Republic of Iraq Ministry of Higher Education And scientific Research University of Baghdad College of Dentistry



Lingual orthodontic appliances

A project Submitted to Collage of Dentistry, University of Baghdad. Department of orthodontics in fulfillment for the requirement of B.D.S degree

Done by

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Baghdad-Iraq

2017-1438





Acknowledgement

At the beginning I would like to express my gratitude to my dear God for his continuous reconcile.

I would like to dedicate this project to Imam Al-Mahdi (Oh Allah hasten his appearance).

Also I would like to express my special thanks of gratitude to Dr Hussein Al-Huwaizi , Dr Dhiaa Al-Dabbagh and my supervisor Dr. Ammar Salim who gave me the golden opportunity to do this wonderful project on the topic Lingual orthodontic appliance, which also helped me in doing a lot of research and I came to know about so many new things I am really thankful to them. Secondly I would also like to thank my parents, friends and specially my husband who helped and supported me a lot in finalizing this project within the limited time frame.

Abstract

The development of lingual orthodontic appliances dates back to the 70's of the past century. A lot of development occurred since then. These appliances are usually associated with more patient discomfort, more technically demanding, and greater cost. However, their greatest advantage is esthetic, being placed on the lingual side of the teeth, patients can enjoy smiling. The latest advances that depend on CAD/CAM technology have overcome lots of the problems associated with the previous lingual appliances, and they can be considered a good treatment choice when esthetic is a major concern.

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Introduction

Lingual orthodontics as we understand it today began in the 1970s. A Japanese orthodontist, Dr Kinja Fujita, developed the appliance, not primarily for aesthetic reasons but rather to protect the soft tissues (lips and cheeks) of his orthodontic patients who practiced martial arts. Independently, in the USA, Dr Craven Kurz worked to develop a lingual appliance at this time. The first lingual appliances used standard labial brackets, which were modified by the clinician and bonded to the teeth using a direct technique, the same technique as is employed to bond labial brackets. Lingual orthodontics achieved a certain amount of popularity in the 1980s; however, its popularity soon decreased due to clinical difficulties associated with the technique (**Buckly et al, 2012**).

The Lingual technique is becoming more widely used as patients are increasingly aware of the advantages and possibilities that it makes available. Many clinicians are now practiced in the technique and are able to offer it to their patients. This treatment is an alternative to conventional fixed appliances and is fixed to the labial aspect of their teeth. Lingual orthodontics was initially pioneered in the 1970s in Japan, where it was intended as an alternative for patients who took part in martial arts, and in America, where it was seen as an aesthetic option. The development was slow as the 1980s saw the introduction of aesthetic bracket and invisible aligners, which offered patients another, less visible, alternative to metal brackets (**Grist, 2010**).

Aims of the study

This project aims to have a brief review about lingual appliance and their use in orthodontic treatment, and to compare them with the conventional labial orthodontic appliance.

Review of literature

1.1. History

Even before the development of a true lingual appliance the orthodontic material company Ormco in conjunction with Dr. Jim Wildman, had attempted to develop a system to align the dentition using the lingual approach. This system consisted of a pedicle positioner, rather than a multi-bracketed system. Although innovative, the inherent limitations of this system prevented it from gaining widespread popularity in the orthodontic community. It was only in the early 1970s that Dr. Craven Kurz, an assistant professor at UCLA School of Dentistry, realized that a major portion of his private orthodontic practice was dominated by adult patients. Since many of his patients were public figures, esthetics became a concern. This led to the development of the concept for the lingually bonded appliance. Dr. Kurz developed the first true lingual appliance, consisting of plastic Lee Fisher brackets bonded to the lingual aspect of the anterior dentition and metal brackets bonded to the lingual aspect of the posterior dentition. The plastic brackets were used for the inherent ease of recontouring and reshaping them to avoid direct contact with the opposing teeth. Around the same time Dr K Fujita of Japan published cases treated with his modification of the Begg light wire appliance. He had bonded the Begg brackets lingually and used the same Australian AJ Wilcock wires contoured to the lingual aspect of the teeth. He explained the arch form which resembled a mushroom (when viewed occlusally) and advocated the same basic steps as in the conventional Begg technique to be used with the Begg bracket with a modified base. Further research was carried out by individuals and groups of individuals associated together, with financial funding from the orthodontics manufacturing companies. The Lingual Task Force was set-up (by the orthodontic material company Ormco) to develop (Singh et al, 2007).

