EAS Journal of Dentistry and Oral Medicine
Abbreviated Key Title: EAS J Dent Oral Med
ISSN: 2663-1849 (Print) & ISSN: 2663-7324 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-2 | Issue-3 | May-June-2020 | DOI:10.36349/EASJDOM.2020.v02i03.004

Research Article

Lingual and Labial Orthodontics- The Two Sides of A Coin

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Article History
Received: 11.05.2020
Accepted: 29.05.2020
Published: 10.06.2020

Journal homepage:
https://www.easpublisher.com/easjdom

Quick Response Code

Abstract: The two mechanotheray used in orthodontics, i.e labial and lingual orthodontics are basically the two sides of a same coin. The discovery of lingual orthodontics gained popularity because of the most esthetic demands of the patients. This technique has been used by the orthodontist since last 30 years. The patient for invisible orthodontics technique have a different criteria right from the beginning to end i.e patient selection, diagnosis and treatment planning, bonding techniques, the arch form. From past few years the authors present progress in this field with the evolution of brackets, their precise placement in the lab procedures, the making procedure of wires which increases patient's comfort. This article, a brief review regarding the history, criteria, diagnosis, laboratory procedure and the biomechanics involved in lingual orthodontics have been discussed.

Keywords: Lingual, esthetic, biomechanics, technique.

INTRODUCTION

With the development of various Orthodontic procedures together with notable progress from a commercial technological point of view have led to the achievement of exceptionally high Orthodontic standards. In fact, of any kind of malocclusion, whether dental or skeletal, there are no limits to the solution with a high % of success.

The demand and popularity of orthodontic treatment is increasing day by day and if the patient concern is esthetics, then there is a need to look the other side of coin which includes shifting of treatment plan from labial to lingual orthodontics.

History

- 1726- Pierre Fauchard- gave the concept of lingual appliance.
- 1841- 1st lingual arch was designed.
- 1970- Kinja Fujita- developed 1st lingual appliance on demands of martial arts sports person from possible impact against brackets.
- Fujita also developed first multi-bracket technique using the mashroom shaped archwire.
- Later on Ormco founded a Task Force comprising Craven Kurz, Jack Gorman, Bob Smith, Wick Alexander and Moody Alexander, James Hilgers and administrators Floyd Pickrel, Ernie Strauch and Michael Swartz (Echarri, A., 2006).
- 1982- In United States, Kelly a pioneer in this field who used the Unitek labial brackets on lingual sides.
- 1987- Foundation of American Lingual Orthodontics Association
- 1990- The interest in lingual technique decreased due to poor standard of complete cases.
- 1996- Relaunching of lingual Orthodontics in US by Kurz and his colleagues.

From last 20 years, the lingual technique have become so popularized in almost all parts of the world and it best fit with conventional labial technique and its acceptance by the specialist is growing very fast1.

LINGUAL ORTHODONTICS VS BUCCAL ORTHODONTICS

The biomechanics involved in lingual orthodontics is different in some respects, because of the variaion in the Brackets position (Goren, S. *et al*., 2002). There is no doubt that lingual appliances have several advantages over labial appliances therapy (Caniklligou, S. et al., 2000):

1. The labial surfaces of the teeth are not damaged with bonding, debonding and there is adhesive removal or decalcification from plaque retained around the labial appliances.
2. The tooth position can be more precisely seen when brackets and archwires do not obstruct their surfaces.
3. Labial contours are truly visualized since the contour and drape of the lips are not distorted by protruding labial appliances.
4. The young generation especially schools and colleges patients would prefer “invisible” lingual appliances if costs, treatment times, and results were comparable to those of labial appliance treatment.

As mentioned these above advantages for patients, the perfection of lingual treatment seems worthwhile. An acceptable lingual orthodontic appliance system must include the following points:

1. The appliance should work efficiently like a labial appliance.
2. A means of positioning brackets precisely to create a near straight wire appliance on the lingual aspect.
3. A consistent and accurate indirect bonding technique.
4. A selection of preformed archwires complete with canine – premolar offsets
5. Specially designed pliers with longer handles and offset beaks.
6. Lingual bracket removing pliers
7. Offset torquing keys
8. Training for the orthodontist and staff to develop their lingual treatment technique so that it becomes routine to the labial treatment.

