

Invisible Orthodontics -A Review

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Abstract: Man has been determined for generations to improve his outlook, his appearance- the aesthetic value. Appearance does count at any age. The face and the teeth have also come to play a part in his presentation to the outside world. To enhance this desire, attention has been given to correct malformations of teeth. In earlier times this was done by crude methods. And then evolved the concept of braces; fixed on the labial surfaces. Esthetic requirements repels adult patient from accepting traditional metallic look orthodontic appliance. Tooth colored brackets and wires gained popularity for a few decades but gradually declined owing to its own disadvantages. Orthodontists have given a new dimension by shifting from the labial to the lingual so as to give rise to the concept of Invisible braces or Lingual Orthodontics. Then they have come with the clear thermoplastic aligner trays, customized to individual orthodontic needs.

Keywords: Clear Aligner, Esthetic Brackets, Esthetic Wire, Invisible Orthodontics, Lingual Orthodontics

I. Introduction

Dental and facial esthetics is considered a new paradigm in diagnosis and planning for orthodontic treatment [1]. Patient demands for esthetic orthodontic treatment outcomes have grown to include esthetic appliances during treatment. Efforts have been made to increase the esthetic quality of orthodontic appliances.

Bands with attachments evolved into bondable brackets. Bondable brackets were produced in ceramic and plastic. Coated, tooth colored wires that more closely resemble natural tooth color can be used during part of the treatment period. Although less visible, lingual orthodontic appliances have some popularity. More recently, plastic trays were developed to gradually align the teeth. Although these trays are less visible, there appear to be limits to the types of malocclusion that they can efficiently correct [2,3,4].

Ziuchkovski et al [5] examined appliance attractiveness and found a hierarchy of appliance types: alternative appliances (clear trays and lingual appliances) were found most acceptable followed by ceramic appliances; all stainless steel and self-ligating appliances, with a few differences in each type of appliance. Furthermore, acceptability of appliances can also be determined by attractiveness, esthetic, comfort, economic value to the patient. This concept was explored by Parekh et al [6] when evaluating smiles and attractiveness.

II. Esthetic Brackets

As the number of adults seeking orthodontic care increased, orthodontists felt the need to provide their patients with more esthetically appealing appliances. This perceived need motivated manufacturers to provide acceptable esthetic brackets. The material that Orthodontists selected for esthetic brackets was Ceramic as the Dentists are familiar with its resemblance to dental enamel.

2.1 Ceramic Brackets

After their introduction in 1986, various types of ceramic brackets are currently available by all major orthodontic manufacturers [7,8], thus gaining widespread popularity and becoming an integral part of the clinician[9].

All currently available ceramic brackets are composed of aluminum oxide. However, because of their distinct differences during fabrication, there are two types of ceramic brackets, namely, the polycrystalline alumina and the single crystal alumina [7-13]. The manufacturing process plays a very important role in the clinical performance of the ceramic brackets [14].

Because production of polycrystalline brackets is less complicated, these brackets are more readily available at present [10]. The most apparent difference between polycrystalline and single crystal brackets is in their optical clarity. Single crystal brackets are noticeably clearer than polycrystalline brackets, which tend to be translucent. Fortunately, both single crystal and polycrystalline brackets resist staining and discoloration [10-15].

Ceramic brackets come in a variety of edgewise structures including true Siamese, semi-Siamese, solid, and Lewis/Lang designs. Many brackets are made by specialized ceramic manufacturers and are sold under proprietary names by manufacturers or distributors of orthodontic products.