1.2. Generation development of lingual appliance

1.2.1. Generation #1—1976

The first Kurz Lingual Appliance was manufactured by Ormco. This appliance had a flat maxillary occlusal bite plane from canine to canine (Figure 1). The lower incisor and premolar brackets were low profile and half-round, and there were no hooks on any brackets (**Romano, 1998**).



Figure 1. Generation #1—1976 Flat maxillary occlusal bite plane from canine to canine The lower anteriors and premolars had low profile, halfround brackets. There were no hooks on any brackets.

1.2.2. Generation #2—(1980)

Hooks were added to all canine brackets (Figure 2) (Romano, 1998).



Figure 2 Generation #2—1980. Hooks were added to all canine brackets.

1.2.3. Generation #3—(1981)

Hooks were added to all anterior and premolar brackets. The first molar had a bracket with an internal hook. The second molar had a terminal sheath without a hook but had a terminal recess for elastic traction (Figure 3) (**Romano, 1998**).



Figure 3 Generation #3—1981. Hooks were added to all anterior and premolar brackets.

1.2.4. Generation #4—(1982–1984)

This generation saw the 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 (Figure 4) (**Romano, 1998**).



Figure 4 Generation #4— Addition of a low profile anterior inclined plane on the central and lateral incisors. Hooks were optional.

1.2.5. Generation #5—(1985–1986)

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 (Figure 5) (**Romano, 1998**).



Figure 5 Generation #5—1985–86. A transpalatal bar attachment was now available for the first molar bracket.

1.2.6. Generation #6—(1987–1990)

The inclined plane on the maxillary anteriors becomes more square in shape (Figures 6). 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 (**Romano, 1998**).



Figure 6 Generation #6—1987–90. The inclined plane on the maxillary anteriors became more square in shape.

1.2.7. Generation #7—1990 to present

The maxillary anterior inclined plane is now heart-shaped with short hooks. The lower anterior brackets have a larger inclined plane with short hooks. All hooks have 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 (Figures 7) (**Romano, 1998**).



Figure 7 Generation #7—1990–present. The maxillary anterior inclined plane is heart-shaped with short hooks. The lower anterior brackets have a larger inclined plane with short hooks and all hooks have a greater recess/access for ligation.

1.3. Advantages of lingual orthodontics

- A. Aesthetics.
- **B.** No risk to the labial enamel through decalcification.
- **C.** Position of the teeth can be seen more accurately as it is not obscured by the appliance.
- **D.** Some lingual brackets create a bite-plane effect on the upper incisors and canines, making these types of brackets useful for treating deep overbites (**Michelle, 2013**).
- E. More beneficial to patients who play musical instruments by mouth, especially clarinets and saxophones (Grist, 2010).

1.4. Disadvantages

- A. Patients sometimes have difficulties with speech (Grist, 2010; Papageorgiou et al, 2016).
- B. Masticatory difficulties (Michelle, 2013; Papageorgiou et al, 2016).
- **C.** There can be trauma to edges of the tongue (ulceration) Because of their position in the mouth, the pliers and hand instruments that are used to fit and adjust labial appliances would be of little use with lingual appliances. They need to have very fine edges which allow easy access to the brackets and give a less restricted view in the mouth. Impression materials are usually rubber based and models are cast in stone or a hard material (**Grist, 2010**).
- D. More technically demanding for the operator, which increases them Chair-time and therefore the cost of this approach (Michelle, 2013).
- E. Operator proficiency in indirect bonding is required and rebonding failed brackets can be difficult (Michelle, 2013).
- F. More difficult to clean (Michelle, 2013; Ata-Ali et al, 2015).
- **G.** Initial alignment can be more challenging in more crowded cases due to reduced interbracket span (**Michelle, 2013**).
- H. Increased bracket loss (Michelle, 2013).
- I. Decreased intermolar width (Papageorgiou et al, 2016)

1.5. Main differences between labial and lingual techniques:

1.5.1. Anatomic Variations of the Lingual Tooth Surfaces

The labial surface of an upper central incisor always follows a similar pattern, but its lingual surface shows marked morphologic variations among individuals. Even a small height (vertical) deviation in the position of the brackets results in a marked effect on the third-order prescription.



Figure 8 A slightly different positioning height of the bracket has only a small impact on torque (2 degrees) with a labial appliance. On the lingual aspect, the same height difference results in a major torque difference (22 degrees).

1.5.2. First-Order Compensations

While looking at an ideal dental arch from the occlusal view, the labial surfaces of the teeth can be found along a regular arch line. On the lingual side, the teeth exhibit a pattern where surfaces are irregular. To develop an efficient lingual appliance, these differences in thickness occurring among teeth have to be compensated for with a laboratory process. There are three main strategies to compensate for these differences:

1- Compensation with first-order customized archwires that level out the tooth thickness differences.