Biomechanical differences between labial and lingual appliances are (Goren, S. *et al*., 2002)

The ratio of anterior lingual distance to labial interbracket distance is 1:1.47.

- In vertical direction, on applying an intrusive force in labial orthodontics on a tooth that is initially positioned between a retroclination of 20° and proclination of 45° will create a lingual root movement (proclination). In lingual orthodontics the labial root moment (retroclination) will occur when the tooth is retroclined more than 20°.
- In sagittal direction, both the systems, the direction of force applied passes relatively far from the Centre of resistance and therefore a moment is created. The moment tends to move the crown in the force direction and the apex in the opposite direction. So in this sense, there is no difference between lingual and labial orthodontics.
- In transverse direction in both systems, the vectors of force are passing similarly relative to the Centre of resistance (Cr), and hence produce similar moments: the moment tends to create a movement of the crown in the force direction and a root movement in the opposite direction. Clinically, it seems that expansion is easier in lingual than in labial orthodontics.

PATIENT SELECTION AND DIAGNOSTIC CRITERIA

It is not necessary that all the patients that can be treated with labial orthodontics also fit in the lingual orthodontics. Following criteria should be overlooked before planning a case for lingual technique.

Favourable cases (Echarri, P. 2006)

- Cases with anterior deep bite mild incisor crowding
- Lingual tooth surfaces without restorations, crowns, or bridges
- Good gingival and periodontal health status.
- Keen, compliant patient
- Class I Skeletal pattern
- Mesocephalic or mild/moderate brachycephalic skeletal pattern
- Patients who are able to adequately open their mouths and extend their neck

Extraction cases (Echarri, P. 2006)

- Class II upper 1st premolar and lower 2nd premolar.
- Class II upper 1st premolar extraction.
- Mild bimaxillary protrusion with 4 premolar extraction.
- Class III tendency with deep bite.

Unfavorable Cases (Echarri, P. 2006)

- Dolichocephalic skeletal pattern
- High anchorage cases, unless treated with
- micro implants
- Skeletal class II and Class III cases require orthognthic surgery
- limited mouth opening (trismus)
- Patients with cervical ankylosis or other neck
- injuries that prevent neck extension

Diagnostic Considerations in Lingual Orthodontics: (Echarri, P. 2006)

Diagnosis is an important issue for all orthodontic treatment techniques and even more so in lingual orthodontics.

1. Lingual crown height: Lingual crown heights are usually 30% shorter than their labial surfaces. The most suitable teeth for lingual orthodontics are those with long and smooth surfaces with at least

7mm of lingual crown height of incisors and incisors with lingual surfaces shorter than 7 mm should be reconstructed.

2. Periodontal and gingival considerations: Before starting active orthodontic treatment, the patient should have a healthy periodontium and should be able to maintain a high level of oral hygiene.
3. Restorative considerations: The likelihood of encountering more extensive restorative and prosthetic work is naturally increased in the adult patient. Many of the adult cases presenting for lingual orthodontics have mutilated malocclusions, and treatment planning for these cases, particularly when using thelingual technique, requires special consideration. The presence of crowns, bridges, and large restorations impact negatively on achieving good adhesion and these needs to be treated with special bonding techniques for plastic, metallic, or porcelain surfaces.
4. Surgical Cases: With these cases, the best possible presurgical tooth position should be achieved to minimize the postsurgical orthodontic treatment time.The patient must be consulted on the possibility of bonding labial brackets just before surgery to assist with the postsurgical fixation.
5. Preprosthetic Cases: Lingual orthodontic treatment is often indicated in patients requiring preprosthetic tooth movement

Development of Lingual Orthodontic Bracket from 1st To 7th Generation: (Romano, R. 2008)

Generation #1—1976

- The first Kurz Lingual Appliance was manufactured by Ormco.
- The appliance had a flat maxillary occlusal bite plane from canine to canine.
- low profile and half-round lower incisor and premolar brackets and
- no hooks on any brackets.