2.1.1 Advantages

- Esthetics
- Tooth colored material
- Acceptance by patient

2.1.2 Disadvantages

- Ceramic brackets have a higher incidence of fracture during debonding, particularly with the conventional debonding techniques.
- Ceramic brackets are unable to withstand strong torsional forces, especially after the bracket surface has been nicked during treatment.
- Enamel wear occurs if ceramic brackets contact opposing tooth surfaces. Therefore, placement of ceramic brackets is contraindicated on the lower anterior teeth in cases with deep overbite and minimal overjet. In such cases, sufficient overjet has to be created before bonding the lower incisors. Similarly, during maxillary incisor retraction, the overbite should be reduced first so that the maxillary incisors do not contact the mandibular ceramic brackets.
- Ceramic brackets can cause nicks in the arch wires, resulting in more friction between the bracket and the arch wire. This can decrease the efficiency of tooth movement.
- The use of ceramic brackets in patients who will undergo orthognathic surgery should be discouraged. The fracture of the brackets before, during, or after surgery creates the potential for undesirable and avoidable complications.

III. Esthetic Wires

At the beginning esthetic production, there were transparent brackets made of ceramic or composite but the archwires were still made of metals such as titanium molybdenum alloy, nickel titanium, or stainless steel. Recently, coated metallic and fiber-reinforced wires have been introduced to solve esthetic appearance problem [16].

Fiber-reinforced wires are experimental and not universally commercial available, there are good expectations from them for the future [17]. Coated esthetic wires are the only esthetic archwire available for usage. Materials used for coating are plastic resins such as epoxy resin or synthetic resin [18]. Teflon coating improves esthetics but has some disadvantages. But there are controversial studies in the literature. When the frictional manner of coated archwires was compared with non-coated archwires by the same manufacturer, coating was found to have an effect in decreasing friction. In contrast, a similar study described coating as undurable [19]. Elayyan F et al [20] found that, when coated, the colored wires are damaged from mastication forces and enzyme activities in the oral cavity [2]. Lim KF et al. encountered difficulties with these coated archwires, expressing that the color tends to change with time and the coating splits during usage in the oral cavity, exposing the underlying metal [21].

Surface topography including reflecting light images and scanning electron micrographs revealed delimitations, discolorations, ditching, and cracking in most cases when used approximately 5 weeks in the mouth. By the help of quantitative analysis, it was detected that 25% of the coating was lost, exposing the metallic surface below. The loss of surface coatings led to significant reduction of the esthetic quality. The coating peeled off in many areas during in vivo usage [5]. Irregular surfaces might lead to plaque accumulation and tooth movement might be affected due to entrapment of brackets inside these defects [22].

IV. Lingual Orthodontics

With invent of lingual appliances an entirely new treatment biomechanics emerged. Orthodontists are also determined towards this goal and have given a new dimension by changing from the labial to the lingual so as to give rise to a new concept the Invisible Braces concept or Lingual Orthodontics[23-25]. Due to increasing social awareness and esthetic demands of young patients , the application of lingual orthodontics today is not only restricted to adults, but has been extended to adolescents as well[26-29].

4.1 Advantages [25-27,30-32]

- Facial surfaces of the teeth are not damaged.
- Facial gingival tissues are not adversely affected.
- The position of the teeth can be more precisely seen.

- Facial contours can be truly visualized as the contour and drape of the lips are not distorted by protruding labial appliances.
- Most adult and many young patients would prefer invisible lingual appliances if costs, treatment times, and results are comparable to those of labial appliance treatment.

4.2 Indications

Lingual orthodontics is indicated in cases like Low Angle Deep bite, Diastema, Class I minor crowding, Class II upper bicuspid extractions, 4-Bicuspid extractions, Posterior cross bite, High angle, Open Bite as well as in surgical cases[25-27,30-32].

Recent advances in Lingual Orthodontics have made it possible to treat almost all orthodontic problems with lingual technique, However there are some limitations due to contraindications mentioned below [33].

4.3 Contraindications

Lingual orthodontics is contraindicated in cases with Very short clinical crown, Severe Periodontal disease and Severe TMD [27,33].