The customization of the brackets only incorporates the customized programming of the second-order and third-order dimensions, which allows for a comparatively flat profile.

2- Compensation by adjusting the bracket base thickness.

In this strategy, brackets are set up not only with second-order and third-order programming but also with first-order programming. This results in a considerable increase in appliance thickness, which may lead to patient discomfort. Because the brackets incorporate the three-dimensional programming in its entirety, "straight wires" may be used. Although the use of straight wire appliances has been established in labial techniques, it results in considerable disadvantages in the lingual technique for both the patient and the orthodontist because of the markedly thicker brackets. (Graber et al. 2017).

Hohoff et al (2003) reported that thicker appliances cause more patient discomfort and more problems during speaking and eating. Tongue irritation is also observed more frequently when brackets encroach on tongue space.

The interbracket distance becomes even shorter because of the increased bracket thickness. This not only makes inserting the archwires more challenging but also makes complete bonding of all brackets impossible at the start of treatment, even in moderate cases of crowding, because of the brackets' size. When thicker brackets are used, the distance between the center of resistance of the tooth and the point of force application increases, making it more challenging to correct torque problems in the third dimension. The larger and thicker the bracket, the higher the rate of bracket loss because there is more chance of biting and debonding a thicker bracket (**Graber et al. 2017**).

3- Compensation by partial first-order bend of the archwires.

In this case, only the difference in thickness between the canine and the first premolar is compensated with a first-order bend of the archwire. The archwire is straight from canine to canine and from first premolar to second molar. The shape of this archwire setup reminds one of a mushroom, which is why the lingual technique was also called the "mushroom technique" by its pioneers.

1.5.1. Torque Control

Incorrect torque control results in a completely different effect in a labial bracket versus a lingual bracket . Two upper central incisors are depicted, one of which exhibits an ideal position; the other one displays a torque problem of -10 degrees. When a labial appliance is used, the effect of 10 degrees of torque discrepancy will be unnoticed by the patient, and only a very detail-oriented orthodontist could recognize the problem. When a lingual appliance is used, an incorrect torque of -10 degrees

directly causes a visible malposition in the vertical plane, and the tooth appears extruded. This is even more severe as the distance between the tooth surface and the archwire increases, which is the standard situation when using a lingual straight wire approach with thicker brackets; vertical discrepancies are easily detected by the patient (**Graber et al., 2017**).



Figure 9 A, Different tooth thicknesses are compensated by first-order archwire bends. B, The archwire is straight. C, Mushroom arch form. D, Superposition of the three types of archwires.

Torque ideal Torque -10°



Figure 10 Effect of incorrect torque (-10 degrees) on the vertical position of the incisor edge of an upper central incisor. A, With a labial appliance, only 0.2 mm of vertical discrepancy an be noticed. B, The same incorrect torque creates an increased vertical discrepancy (0.7 mm) even if a very flat lingual appliance is used. C, Thicker lingual appliances (e.g., lingual straight wire appliances) are not only much more uncomfortable for the patient; they are also much more prone to third-order problems.

1.5.2. Exposure of Bonding Area

Most orthodontic patients are children and adolescents. Within this age group, the bonding area of the lingual surface can be reduced, especially in teeth that have just erupted. This is true, particularly for the upper and lower second molars and the lower premolars. Bonding conventional lingual appliances is therefore difficult or impossible in this age group. This is one of the main reasons why in the past, lingual treatment has been provided only to adults. For this reasons alignment and leveling are different in lingual orthodontics.

1.5.3. Efficient leveling and aligning with lingual appliances

The leveling and aligning stage presents important differences between common labial and lingual approaches. Labial appliances allow bonding of all brackets from the start of treatment in most cases. This is not often the case for lingual systems, where in the mandibular arch braces have to be bonded in a multistage process depending on the inserted system. Because of both the repeated performance of bracket bonding sessions and the more complex task this represents for the preparatory step of gaining space for the respective individual teeth and attachments, this multistage bonding process is associated with a considerable additional investment in treatment time (Graber et el, 2017).

1.5.3.1. Aligning Type 1

Aligning type 1 is used when all brackets can be bonded from the start of treatment (**Graber et el, 2017**).



Figure 11 Aligning type1

1.5.3.2. Aligning Type 2

Aligning type 2 is indicated when there are brackets that cannot be bonded because of insufficient surface exposed (**Graber et el, 2017**).



