

Lingual orthodontics: an illustrated review with the incognito fully customised appliance

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Introduction

One of the major challenges in orthodontics is to achieve an excellent result with appliances that are both aesthetic and comfortable. There is currently enormous interest in so-called 'invisible orthodontics'; this has been contributed to by the intensive marketing campaigns run by the manufacturers of various removable clear aligner systems. However, the available research tells us that the mean accuracy of tooth movement with Invisalign is only 41%.¹ Aligner systems, because of their inherent biomechanical limitations, can only accomplish certain types of tooth movement. Their role is therefore limited to the correction of specific malocclusions.

In this article the author will describe how lingual orthodontics has evolved and how many of the problems originally associated with the lingual technique have been minimised. The manufacture of one type of fully customised lingual appliance, namely the 'incognito appliance', will be described, and the lingual technique will be illustrated with two treated cases.

Lingual orthodontics

Lingual orthodontics as we understand it today (a full multi-bracket appliance, e.g., **Figures 1** and **2**) began in the 1970s. A Japanese orthodontist, Dr Kinja Fujita,² developed the appliance, not primarily for aesthetic reasons but rather to protect the soft tissues (lips and cheeks) of his orthodontic patients who practised martial arts. Independently, in the USA, Dr Craven Kurz worked to develop a lingual appliance at this time.^{3,4} 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.

There has been an enormous resurgence of interest in lingual orthodontics in the last ten years. This can be accounted for by two factors: the invention of the incognito lingual appliance; and, the increase in the number of adults seeking orthodontic treatment. This appliance has now been used worldwide to treat over 30,000 cases. It has succeeded in minimising the traditional problems associated with lingual orthodontics. Recent research would suggest that it is an effective appliance, which can achieve the objectives of the orthodontic treatment plan.⁵

Orthodontic treatment should not be commenced, or indeed continued, in the presence of inadequate oral hygiene, or when the patient has unsatisfactory dietary habits. However, decalcification remains a significant risk in labial orthodontics.^{6,7} Lingual orthodontics has the advantage that split mouth studies have shown that the incidence of decalcification is one-quarter of that associated with labial orthodontics, and when decalcification does occur it is one-tenth as severe as the decalcification seen in labial orthodontics.⁸ In addition, the decalcification is not of aesthetic importance, as it is on the lingual surface of the teeth. The reduced risk of decalcification is a significant advantage when treating teenagers, although, of course, the practitioner must endeavour to ensure that excellent oral hygiene and dietary habits are maintained throughout the course of orthodontic treatment.

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FIGURE 1: Contemporary upper lingual appliance.



FIGURE 2: Contemporary lower lingual appliance.



FIGURES 3a and 3b: Two-phase polyvinyl siloxane impressions are taken to produce accurate models of the patient's teeth. (Figures 3-12 inclusive courtesy of 3M Unitek; Monrovia, California, USA).

The incognito lingual appliance

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 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. 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 3). The plaster models are used to prepare an individualised therapeutic target set-up that is created by cutting between the teeth and setting them up to the desired target position in wax.

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 4).

Specialised CAD/CAM software is used to design and build customised brackets and bases (Figure 5). Because of the extreme accuracy of the scan, the bases mould precisely to the teeth (Figure 6). 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 customised brackets are created using rapid prototyping wax printers (Figure 7). 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 8). 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 9).

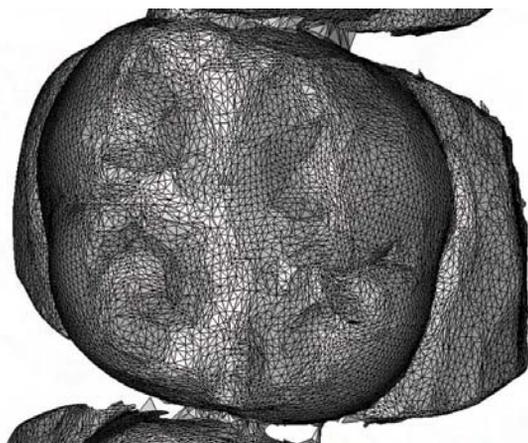


FIGURE 4: 3D digital representation of a tooth from the target set-up.

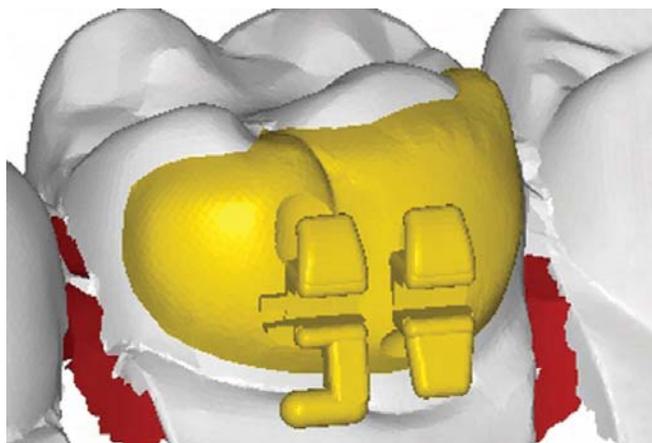


FIGURE 5: The virtual brackets conform exactly to the individual patient's dental morphology.



FIGURE 6: Complete set of virtual brackets constructed for an individual's maxillary arch.



FIGURE 7: The virtual brackets are now a reality in wax (wax patterns) prior to casting.



FIGURE 8: The final brackets after investment casting.



FIGURE 9: The polished gold brackets are placed on the original malocclusion model.



FIGURE 10: An indirect bonding tray containing the brackets. (The fitting surfaces of the lingual brackets are a dark colour due to the application of bonding materials.)

