virtual setup followed by customization of some or all of these steps: Bracket fabrication, bracket positioning, archwire fabrication and bracket-transfer methods.

CONCLUSION

Customized lingual appliance systems have the ability to enhance the reliability, precision, and feasibility of lingual orthodontics along with an improved patient comfort. With the help of customized lingual appliances, dentists are able to finish lingual orthodontic cases to the same standards as labial orthodontics.

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