Generation #2—1980

- Hooks were added to all canine brackets.

Generation #3—1981

- Hooks were added to all anterior and premolar brackets.
- The first molar bracket had an internal hook.
- The second molar had a terminal sheath without a hook button a terminal recess for elastic traction.

Generation #4—1982–84

- An addition of a low profile anterior inclined plane on the central and lateral incisor brackets.
- Hooks were optional, based upon individual treatment needs and hygiene concerns.

Generation #5—1985–86

- The anterior inclined plane became more pronounced, with an increase in labial torque in the maxillary anterior region.
- The canine also had an inclined plane; however, it was bi beveled to allow intercuspation of the maxillary cusp with the embrasure between the mandibular canine and the first premolar. Hooks were optional.
- A transpalatal bar attachment was now available for the first molar bracket.

Generation #6—1987–90

- The inclined plane on the maxillary anteriors becomes squarer in shape.
- Hooks on the anteriors and premolars were elongated. Hooks were now available for all the brackets.
- The transpalatal bar attachment for the first molar band was optional.
- A hinge cap, allowing ease of archwire manipulation, was now available for molar brackets.

Generation #7—1990

- The maxillary anterior inclined plane is now heartshaped with short hooks.
- The lower anterior brackets have a larger inclined plane with short hooks. All hooks have a greater recess/access for ligation.
- The premolar brackets were widened mesiodistally and the hooks were shortened. The increased width of the premolar bracket allows better angulation and rotation control. The molar brackets now come with either a hinge cap or a terminal sheath.

Laboratory Procedures Used in Lingual Orthodontics

Materials used for attaching brackets to the working models: (Kalang, JT. 2007)

- Softened sugar daddy candy
- Sticky wax
- Water soluble adhesive
- Adhesive coated brackets
- Soluble water-paper paste
- Composite adhesives (CLASS)
- Macrofilled resin (BEST AND TARG)
- Bonding paste

Bracket positioners: (Kalang, JT. 2007)

- Individual bracket placement indicators (1982 Myrberg)
- Individual preformed height gauges (Reichheld)
- Customized lingual appliance setup service (CLASS) system
- Toque angulated device (TARG) system
- Equal specific thickness (BEST) system
- KIS bracket positioner
- Mushroom bracket positioner
- Brackets positioned using ideal archwire (HIRO) system
- Bracket positioning using Tip, torque, angulation (Ray set) system

- Slot machine (Creekmore)
- Lingual bracket jig
- German Transfer Optimized Positioning (TOP) system
- Computer driven system (Sure smile)
- CAD-CAM (Ortho CAD, Lingual care) system

Materials used for making Transfer trays: (Kalang, JT. 2007)
- Vaccum formed clear placement trays
- Impression compound (Memosil)
- Optosil transfer trays
- Xantopren transfer trays
- Duel clear tray systems (Inner softer and outer harder trays)
- Clear acylic transfer trays
- Silicone transfer trays – low, medium and high viscosity
- Polyvinyl siloxane transfer trays
- Hot glue guns
- Transfer wires
- Resin core transfer trays (Dura lay)

Full arch transfer trays: (Echarri, P. *et al*., 2004)
- Opaque silicone trays (Xantopren, Optosil)
- Translucent silicone trays (Memosil)
- Thermoplastic trays (Copyplast, Bioplast)\

Single tooth transfer system:(Echarri, P. et al., 2004)
- The Hiro System
- Kyung's Individual Indirect Bonding Trays
- Kim's Convertible Resin Core (CRC) Ready-Made Transfer Tray

Materials used for bonding brackets: (Kalang, JT. 2007)

A) Chemically cured
- Composites (Thomas)
- No mix adhesive (Fried and Neumann, 1983)
- Resin-reinforced glass ionomers
- Acrylated epoxy adhesives
- Cyanoacrylates
- BIS-GMA based adhesives

B) Light cured
- Visible light cured adhesives
- Light cured lightly filled sealant
- Filled flowable composite
- Fiber reinforced composite

C) Thermally cured

D) Dual cure adhesives (cement setting / light activated) – Glass Ionomer components + Resins

E) Tri-cured adhesives (chemical / light activated and cement setting reaction) – Glass Ionomer components + Resins

ANCHORAGE CONSIDERATION IN LINGUAL ORTHODONTICS

Maintaining an anchorage during treatment is a challenging issue in lingual as well as labial orthodontics,.