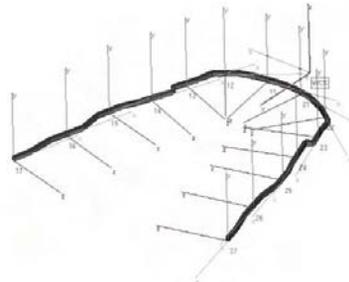


FIGURE 11: Computer-designed wire to match the target set-up.



FIGURE 12: Robot bending the arch wire to patient's individual prescription.



FIGURE 13: Comparison of a conventional lingual bracket (left) with an incognito bracket (right) shows a pronounced difference in size. (Figure courtesy of Dr D Wiechmann, Bad Essen, Germany.)



FIGURE 15: Incorrect torque will cause vertical discrepancies in the position of the incisal edges. (Figure courtesy of Dr D Wiechmann, Bad Essen, Germany.)

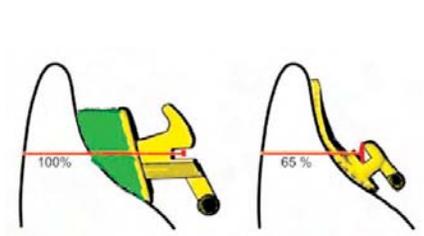


FIGURE 16: In the incognito bracket system (right), because the arch wire is closer to the labial surface of the tooth, an incorrect torque will have a lesser effect, especially on the vertical dimension.⁸ (Figure courtesy of Dr D Wiechmann, Bad Essen, Germany.)

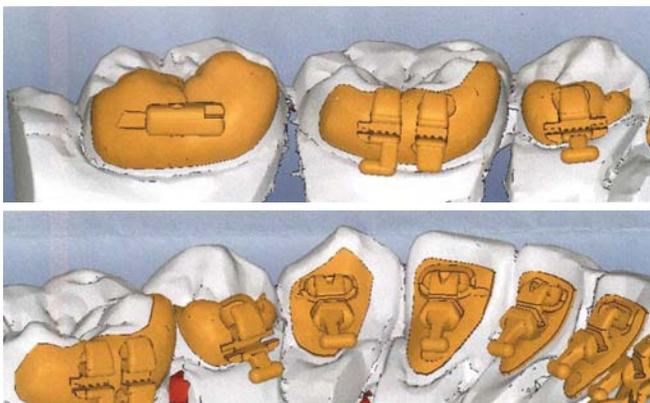


FIGURE 14: Screen shots of the 3D representation of the positioned brackets from various angles (as above) serves as an additional rebonding aid.

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 10). This is constructed over the brackets, which are set up on the original malocclusion model, as in Figure 9. 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, as in Figures 1 and 2.

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, with a standard upper and lower fixed appliance costing the practitioner approximately €2,000.

Wire fabrication

The wire geometry is calculated by the CAD/CAM program (Figure 11) and then sent to a machine for fabrication (Figure 12). Each wire in the sequence has the same geometry targeted to the final position of the teeth.

Problems

Originally, there were three main problems associated with the lingual orthodontics technique:

1. Patient difficulties during the adaptation stage.
2. Difficulties with exact rebonding in the event of bracket loss.
3. Exact finishing.⁹

The incognito appliance has largely overcome these problems.

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.¹⁰ 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.¹¹⁻¹³ 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 custom-made brackets, which are much thinner than the conventional brackets used in previous lingual orthodontic appliances. The lower profile of the incognito brackets causes significantly less severe symptoms during the adaptation phase, and shortens the period of adaptation (Figure 13).^{9,14}

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.¹⁵ The extensive individualised 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 14) from the manufacturing process, which are routinely supplied with each case.

Exact finishing

Before the development of the incognito lingual appliance, finishing and detailing of the occlusion was a major problem in lingual orthodontics. Three factors originally contributed to problems in the finishing phase of lingual orthodontic treatment:¹⁶

1. Inaccurate bracket positioning.
2. Inaccurate arch wire fabrication.¹⁷
3. Inaccurate fit between brackets and arch wires (torque play).

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 (Figure 14), 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.^{18,19}

Incorrect torque will affect the vertical position of the incisal edges of the teeth (Figure 15). Stamm *et al.* have 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.^{18,19}

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 (Figure 16).⁹

Examples of patients treated with the incognito appliance:

Patient 1

A 20-year-old male presented with a mild Class II Division II type malocclusion. He was treated with an upper and lower incognito appliance and class II intermaxillary elastics (Figures 17-20).

Patient 2

A 43-year-old female with a Class II Division I malocclusion. She was treated with the extraction of the upper left first premolar and upper and lower incognito lingual appliances (Figures 21-24).

Conclusion

Lingual orthodontics has evolved progressively since the 1970s. Technological developments mean that lingual orthodontics is now far more acceptable to the patient, as discomfort and interference with speech and mastication have been minimised. Although lingual orthodontics is more difficult than labial orthodontics to perform, it can achieve a high standard of orthodontic result comparable to labial orthodontics when properly applied.⁵ It is, like labial orthodontics, dependent on patient compliance. The laboratory costs associated with the production of the incognito appliance are high, although it is likely that with increasing competition from other orthodontic manufacturers, the cost of appliances will be reduced in the future.

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FIGURE 17: Patient 1 pre treatment.



FIGURE 18: Patient 1 in treatment.



FIGURE 19: Patient 1 post treatment.



FIGURE 20: Patient 1 – original target set-up used to make the patient's incognito appliance. The post-treatment result achieved is very similar to the target set-up.



FIGURE 21: Patient 2 pre treatment.



FIGURE 22: Patient 2 in treatment.



FIGURE 23: Patient 2 post treatment.



FIGURE 24: Patient 2 – original target set-up used to make the patient's incognito appliance. The post-treatment result achieved is very similar to the target set-up.

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