Figure 12 Aligning Type 2

1.5.3.3. Aligning Type 3

Aligning type 3 is defined by a clinical situation when the dental surface is not exposed at all, typically when the tooth is impacted or deviated out of arch form (Graber et el, 2017).



Figure 13 Aligning type 3

1.6. INDICATIONS and contra indications:

Gupta and Thukral (2015) identified the indications for lingual appliances as follows:

- 1. Deep bite cases
- 2. Class I with mild crowding
- 3. Class I with generalized spacing
- 4. Arch expansion
- 5. Diastema closure
- 6. Class II with retruded mandible
- 7. Class I bimaxillary protrusion all first bicuspid extraction, where in anchorage is not critical
- 8. Class II only upper bicuspid extraction

- 9. Surgical cases
- 10. class III cases

While they listed contraindications as follows:

- 1. Acute Temporo mandibular joint dysfunction
- 2. Mutilated posterior occlusions
- 3. High angle / dolichofacial patterns
- 4. Extensive anterior prosthesis
- 5. Short clinical crowns
- 6. Critical anchorage cases
- 7. Poor oral hygiene or unresolved periodontal involvement
- 8. Unadaptable or demanding personality types.

1.7. <u>Situations where lingual appliances are more effective</u> than labial appliances

There are four distinct situations exist where lingual appliances may be more effective than labial appliances because of their unique mechanical characteristics. These include:

- 1. Intrusion of anterior teeth.
- 2. Maxillary arch expansion.
- 3. Combining mandibular repositioning therapy with orthodontic movements.
- 4. Distalization of maxillary molars (Romano. 1998).

1.7.1. Intrusion of Anterior Teeth

The biomechanics of lingual techniques differ considerably from labial biomechanics. Both arch circumference and inter bracket distance are reduced, requiring lighter force application for tooth movement.

Lingual bracket position, which is dictated by the morphology of the lingual surface of the tooth, places the bracket closer to the center of resistance of the tooth than is found with labial bracket placement (Figure 14).10 An important clinical implication of this unique bracket position and design is that the intrusive force vector is directed through the center of resistance of the tooth (**Romano, 1998**).



Figure 14. The center of resistance of the tooth is located closer to the lingual bracket



Figure 15 Occlusal view of the mandibular arch, just after the partial lingual bonding; the molars were banded afterwards)

As the mandibular anterior dentition occluded with the anterior horizontal plane of the maxillary anterior brackets, a bite plane effect results. Since the appliance is bonded, the bite plane is always present. The net effect appears to be a light, continuous, intrusive force. In addition to these active intrusive forces on the anterior dentition, a passive extrusion occurs in the posterior segments. Deep-bite correction through this passive increase in posterior vertical dimension and active decrease in anterior vertical dimension occurs quickly and easily.

Malocclusions requiring open-bite correction obviously would not benefit from this technique. To prevent the passive extrusion of the posterior segments in these patients, acrylic posterior overlays are used (**Romano, 1998**).

1.7.2. Maxillary Arch Expansion

With some kinds of malocclusions we are occasionally faced with the need to expand the upper arch both transversally and sagittally. It is not yet totally clear why but, clinically, we obtain more remarkable dento-alveolar expansions through lingual mechanics than through labial mechanics, some possible reasons are:

1. The force which is developed is of a centrifugal type, from the inside towards the outside of the arch. The same occurs with the Quad-Helix and the Rapid Palatal Expansion (RPE) devices.

2. Some authors point out that the thickness of the brackets, which interpose themselves between the tongue and the lingual wall of the teeth, can contribute to this expansive effect.

3. It is even likely that the shorter interbracket distance may play a significant role in this effect. In fact, by using this method, not only is the expansive effect so evident but also the teeth do not become too labially tipped. The tooth movement probably takes place without incurring a significant labial inclination because the application point of the force is more palatal than the center of resistance of the tooth (**Romano, 1998**).



Figure 16 (Left) The upper arch (occlusal view), just after placing the first superelastic Twist-Flex type archwire. (right) Four months later, notice the amount of the transverse and sagittal expansion

1.7.3. Combining Mandibular Repositioning Therapy with Orthodontic Movements

When patients have temporomandibular dysfunction (TMD), it is often necessary to treat in two distinct clinical phases. The initial phase of treatment addresses the TMD and associated pain symptoms. It is often accomplished with splint therapy until the muscle and joint symptoms resolve. Depending on the practitioner, the patient is then maintained, symptom free for a period of time from several months to more than a year. The second clinical phase of treatment addresses changes in the occlusion as a result of the new mandibular position. It generally involves orthodontics, prosthodontics, and/or orthognatic surgery. The orthodontic phase of treatment is often tedious and time consuming. Often, labial appliances are placed on one arch, and a positioning splint is kept on the opposing arch to maintain the maxillomandibular relationship. This is then reversed with appliances placed on the opposite arch and a splint fabricated for the opposing arch obviously, treatment times can be significantly extended (**Romano, 1998**).



