Comparative Biomechanics of Labial versus Lingual Fixed Appliances - A Review

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Abstract

Lingual orthodontics is a great transition from the conventional labial orthodontics that eliminates the visibility of the fixed appliance by avoiding the orthodontic attachments on the labial surface of the teeth, to meet the esthetic demands of the patients. This lingual technique is quite challenging in terms of treatment approach as compared to labial orthodontics due to working in areas with poor accessibility, variable morphology of lingual surfaces posing difficulty in bracket positioning, different mechanical considerations with respect to the position of orthodontic attachments having different relationship with the centre of resistance, patient irritability due to tongue irritation. It necessitates a lot of patience, efforts, expertise and time from the orthodontist and good cooperation from the patients in understanding the need of extended chairside time, increased expense, prolonged treatment duration as well as the distress associated, the speech and tongue soreness mainly. This article is an attempt to present overview of lingual orthodontics as compared to labial orthodontics.

Keywords: Lingual Orthodontics, Labial Orthodontics

Introduction

Aesthetics has always been of a paramount concern among orthodontic patients. To be able to cater to such patients, the orthodontic community came out with the lingual appliance. Apart from offering the aesthetic benefit, it also provides certain mechanical advantages. Since its inception in the 1970s major advances have been made in its mechanics. Lingual orthodontics is a holistic system in itself and demands accurate diagnosis, case selection, treatment protocol, clinical skills and laboratory support. [1]

In 1726 Pierre Fauchard suggested the possibility of using appliances on the lingual surfaces. In 1841 Pierre Joachim Lefoulon designed the first lingual arch for expansion and alignment of the teeth. However, Mershon's lingual arch, Goshgarian's transpalatal arch, Ricketts' Quad helix; all these appliances were used as supplements to labial mechanics, with no cosmetic incentive. [2] The advent of orthodontic bracket bonding in the early 1970s paved way for some orthodontists to use lingual tooth surface for bracket bonding.

Historical Perspective

In 1975, Dr. Craven Kurz modified labial edgewise appliance to create lingual appliance. He limited his treatment to the mandibular arch avoiding placement on maxillary lingual surfaces for fear that the forces of occlusion would dislodge brackets. Later in 1976, he filed for the patent rights to the U.S. Patent Office for his unique edgewise lingual appliance. In collaboration with Ormco Company its prototype was developed. A bite plane was incorporated in the maxillary anterior brackets, mesh bonding pads were designed to adapt to the lingual surface of the teeth, and torque was incorporated in the slots based on pre-adjusted labial torque values. [3] In 1979, Dr. Kinya Fujita of Japan, developed an appliance with a lingual bracket design and mushroom shaped archwires. His work confirmed the experiences of Dr. Kurz and Ormco that, certainly with refinements, lingual appliances were a viable adjunct to the orthodontist's armamentarium. [4,5,6]

Dr. Giuseppe Scuzzo and Dr Kyoto Takemoto introduced a new STb bracket (Ormco) which

was quite smaller than earlier Ormco brackets and was designed to make the use of light forces with reduced friction.[7] Dr. Wiechmann introduced the first fully customized lingual bracket system. Using CAD-CAM technology, the Incognito (3M Unitek) bracket was developed to perfectly adapt to the lingual surfaces of the teeth. Orapix utilizes CAD-CAM to manufacture a lingual 'straight wire' appliance. Harmony bracket consists of a self-ligating fully customized appliance. Suresmile (OraMetrix)technology uses customized robotically bent wires that help overcome the task wire of wire bending when not using a customized lingual appliance.[8]

Changes Induced by the Lingual Appliance:

- The unique and immediate change induced by the appliance is the bite opening resulting from the lower incisors occluding on the maxillary incisor bracket bite planes
- The bite opening resulting in posterior disclusion is beneficial in brachyfacial cases, TMD cases and rapid tooth movement
- Because of the vertical opening and the downward, backward rotation of the mandible, the lingual appliance induces a Class II tendency
- With bite opening, sagittal molar correction becomes simpler
- The lingual appliance has a tendency to cause expansion