The pimportance of anchorage control is a valuable tool for the successful treatment of most malocclusions irrespective of the treatment technique. Various factors are involved to provide an adequate anchorage while using the lingual technique. (Kyung, RP. *et al.*,2006)

Anchorage Assessment in the Sagittal Plane:(McLaughlin, RP. et al., 1991)

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. With a labial system,the direction of net force is towards the centre of resistance. Net force in lingual orthodontics produces a lingual tipping force along with vertical bowing effect.(Liang, W. et al., 2009) Therefore during en masse retraction the retraction force should be minimum while more intrusion and torque force is required.

Vertical

In lingual orthodontics, the intrusion of normally inclined or proclined teeth occurs with little or no labial tipping because of force vector passing through or closer to centre of resistance whereas in retroclined teeth, there is 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 different meaning that teeth with different inclinations except those with greater than 20% inclinations to the occlusal plane show lingual root movement and latter shows labial root movement. (Liang, W. et al.,2009) on the other hand, if the root tips are forward and the crowns lingually inclined, intrusion should be controlled because the point of application of force is distal to the axis passing through centre of resistance of incisors and this leads to increase the lingual inclination, so crowns should be tipped labially first and then it should be intruded. In the mandibular arch, lingual bracket is close to axis passing through the centre of resistance, in normally inclined lower incisors. Because of this, during levelling lingual application of force allows easier intrusion coupled with less labial inclination of crown compared with labial application of force.

Clinical implication:

There is tendency for retroclination of anterior teeth which 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) (Geron, s. et al.,)

Transverse

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

Frictional (Sliding) Versus Frictionless Mechanics

In sliding mechanics there is more anchorage loss due to wire friction and uncontrolled retraction forces. The sliding mechanics is more time consuming because heavy retraction forces are needed to overcome the wire-bracket friction. Loop mechanics requires skill, and it is difficult to bend the wires into different loops. Compared with sliding mechanics, loop/ frictionless mechanics have a better bite and torque control. To close spaces with lingual appliance, however sliding mechanics performs better. Retraction of upper arch tends to widen the premolar region due to molars rolling and by creating a transverse bowing effect.

Advantage of frictional mechanics with lingual orthodontics- it is effective in preventing the transverse bowing effect which leads to unwanted buccal tipping of premolars and distolingual rotation of molars without using any auxiliary such as transpalatal arch .(Romano, R. 2008)

Six ‘’6’’ keys for anchorage:

On the basis of anchorage requirements the “six keys for anchorage control in lingual sliding mechanics” have been suggested in order to provide maximum anchorage control [Geron, S. et.,2003)]

1. Standard lingual-bracket-jig prescription in the anterior segment with a slight extra torque and no extra tip for extraction treatment, and posteriorly, mesial off-center position and mesial angulation of the molar brackets.
2. Bi dimensional approach, with its inherent feature of less friction during sliding mechanics.
3. Bite stops in the posterior region for bite opening.
4. A light orthodontic forces for space closure, by using Class I (elastomeric chain), class II or class III (elastic) mechanics.
5. Inclusion of second molars as an anchorage unit.
6. Placement of an exaggerated or reversed curve of spee, in the maxillary and mandibular space archwire respectively

The Lingual Appliances are Effective than Labial Appliance in Following (Romano, R. 2008)

1. Intrusion of anterior teeth
2. Maxillary arch expansion
3. Mandibular repositioning therapy
4. Distalization of maxillary molars

BONDING IN LINGUAL ORTHODONTICS

(Laura, B. & Diller. F., 2006)

In order to fully exploit the potential of the device used in lingual orthodontics, it is essemtial to know the exact and accurate bracket position.