Figure 17 Left intraoral view during the last phases of the Class II mechanics

1.7.4. Distalization of Maxillary Molars

Lingual brackets are placed closer to the center of rotation (CR) of the tooth than labial brackets. It is possible that molar distalization through lingual techniques produce more bodily movement of the tooth and less distal tipping. Because of the angulation of the multiple roots of maxillary molars, the center of resistance is found just lingual to the average long axis of the roots (**Romano, 1998**).

1.8. Problem associated with lingual appliance

The following is a summary listing of some of the difficulties encountered during the development of lingual orthodontic therapy and the current solutions:

1.8.1. Tissue Irritation and Speech Difficulties

The earlier brackets placed on the lingual surface of the teeth were irritating to the tongue and impeded normal speech. The current generation of brackets has been (Figure 18). Initially, anterior brackets had long gingival hooks responsible for calculus build-up. Lingual orthodontics redesigned with smooth exterior surfaces and a low profile. The increased comfort allows normal tongue activity, hence speech is not affected significantly (**Romano, 1998**).

1.8.2. Gingival Impingement

Earlier generations of the lingual appliance had a broad bonding base extending towards the gingival margin (Figure 18). Access for adequate oral hygiene and the self-cleansing nature of the oral cavity were compromised. Brackets have been redesigned to be more self-cleansing. The base now extends incisally and mesiodistally, providing adequate bond strength, yet retaining hygienic qualities. The mandibular anterior teeth are particularly vulnerable to calculus accumulation due to their close proximity to the submandibular salivary glands. These brackets have 1.5 to 2 mm clearance between the base and the gingival margin. Additionally, the bracket hooks have been redesigned with a lower profile and are located several millimeters from the gingival margin (Figures 19) (Romano, 1998).



Figure 18 Initially, anterior brackets had long gingival hooks responsible for calculus build-up.

1.8.3. Occlusal Interference

A predominant problem with the original appliance was the effect of the shearing forces on the brackets, particularly in the maxillary anterior dentition. (In the absence of a cross-bite, the lingual aspect of the mandibular dentition is generally not in direct contact with the maxillary dentition; therefore, the shearing forces were not a problem. Likewise, the relatively high maxillary crown height and low mandibular cusp height in the posterior segments allow adequate clearance to avoid the severe shearing forces seen in the maxillary anterior region.) The bracket was redesigned with an inclined or bite plane strategically placed to redirect the vertical shearing forces to a horizontal seating force (Figure 19). The location of the inclined plane is such that when a 1 mm overjet and overbite relationship is obtained; all mandibular anterior contact with the inclined plane is eliminated. To avoid deleterious effects caused by tooth contact with the archwire, the inclined plane is located incisal to the slot. Patient tolerance of the bite plane effect of the inclined plane has been favorable

(Romano, 1998).



Figure 19 The incline plane. The red arrows represent the primary force applied, and the broken black lines represent the secondary/resultant forces exerted

1.8.4. Appliance Control

Since the introduction of lingual therapy, control has been a concern. To allow better control of tooth movements, the appliance was fabricated in high tensile metal which provides a greater degree of accuracy. First and second molar bands were manufactured, allowing control from both the buccal and lingual sides of the posterior segments. An initial treatment approach joined the buccal and lingual attachment when the wire was engaged. This coupling was thought to prevent vertical and horizontal rotation of the buccal segments (Figure 20). Clinically, however, this coupling proved to be unnecessary because one full arch wire from 7-7 was able to offer much more stability. Currently, transpalatal bars are used for additional stability. They can be attached to either the first or second molar (**Romano. 1998**).



Figure 20 Locking of the molars to the lingual attachment was thought to give greater appliance control.

1.8.5. Base Pad Adaptation

As with all appliances, accurate contour of base pads improves not only retentive capabilities but also the accuracy of bracket placement and therefore the quality of treatment. Topographic maps were constructed for each tooth and individual bracket base curvatures were calculated (**Romano, 1998**).

1.8.6. Appliance Placement and Bonding

The original appliances were direct bonded. With the variability of lingual tooth contours, accurate bracket placement was difficult. This approach produced unpredictable tooth alignment with tremendous variations in tip, torque, and tooth height. Initially, the Torque Angulation Referencing Guide (TARG) system was used.