4.4 Patient Selection

Lingual orthodontics is demanding on both the patient and the orthodontist. So the patient must be made aware that it will require greater effort and chair time [34]. The most important factors in selecting patients for lingual treatment seem to be their personalities and reasons for seeking treatment. The patient should be informed of the rationale and the effects of lingual appliance, speech, soreness, bite opening and told that their attitude should be one of understanding and a desire to do whatever is necessary to accomplish the optimum results [35].

4.5 Bracket Design

To compensate for the tooth form and shape seen on the lingual aspect, some considerations in bracket design need to be followed: [26-29,36]

- Inter bracket distance is reduced on the lingual, so the bracket must be designed to be as narrow as possible.
- Because of decreased bracket width, mesio-distal root control becomes difficult which can be taken care of using vertical slots for auxiliaries.
- The lingual contours of teeth vary a lot, so the amount of torque supplied by the bracket is very sensitive to its occluso-gingival placement. This can be solved by indirect bonding procedures with pre-angulated pre-torqued brackets.
- Consideration should be given to the ease of insertion, ligation and removal of t/he arch wires.

Eventually the method selected for the determination of lingual bracket torques and thickness was to relate the lingual determinants to labial tooth anatomy. Tracings of the labial and lingual profiles were made and a line was drawn through the LA point (FA point), representing the plane to the arch wire, to define labial torque. Lingual equivalent torque values were then calculated studied statistically and reduced to set of average lingual torque values. Similar studies were conducted to define lingual pad profile and contours, lingual molar bracket torques, rotations, base curvatures and in-out relationships.

4.6 Bracket Placement

There are many variations in tooth size, lingual contour, cingulum and marginal ridge anatomy, inconsistencies in tooth form, shape and inclination of the lingual surface make the use of predetermined bracket placement of no much utility. Smith et al [31] suggested the use of indirect bonding by TARG (torque and angulation reference guide). The TARG instrumentation is designed to transfer bracket prescriptions from the more reliable labial surfaces of each tooth to the lingual at a given bracket height. This allows to set customized torque and angulation for each tooth [32,37].

4.7 Arch Wires

There is a dramatic difference in the arch form with lingual treatment. Fujita [38-39] described the Mushroom Arch as necessary in lingual treatment because of the difference in faciolingual thickness of anterior and posterior teeth; also there is a large constriction in arch width as one proceeds distally from the lingual surface of canine to the bicuspid. Since the brackets are designed to minimize bracket profiles, it is necessary to place compensating 1st order bends interproximally at cuspid-bicuspid and bicuspid-molar regions.

4.8 Bonding

For bonding of lingual brackets, the preferred mode of placement is indirect because: [31-32,36-37]

- The variation in lingual tooth morphology creates the need for custom measurement for selection of appropriate bracket base thickness and torque.
- The clinician's lack of familiarity with lingual tooth morphology makes it difficult to visualize angulations and bracket heights.
- It is difficult to obtain a direct line of sight for bonding.
- Increased accuracy in bracket placement is required because compensating lingual arch wire bends are more difficult and time consuming to form.

A modified dental surveyor and TARG (torque and angulation reference guide) are used to align the lingual surfaces relative to the labial crown inclinations. Once the bracket slot height and angulation are marked, indirect bonding of the brackets on the lingual is done.

4.9 New Straight Wire Technique

Takemoto and Scuzzo developed the lingual straight-wire technique in 1995 [41] Mushroom shaped arch wires require inset bends and vertical steps between canines and premolars thus requiring complicated wire bending [38].

A new STb light lingual system was introduced in 2009 which is narrower mesiodistally, which increases the interbracket distance and thus reduces both the force transmitted by the arch wire and resistance to sliding mechanics. The thinner bracket pad, the bracket slots are much closer to the lingual tooth surfaces, further increasing the interbracket distance [42].

The new gingival-offset slot position reduces in-out thickness, enhancing patient comfort and avoiding occlusal trauma from the opposing teeth. New lingual straight wire appliance uses a planar arch form to make arch coordination less difficult and simpler mechanics, such as sliding techniques [42]. It eliminates the need for inset bends between canines and first premolars.