Bio Mechanical Considerations in Lingual Orthodontics

Reduced Inter Bracket Distance (Ibd)

In a study, ratio of the lingual to labial interbracket distance was found to be 1: 1.47. Decreased interbracket distance associated with lingual appliances makes a wire seem approximately 3 times as stiff as when used with labial appliances for first- and second-order bends, and approximately 1 1/2 times as stiff for third-order bends.[9]

The key is to use less stiff wires in lingual than those used in labial orthodontics; therefore 0.018 inch slot brackets are more often useful than 0.22 inch slot brackets as the working archwires in the previous type will be of smaller dimension compared to the latter and therefore will be less stiff. Also because of limited IBD, lingual brackets greatly reduce possibility of introducing loops and en-masse retraction with sliding mechanics is preferred.

The Wire Stiffness

The load/deflection ratio is determined by the modulus of elasticity of the wire, the wire cross-sectional area, and the wire length.

Reduced arch perimeter in the anterior region of lingual tooth aspect makes it difficult to apply light forces and also reduces activation range as well as constancy of force. Increasing the wire length by incorporating loops is difficult because of limited space.

Hence, the options for increasing the resiliency of the wire are either by the use of resilient wires with decreased modulus of elasticity such as shape memory wires or decreased cross section of the wire.[10] The smaller IBD makes the same wire stiffer in lingual than in labial orthodontics.

Friction

Many studies have been conducted to evaluate the principal factors that may influence frictional resistance. The most important factors are bracket and wire materials [11, 12] ,type and force of ligation[13], the relative bracket–wire clearance [14],and the archwire size as related to stiffness .[15]The wire and bracket materials in lingual and labial appliances are the same. One must remember, however, that most of the sliding procedure is done clinically at the posterior regions, where the difference in IBD is less. Ligation of the archwire has a critical influence on the friction values. Double overtie is the most common mode of ligation with the Ormco 7th generation brackets. This ligature tie generates heavy friction, especially in lingual technique where the saliva is in direct contact with the brackets and the elastics. [16]

According to some researchers, stiffer wires reduce the binding and thus reduce the resistance to friction. On the other hand Kusy and Whitley [17]suggest that stiffer wires will increase resistance to sliding in tipped brackets. In lingual mechanics the archwires are usually smaller in diameter than those used in labial mechanics by virtue of use of 0.018 inch slot brackets. [18]Due to the small inter-bracket distance, it is near impossible to insert a stainless steel archwire of dimensions greater than 0.016 X 0.022 inches into a 0.018 inch bracket slot, or a TMA archwire of greater dimension than 0.017 X 0.025 inches. The use of smaller dimension archwires generates less friction in lingual retraction mechanics, however consequently leading to reduced torque control. The most commonly used working archwire for space closure is a 0.016X0.022 inch stainless steel in a 0.018 inch slot causing torque loss of approximately 14°.

Clinical Implications

Retraction of anterior teeth in lingual technique should never be carried out on round archwires even if the teeth are proclined at the start of the treatment. The bracket prescription should incorporate additional torque.

Active torque bent into the archwire automatically induces an opposite and usually undesirable torque reaction in adjacent teeth. With the lingual technique, due to the reduced inter-bracket distance, this type of activation needs to be applied repeatedly in small increments, and the use of light flexible archwires is recommended. It is important in lingual technique is to allow the wire to express itself over a sufficiently long period of time. The clinician is advised to follow the patient every 6 to 8 weeks, to assess activation, engagement of the archwire, and to confirm that no undesirable side effects have occurred.

There are certain types of malocclusions that are easier to treat with lingual than with labial technique. Bite opening and anterior intrusion are easily achieved with the built-in lingual bite plane.

In cases where bite closure and anterior extrusion are needed (open bite cases), the lingual practitioner must execute certain biomechanical principles to overcome the natural tendency of the lingual appliance to intrude the anterior teeth and to open the bite. [18]

Anchorage Control

Antero-Posterior (Sagittal)

When same amount of force is applied in both systems (labial and lingual) so that the intrusion force equals the retraction force, results are different. Using labial system, net force is pointed directly towards centre of resistance. Net force in lingual orthodontics, produces a lingual tipping force and vertical bowing effect. [19]Thus retraction force should be minimized during en masse retraction and more intrusion and torque force is needed to retract anteriors.