The TARG instrument was designed to place brackets on the lingual surfaces using conventional landmarks as references. Although substantial improvements were made in the accuracy and efficiency of bonding, the system was still inadequate. A more sophisticated system, using a diagnostic set-up constructed from articulated models was developed and has met with considerable success.

This method, the Custom Lingual Appliance Set-Up Service (CLASS), involves indirect bonding set-up on a diagnostic or ideal model of the teeth. The brackets are then transferred back to the original malocclusion, and transfer trays prepared (**Romano, 1998**).

1.8.7. Appliance Prescription

In the early 1970s, Dr. Lawrence Andrews developed and patented a fully programmed orthodontic appliance, which he introduced as the Straight Wire Appliance. This philosophy involves programming all the elements necessary to achieve an optimal occlusion into each bracket.

The initial lingual appliance used a custom-modified labial appliance bonded to the lingual surface. Tip and torque angulations were not ideal. A similar philosophy was used to design the Kurz Lingual Appliance. A site was selected on the lingual surface of each tooth. It was consecutively transferred from the lingual first molar, as high as it could go, without missing the rounded lingual anatomy.

Reciprocal tip and torque values to Andrew's published values were used to establish the prescription. There was no grand procedure used in obtaining the reciprocal lingual reference of angles with regard to Andrew's published values.

It was a simple matter of mathematically milling a hundred molds to a constant labial vertical.

The in-out values varied dramatically between the anterior and posterior segments. To adjust for this with bracket design alone would make the anterior z brackets thicker than is reasonable, so a true straight wire was not feasible. A first

order bend was placed at the junctions of the canine and premolar, and the premolar and molar. These wires could be prefabricated in the laboratory (**Romano, 1998**).

1.8.8. Wire Placement

Access for the placement of wires in the molar tubes from the lingual was limited. Tubes were redesigned by widening the mesial aperture of the slot of the first molar bracket, creating a funnel effect (Figure 21) (**Romano, 1998**).



Figure 21 Widening of the mesial aperture to provide ease of wire insertion.

1.8.9. Ligation

To permit stable ligation with ligature wires or elastics, ligature locking grooves that are both deep set and easy to hook have been designed. When teeth are crowded and slot engagement is especially difficult, a vertical slot is provided so the archwire can be attached to the bracket even through the initial stages of leveling and aligning (Figure 22). A double over-tie with metal is used when a tooth is to be an attachment for anchorage or rotation of the other teeth (**Romano, 1998**).



Figure 22 Frontal view of the lingual bracket designed for the maxillary

1.8.10. Attachments

A gingival hook is an integral part of the bracket and provides rotational control. The original hook was large and in close proximity to the gingival margin, impeding access for hygiene. This hook was redesigned with a lower profile and moved away from the gingival margin (**Romano, 1998**).

1.9. Bonding in lingual orthodontic appliance

Among the challenges of lingual orthodontic treatment is the management and handling of the appliance. This is because the clinician cannot directly see the lingual surfaces of the teeth and the morphology of the lingual surface of teeth not only varies among individuals but also presents several features including the cingulum in anterior teeth, marginal ridges, linguoincisol edge, and lingual grooves. Thus it can be difficult to place lingual brackets precisely. For these reasons, indirect bonding systems have become invaluable in lingual orthodontics Lingual orthodontics a new approach using STB light lingual system & lingual straight wire (**Romano, 1998**).

1.9.1. Indirect Bonding

Indirect method is highly recommended due to the great difference in the palatal and lingual tooth anatomy. It must be easy to make, permit accurate bonding, have control of the possible failures, easy to rebond when it is necessary, and have high precision and reduced cost. The first step is to clean the enamel surface using a pumice paste with a rubber cup or a polishing brush (Figure 23) (**Harfi et al, 2015**).



Figure 23 A low-speed handpiece with a cleansing brush is recommended

The second step is to rinse with water to remove any pumice paste and to dry thoroughly with oil-free air. Cheek, lip, and tongue retractors are very helpful to maintain a completely dry field during all the bonding process (Figure 24) (**Harfi et al, 2015**).



Figure 24 Cheek, lip, and tongue retractors

Thirty-seven percent phosphoric acid gel for about 30" is used for enamel conditioning. Acid gel provides more control on the surface to be etched. Since the enamel surface must not be contaminated with saliva, a wet gauze to remove the acid gel is recommended (Figure 25) (**Harfi et al, 2015**).