Customized Lingual Appliance Set Up Service System (CLASS)

The CLASS technique is a method of placing lingual bracket that takes in account the anatomic discrepancies on the lingual surfaces of the teeth. First of all, it is accomplished by constructing an ideal diagnostic set up from a duplicate set up model of the patient’s ideal malocclusion. Then this ideal set up or template is used as a physical guide to place the lingual brackets in an ideal configuration. The brackets placement on the diagnostic set up using composite adhesive, which acts as spacer between the metal mesh pad and the individual dental surfaces. After the brackets placement on the ideal diagnostic set- up, they are again transferred back to the malocclusion cast. At this point, transfer trays are fabricated so the brackets and can be delivered clinically via the indirect bonding method.

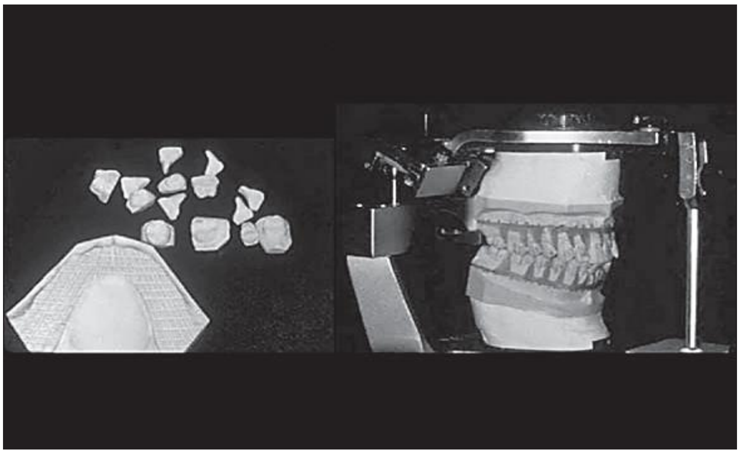

Figure 1- Set-up models

Torque Angulation Reference Guide (TARG) System

- In 1984, Ormco Society launched The TARG machine and considered as an important tool to the laboratory technique.
- It allows an accurate brackets positioning at a precise distance from the incisal and occlusal surfaces of the teeth. It also make possible to prescribe the individualized torque and angulation for each tooth. Thus it creates a "virtual" set-up, and the brackets can be bonded on the malocclusion model, with each bracket having a specific resinmodified base. (Figure 2)

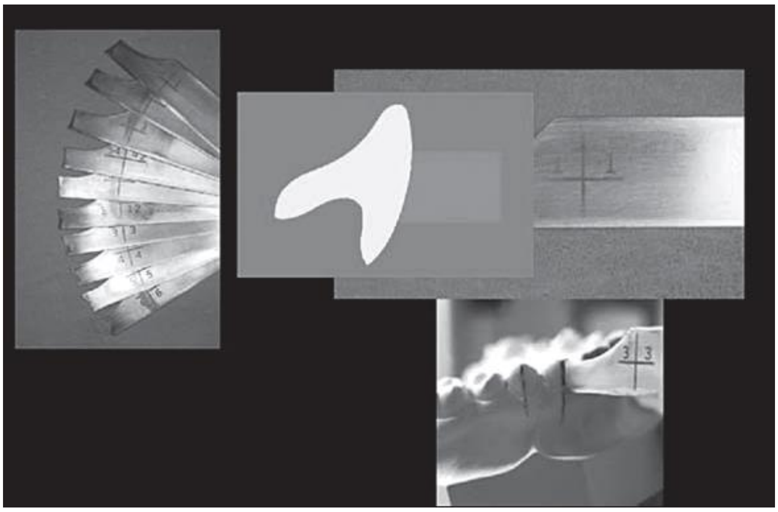

Figure2:

Bonding with Equal Specific Thickness (BEST) System

- Fillion in 1986, developed a new system and realized that there was an important feature missing from the original TARG machine.
- A precise measuring device is added a to the original TARG machine in order to compensate different thickness between the teeth. (Figure 3).