The Kommon base, developed by Komori in 2008, is the latest indirect-bonding method for lingual orthodontics. In this system, an anatomical extension of the resin pad between the bracket base and tooth surface allows customization of the lingual brackets. Using a glass-ionomer cement for bonding not only permits working in wet conditions without etching, but also allows direct transfer of the brackets to the teeth without the need for a tray [42].

With proper attention being given to setup, accurate bracket positioning and indirect bonding technique, straight wire technique will not only save chair side time but will also enhance patient comfort.

4.10 Self Ligation in Lingual Orthodontics

Self ligation in lingual orthodontics was first described by Macchiet al [43] in 2002 the Philippe Self Ligating Lingual Brackets that can be bonded directly to the lingual tooth surfaces. Self ligation in lingual orthodontics has come with interactive lingual brackets. It has a non-locking rotating clip resulting in unique flexibility. It comes with a self-ligating clip flexes like an elastomeric ligature and therefore responds to the actual malocclusion without losing force, which reduces binding and prevents notching especially with highly rotated teeth. The Evolution SLT Smart cap is a unique indirect bonding system based on the principles of the HIRO system. It offers the practitioner the benefits of bonding each tooth individually, offering at the same time the speed of a full bonding tray [44].

Another precise Lingual Self ligating system comes as Inovation L by GAC which is an interactive, twin, self-ligating lingual bracket system [45]. Only an interactive bracket provides full functionality throughout the course of treatment.

Passive function is achieved with a round Sentalloy NiTi wire that slides freely for efficient leveling and alignment. This is created with the light seating of a BioForce wire into the base of the slot so programming may be expressed and rotations are corrected. Active function with full control is provided by the introduction of a full-size Resolve Beta-Ti wire, enabling full expression of the bracket's torque and achievement of the desired result.

Dentaurum has come up with the World's first Nickel free Lingual Brackets called Magic. Due to the magic bracket's unique geometrical form, arch wires can be inserted occlusally. The innovative combination of occlusal and horizontal slot directions enables the arch wire to be automatically pressed into the slot[46].

4.11 Customisation in Lingual Orthodontics

It was first described by Wiechmann et al in 2003 [47]. Conventional manufacturing processes cannot completely eliminate the problems associated with Lingual appliance system; instead complete individualization of all appliance components is needed. The processes of bracket fabrication and optimized positioning of the fabricated brackets on the tooth, which are normally quite separate, are fused into 1 unit. Each tooth has its own

customized bracket, made with state-of-the-art CAD/CAM software coupled with high-end, rapid prototyping techniques [47].

This computer-generated appliance uses three dimensional (3D) computer scanning to ensure efficiency of tooth movement by designing brackets and bonding pads specifically for each individual tooth with the bracket slot in the most advantageous position on the lingual surface of the dentition [48]. Brackets are printed using a stereo lithography apparatus and then cast in gold bracket bases are drafted, tie-wings and hooks are adjusted and brackets are assembled on the base in the optimal position. A series of archwires is then created by a wire-bending robot to achieve the orthodontist's treatment goals. Bending archwires by hand would be difficult and reduce the efficiency of this appliance [48]. The customized brackets and robotically bent wires are engineered to work together to deliver the targeted result through a high-quality appliance system.

V. Clear Aligners

Orthodontic treatment is mainly surrounded with metals like wires and brackets. This esthetic compromise repels adult orthodontic patient from accepting treatment. Tooth colored brackets and wires tried to overcome these limitations but could not proved to be good option to metals because of its bulk, and cost. In last few decades lingual orthodontics has gained worldwide popularity in terms of esthetics but its widespread use is restricted because of complexity in bracket positioning, treatment mechanics, limited access to the lingual / palatal surface and cost. In addition, bracket bonding procedure endangers the precious enamel to chemical insult, making it unaesthetic and susceptible to microbial attack. So, clear aligners have emerged as a promising option for adult orthodontic patients [33,49,50].