Figure 25 after the placement of 37 % phosphoric acid gel

Then the enamel surface has to be dried very carefully until it acquires a frosty white appearance. In almost all patients, no micro-etching is necessary (Figure 26) (Harfi et al, 2015).



Figure 26 A dry air syringe is useful to obtain a frosty enamel surface

After this, a small amount of primer is applied to the tooth and to the bracket base at the same time. Light-curing primer with filling microparticles is highly recommendable in order to diminish enamel decalcifications or carious lesions under the brackets (Figure 27) (**Harfi et al, 2015**).



Figure 27 Light-cure bonding agent adhesive in place

It is important that all the excess adhesive is carefully removed to improve oral hygiene and less gingival inflammation or decalcification around the bracket. It is preferred to start transferring individual caps from the last molar to midline avoiding unnecessary contamination risks (Figure 28) (**Grist, 2010**).



Figure 28 Easy method to remove the individual transfer cap

The cap can be easily removed with a thin dental explorer instrument from occlusal to gingival (Figure.29) (**Grist, 2010**).



Figure 29 Molar transferring cap in place

1.10. <u>The incognito lingual appliance</u>

Lingual orthodontics has advanced to a highly sophisticated level where CAD/CAM (computer-aided design/computer-aided manufacture) technology is employed to manufacture both the brackets and arch wires for each patient



Figure 30 Contemporary upper lingual appliance and Contemporary lower lingual appliance.

individually in the incognito appliance system. The incognito lingual appliance system is used to treat both teenagers and adults. It can be used in combination with functional appliances like the Herbst appliance, and 'bite jumpers' like the Forsus appliance (**Buckly et al, 2012**).

It can be used without difficulty in the management of orthodontic patients who require orthognathic surgery. Fabrication of the incognito lingual appliance Bracket fabrication Two-phase polyvinyl siloxane impressions are taken to produce accurate models of the patient's teeth (Figure 31). The plaster models are used to prepare an individualized therapeutic target set-up that is created by cutting between the teeth and setting them up to the desired target position in wax (**Buckly et al, 2012**).



Figure 31 Two-phase polyvinyl siloxane impressions are taken to produce accurate models of the patient's teeth.

The target set-up is constructed from the plaster teeth set-up to the desired position in wax. A high-resolution optical 3D scanner permits non-contact scanning of the therapeutic target set-up. The scan produces a three-dimensional digital representation of the teeth consisting of many thousands of minute triangles that can be documented and processed in the computer (Figure 32). Specialized CAD/CAM

software is used to design and build customized brackets and bases (Figure 33). Because of the extreme accuracy of the scan, the bases mould precisely to the teeth (Figure 34) (**Buckly et al, 2012**).

Large pad surfaces provide greater bond strength and make them easy to place on the teeth for bonding and re-bonding. Wax patterns of the virtual customized brackets are created using rapid prototyping wax printers (Figure 35). The patterns are then placed in an investment cast, burned out and a dental gold alloy is poured into the cast to create the brackets (Figure 36). After casting, the brackets are tumbled and polished until they are smooth to ensure high patient comfort. They are then positioned on the original malocclusion model (Figure 37) (**Buckly et al, 2012**).



Figure 32 3D digital representation of a tooth from the target setup. arch.



Figure 33 The virtual brackets conform exactly to the individual patient's dental morphology.



Figure 34 The virtual brackets are now a reality in wax (wax patterns) prior to casting.



Figure 35 Complete set of virtual brackets constructed for an individual's maxillary



Figure 36 The final brackets after investment casting, The polished gold brackets are placed on the original malocclusion model.

The brackets are transferred to the patient's mouth using an indirect bonding technique. This involves constructing an indirect bonding tray, which contains the brackets (Figure 37). (Buckly et al, 2012).



Figure 37 An indirect bonding tray containing the brackets. (The fitting surfaces of the lingual brackets are a dark color due to the application of bonding materials.)

This is constructed over the brackets, which are set up on the original malocclusion model. All the brackets in one tray are bonded simultaneously to the palatal surfaces of the teeth in one arch using the acid etch bonding technique. It takes approximately three to six weeks from the time of impression taking until the finished appliance is delivered to the practitioner. The laboratory costs for the incognito appliance are significant (**Buckly et al, 2012**).

1.10.1. Problems

According to Buckley et al (2012), the incognito appliance has largely overcome the three main problems originally associated with the lingual orthodontics technique, namely:

1. Patient difficulties during the adaptation stage.

2. Difficulties with exact rebonding in the event of bracket loss.

3. Exact finishing.

1.10.1.1. Patient difficulties during the adaptation stage

During the initial adaptation stage, immediately after the appliances are fitted, patients may experience three main problems speech disturbances, irritation of the tongue and, masticatory difficulties (Fillion, 1997).