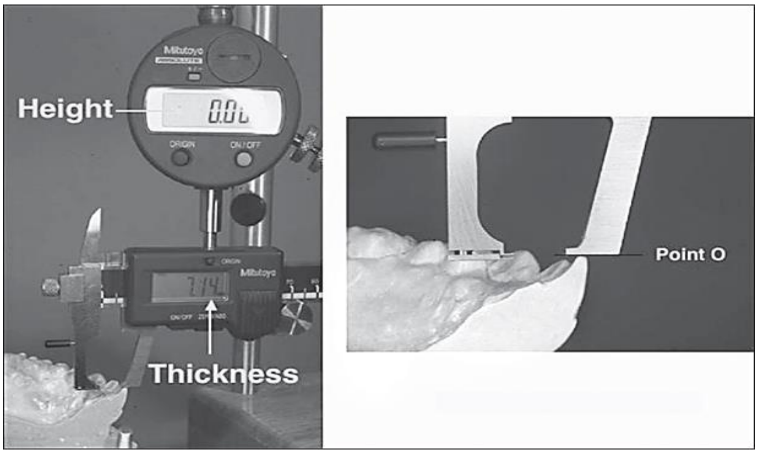

Figure 3: The Electronic TARG the distance (thickness) between the labial surface of the tooth and the slot of the bracket.

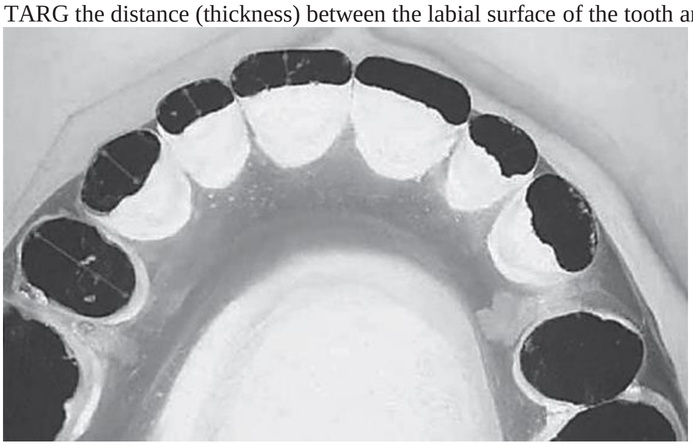

Figure 4: Thickness difference between different teeth need to be compensated for during bracket positioning to allow working with a straighter arch wire.

Slot Machine

Thomas Creekmore developed the slot machine to place both the conventional as well as lingual brackets directly onto the malocclusion model.

Procedure:
- It consists of positioning each tooth to a prescribed torque and angulation
- The machine orientates the bracket slot with the Andrews labial archwire plane (LA plane).
- It can be used for the placement of brackets having either in horizontal or vertical access archwire slots.

Advantage: there is no model tooth set-up required
Disadvantage: Difficulty in managing the many pieces of the slot machine might.

Lingual Bracket Jig (LBJ)
- **Geron** developed this system (Figure 5)
- It is the only system that allows direct as well as indirect positioning of brackets.
- It consists of a set of six jigs for the anterior maxillary teeth, one universal jig for the posterior teeth, and a special ruler.
- The jigs transfer the Andrews labial bracket prescription to the lingual surface.
- An occlusal stop that measures the height of the bracket from the incisal edge.

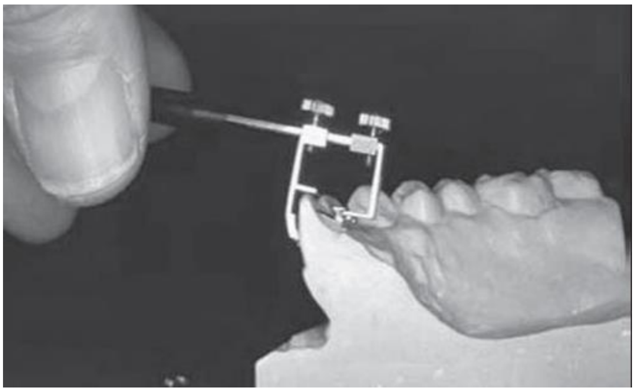

Figure 5: Lingual bracket jig; can be used indirectly on the malocclusion model or for direct bonding in the mouth.