Clear Aligner Therapy is an orthodontic treatment modality in which the patient wears a series of customized clear, removable aligners that gradually moves the teeth to a desired position. The total number of aligners varies depending on severity of malocclusion. Clear aligners do have some limitations and inconveniences. The benefits of Clear Aligner Therapy generally outweigh the drawbacks [51].

Clear aligner treatment falls into two basic categories. The first category consists of those thermoformed appliances, sometimes known as Essix Retainers, that are fabricated by making adjustments to the tooth positions on plaster or stone models and fabricating one or more aligners to correct a minor malocclusion [52]. These types of appliances are sometimes fabricated in the orthodontist's office or sometimes sent out to commercial laboratories. These types of in-office prepared aligner systems have been in use since around 1994[52]. Invisalign[53] is a proprietary orthodontic technique that uses a series of computer generated custom plastic aligners to gradually guide the teeth into proper alignment.

5.1 Transient Problems with Clear Appliances [51-54]

- It may initially irritate oral mucosa and tongue causing soreness.
- A temporary alteration of speech, with slight lisping.
- These immediate discomforts are transient and vanish within a few days, as the patient gets accustomed to the appliance.

5.2 Indications [51-54]

- Ideal for minor crowding (less than 4mm), In cases of crowding, interproximal reduction may be required to create enough space to allow teeth movement.
- Rotation control, intrusion, and extrusion are better controlled by placing tooth colored attachments on the labial and lingual surfaces.
- Open bite, deep bite, cross bite and mild to moderate expansion can also be corrected satisfactorily using clear aligners.
- The aligners can also be used simultaneously for tooth bleaching, if a bleaching gel is placed inside the tray.
- Clear aligners can also be used as active and passive retainers.

5.3 Contraindication [51-54]

- Extraction cases
- Tip control
- Torque control
- Moderate to severe open and deep bite cases

5.4 Advantages [51-54]

- Crystal clear aligners remain unnoticed while wearing.
- The transparent look and option to remove the appliance enhances the cosmetic value of the appliance.
- Less chair side time.

- There are no cuts or abrasions from wires or brackets like with traditional braces.
- The aligner trays are fabricated with soft medical grade polymers and therefore comfortable.
- The patient can remove the appliance while eating and brushing, and therefore can maintain a good oral hygiene.

5.5 Potential Limitations [51-54]

- Patient cooperation is utmost important for the success of treatment and a desired treatment result.
- A short clinical crown can cause problems with aligner retention, affecting stability of the appliance and tooth movement.
- Large edentulous space and sharp cusps may become cause of frequent appliance breakage.
- White spots lesions, tooth decay, gingival inflammation and periodontal breakdown may occur if proper oral hygiene protocol is not followed.
- Missed appointments, not wearing aligners the required number of hours per day, and broken appliances can prolong the treatment duration.
- Allergic reactions to the material used during treatment may occur.
- Teeth may supra-erupt if not covered by the aligner.
- Being removable appliances should be avoided in medically challenged and uncooperative patients to prevent accidental swallowing or aspirating the aligner.

VI. Conclusion

Thorough efforts, methodological approach, and vast experience gained over the years has proved that this specialty of orthodontics has the answer to the ever increasing cosmetic demands of the patients who insist on appliances which are not seen to the outside world and at the same time want to get their malocclusion treated. Today, the main goal is to achieve facial balance, and the development of orthodontic treatment is the balance between esthetical treatment, functionality and a patient's aspirations. Esthetic aspirations are now universal and involve younger patients including both male and female adolescents. In this regard, invisible orthodontics, which is highly esthetic play a fundamental part in achieving dental alignment. A smile revealing esthetic harmony is very important at any age as difficult as that of adolescence. Invisible orthodontics thus represents the best solution for meeting the needs of the patients without the risk of damaging functional efficiency.

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