Vertical

In lingual orthodontics, intrusion of normally inclined or proclined teeth is associated with little or no labial tipping due to force vector passing through or closer to centre of resistance whereas in retroclined teeth, it leads to further tipping as the force vector passes lingual to the centre of resistance. In labial orthodontics, extrusion is accompanied by labial root movement, but in lingual orthodontics, extrusion shows complexity meaning that teeth with different inclinations except those with more than 20% inclinations to the occlusal plane show lingual root movement and latter showing labial root movement. [20]If the root tips are forward and the crowns lingually inclined, intrusion should be controlled because point of application of force is distal to axis passing through centre of resistance of incisors and this further increases lingual inclination, so crowns should be tipped labially first and then intruded. In lower arch, lingual bracket is closer to axis passing through centre of resistance, in normally inclined lower incisors. Because of this, during leveling lingual application of force allows easier intrusion coupled with less labial inclination of crown compared with labial application of force.

The clinical implication of this geometry is that the tendency for retroclination of anterior teeth is more pronounced in lingual mechanics, and therefore in certain cases it is necessary to counteract this tendency by creating a negative buccal force by incorporating additional degree of labial crown torque (palatal root torque). [18]

Transverse

In the transverse plane, as the IBD is smaller than the labial one, the arch wire stiffness increases and the rotational moment is less than that on labial side. In lingual, the point of application of force is closer to tooth axis. In cases of crowding, it is more difficult to engage the arch wire in the lingual brackets than in the labial, so one need to use more resilient wires.

Sliding Versus Frictionless Mechanics

Sliding mechanics- wire friction and uncontrolled retraction forces result in more anchorage loss. Sliding mechanics is more time consuming as heavy retraction forces are required to overcome wire-bracket friction. Loop mechanics requires lot of skill, precision and it is difficult to bend the wires into different loops. Compared with sliding mechanics, loop/ frictionless mechanics accomplishes bite and torque control more readily and they are, of course, free from wire friction. In closing the spaces with lingual appliance, however, sliding mechanics is better and are used more often. During retraction, the upper arch tends to widen in the premolar region with the molars rolling in creating a transverse bowing effect.The sliding mechanics with lingual orthodontics also has the advantage of being effective in preventing transverse bowing effect leading to undesired buccal tipping of premolars and distolingual rotation of molar without using any auxiliary such as transpalatal arch by using stiffer archwires. [3]

Favourable Cases [21]

- Mild incisor crowding and with anterior deep bite
- Long and uniform tooth surfaces without fillings, crowns, or bridges
- Good gingival and periodontal health
- Keen, complaint patient
- Skeletal class I pattern
- Mesocephalic or mild/moderate brachycephalic skeletal pattern
- Patients who are able to adequately open their mouths and extend their neck

Unfavourable Cases

- Dolicocephalic skeletal pattern
- Maximum anchorage cases, unless treated with micro implants
- Short, abraded, and irregular lingual tooth surfaces
- Presence of multiple crowns, bridges, and large restorations
- Patients with low level compliance
- Patients with limited ability to open the mouth (trismus)
- Patients with cervical ankylosis or other neck injuries that prevent neck extension

Lingual Appliances are Effective than Labial Appliance in Following [3]

- Intrusion of anterior teeth
- Maxillary arch expansion
- Mandibular repositioning therapy
- Distalization of maxillary molars

Conclusion

Knowledge of the biomechanics of lingual appliance, particularly where it differs from labial orthodontics, is essential. Lingual treatment can be as successful and as satisfying as the latter. Maintenance of aesthetics during treatment is a major issue in orthodontics, particularly for adult patients, and it is imperative on clinicians to be aware of the necessity to fulfil the patients' concerns and expectations not only relative to the final result, but also in their desire to receive the most aesthetically available or rather invisible appliance. Thus thorough Knowledge and application of the biomechanical principles governing lingual orthodontic appliance is

essential for delivering efficient and successful orthodontic treatment.

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