Transfer Optimized Positioning (TOP/INCOGNITO I BRACES system)
- Developed by **Fillion** (Figure 6)
- It is similar to that used for the BEST system, allowing the brackets to be placed directly on the malocclusion model.
- It uses the TARG Professional, which has a bracket holder for twin brackets and tubes in addition to the horizontal and vertical measuring systems.
- The target set-up is used to find the optimal height for the brackets.

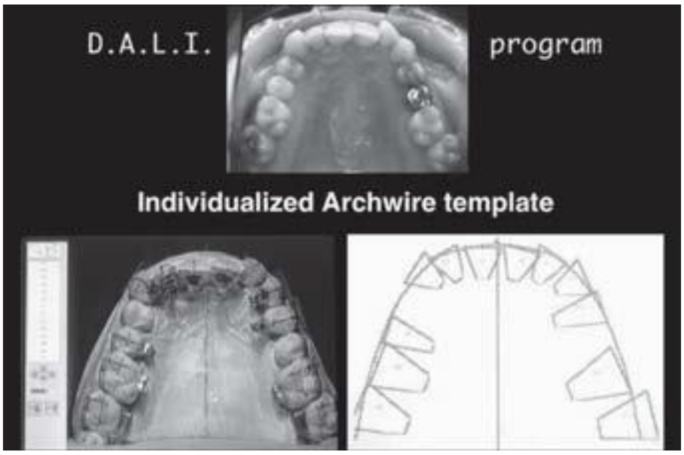

Figure 6: Coordination of upper and lower arch designs in DALI software, thus making it possible to have the wires constructed in advanceand reducing chair side time.

Korean Indirect Bonding Set-up (KIS) System
- This system was developed by the members of Korean Society of Lingual Orthodontics (KSLO)
- They used a bracket-positioning machine that allows the positioning of all brackets at once.
- It is necessary to create a set-up model; however, the set-up is created with the help of a special set-up model gauge for increased precision. (Figure 7)

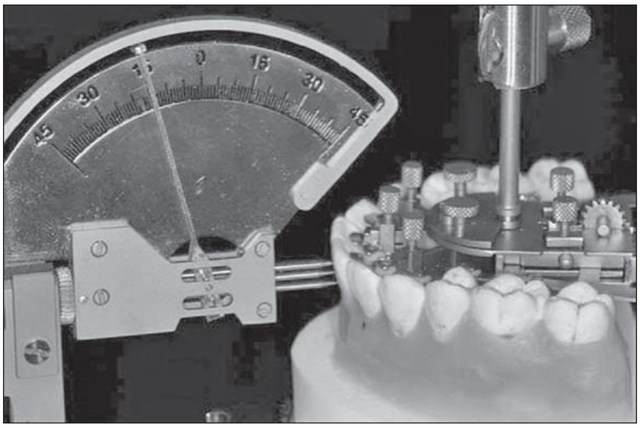

Figure 7: KIS system showing all the brackets are positioned at the same time.

Hiro System: (Figure 8)

- The two laboratory techniques that do not require any special equipment are the Hiro system and the Convertible Resin Core system.
- The Hiro system was developed by Toshiaki Hiro and improved by Kyoto Takemoto and Giuseppe Scuzzo.
- It still relies on the preparation of a set-up model where the teeth are sectioned and correctly aligned.
- The brackets are positioned and placed on the set-up model with the help of a full-sized rigid rectangular archwire.

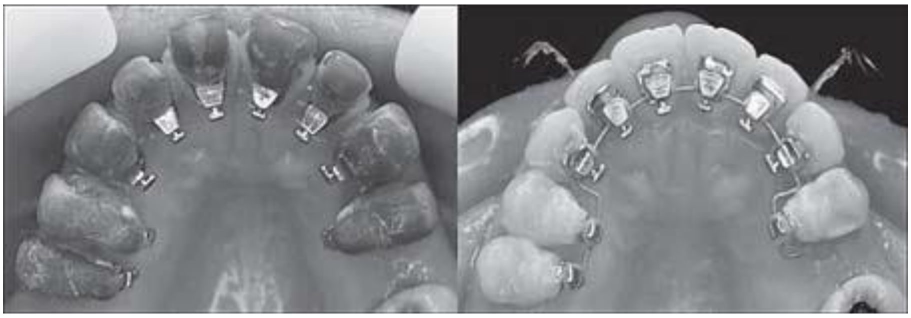

Figure 8: HIRO system- individualized trays are made and transferred from the set up model to the mouth.