Most patients report a decline in these symptoms in the first two to four weeks of treatment, though a few are affected for a longer period (**Fritz et el, 2002; Hohoff et el, 2003**).

At the initial consultation, it is important to explain to patients about these three potential problems and to explain that there is an adaptation phase.

In general, in adults only one arch is bonded initially (normally the lower) and then the other arch is bonded a few weeks later when the patient has had a chance to adapt. Once patients are aware that there is an adaptation phase this provides reassurance during the period immediately after the appliances have been fitted.

In general, with teenagers both arches are bonded at the same time, as they adapt very quickly to the appliances. The incognito lingual bracket system uses custommade brackets, which are much thinner than the conventional brackets used in previous lingual orthodontic appliances (**Buckly et al, 2012**).

The lower profile of the incognito brackets causes significantly less severe symptoms during the adaptation phase, and shortens the period of adaptation (Figure 38) (Wiechmann, 2002; Hohoff et el, 2004).



Figure 38 Comparison of a conventional lingual bracket (left) with incognito bracket (right) shows a pronounced difference in size.

1.10.1.2. Difficulties with exact rebonding in the event of bracket loss

The debond rate of the incognito lingual bracket is very low and comparable to labial appliances. The extensive individualized base of the incognito lingual bracket, which covers much of the tooth surface (significantly more than for a labial bracket on the same tooth), allows each bracket to be directly bonded. This means that a bracket can be directly rebonded accurately without the additional support of positioning aids such as small silicone trays. The fact that the base of the bracket is made to precisely fit the lingual surface of the tooth results in a positive lock when the bracket is pressed onto the tooth; this greatly facilitates accurate repositioning of the debonded bracket.

In addition, where the teeth have less pronounced morphology, as found in particular on the lingual surfaces of the lower incisors, accurate rebonding of the lingual brackets is facilitated by means of 'screen shots' (Figure 39) from the manufacturing process, which are routinely supplied with each case (**Buckly et al**, **2012**)



Figure 39 Screenshots of the 3D representation of the positioned brackets from various angles (as above) serve as an additional rebonding aid.

1.10.1.3. Exact finishing

Wiechmann et el (2003) stated that with lingual appliance, finishing and detailing of the occlusion was a major problem. Three factors originally contributed to problems in the finishing phase of lingual orthodontic treatment:

- 1. Inaccurate bracket positioning (Buckly et al, 2012).
- 2. Inaccurate arch wire fabrication (Rummel et el, 1999).
- 3. Inaccurate fit between brackets and arch wires (torque play) (Buckly et al, 2012).

Inaccurate bracket positioning

The virtual production of the brackets on the computer almost completely eliminates errors in the actual production of the bracket bases. By using the extended bases (positive lock) and the screen shots, positioning the brackets on the individual teeth is relatively easy, with little room for error. Inaccurate arch wire fabrication all of the arch wires in the incognito system are produced with CAD/CAM technology; because of this, inaccurate arch wire fabrication is of minor significance.

This has helped to simplify finishing with lingual orthodontics. Inaccurate fit between brackets and arch wires (torque play) Torque play in lingual orthodontics contributed to substantial difficulty in finishing cases in the past.

This is because before the development of the incognito appliance, the arch wires used tended to be smaller and the slots noticeably larger than the given values these two factors alone contributed to significant torque play. Incorrect torque will affect the vertical position of the incisal edges of the teeth (Figure 40) (**Buckly et al**, **2012**).



Figure 40 : Incorrect torque will cause vertical discrepancies in the position of the incisal edges.

It was shown that a 10-degree discrepancy in torque will cause a vertical discrepancy of 1.2mm in the incisal edge.20 The incognito bracket is manufactured to a much higher degree of accuracy than other available lingual brackets (**Demling et el.2009, Kebert et el.2012**).

The combined effect of accurate bracket slot production and proximity of the bracket slot to the labial surface of the tooth means that the incognito appliance has largely overcome the problems traditionally associated with torque when finishing lingual orthodontic cases (Wiechmann.2002).

Mistakidis et al (2015) found that by comparing the occlusal outcome and treatment duration between lingual (Incognito) and labial appliances there is no significant difference.

Conclusions

- Lingual orthodontic appliances are effective in the treatment of malocclusion, and they represent a good choice for adults where esthetics is a major concern, especially when cost is not a matter.
- 2) With the development of customized lingual appliances much of the problems associated with the previous lingual appliances were overcome.

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