Convertible Resin Core System

- This system uses hard resin
- Resin is used to prepare the individual transfer trays and an elastomeric ligature to hold the tray as well as bracket together.
- It allows accurate repositioning of the bracket within the resin core
- The trays can be reused in cases of bracket failure.
- Unitary trays makes the initial bonding session longer.

Hybrid Core System.

- Introduced by Matsuno
- This is basically a bracket-transfer system.
- It has favorable properties of silicone and composite resin that allows the construction of its indirect transfer tray.
- Silicone covers the bracket and this in turn covered by the composite resin.
- This combination allows a stable positioning of the transfer tray within the mouth, followed by an easy removal of the silicone component from the bonded bracket.

Simplified Technique

With the development of the new STb brackets these brackets are positioned directly on to the malocclusion model with the help of a plier or by using a tweezers. (Figure 9)

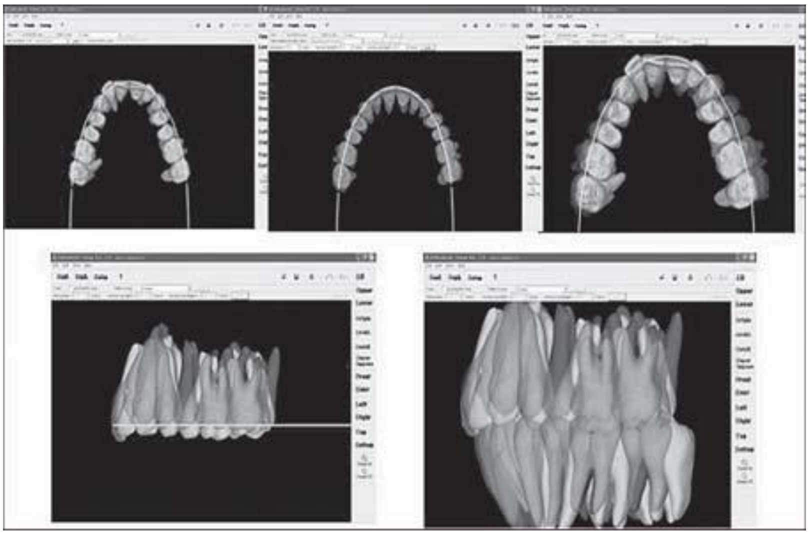

Figure 9: The position of STb brackets onto the malocclusion model at a leve of 1.5 to 2 mm from the incisal edge of the anterior teeth.

Orapix System (Figure 10)

- **Fillion** developed an alternative straight wire technique, using the Orapix digital system to fabricate lingual appliances from a virtual setup.(Fillio. *et al*.,2011)
- It requires a scanner that will scan a patient's model and create a three dimensional (3D) data file. The orthodontist will receive the 3D data file of the patient and a 3-Txer software package via the Internet. With the 3-Txer software the orthodontist will visualize a 3D model and will be able to create his own virtual set-up on his computer for that particular patient.

Figure 10: Orapix System

Retention in lingual orthodontics

- Clear retainer
- Begg-Type retainer
- Spring Retainer
- Passive lingual retainer
- Active lingual retainer (bonded)

CONCLUSION

The labial and lingual orthodontics are the two sides of a coin. The knowledge regarding the biomechanics of lingual appliance, particularly where it differs from labial orthodontics, is important. Lingual treatment can be as successful and as satisfying as the latter. Maintenance of esthetics during treatment is a serious issue in orthodontics, particularly for young adult patients and celebrities , and it is imperative on orthodontist to be aware of the necessity to fulfil the patients' concerns and expectations. So a well knowledge and application of the biomechanical principles governing invisible lingual orthodontic technique is important for delivering efficient and successful orthodontic treatment.

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