The Bracketless Fixed Orthodontics: nine years of clinical experimentation

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The Bracketless Fixed Orthodontics (BFO) is an innovative appliance made up of wires and resin. It comes from the observation of the instable position of frontal teeth still bonded to a fixed retainer and from a period of nine year of clinical experimentation on a way to preactivate a wire to obtain a wished dental movements without brackets. For this historical reasons the first experimental name was: Preactivated Retainers.
It can be used to levelling teeth, as in case of relapse, or to remove the brackets before the end of the therapy. But it can be used also in more complicated clinical cases in patient that never have been treated with orthodontic therapy, alone or associated to other appliances.
In this article are showed only some exemplificative clinical cases. The resolution of crowded teeth, the torque correction and the closing diastema.
This appliance applied whether on the buccal aspect or on the lingual aspect of the teeth offers different advantages, as it guarantees a good control of the dental movement, also in the root movement, does not interfere in patients' phonetics and does not interfere in oral hygiene.
Since don't exist neither precise references, like brackets, nor a codified therapeutic sequence the best results could be achieved accurately applying the principles of biomechanics described by Burstone and Melsen in their segmented approach.

Musilli M. The Bracketless Fixed Orthodontics: nine years of clinical experimentation. Prog Orthod 2008;9(1):72-91.

Introduction

Retainers are widespread appliances to maintain stability after orthodontic therapies in the long-term period[1-3]. Many studies have demonstrated the necessity to use retainers for several years after orthodontic treatments, whether the treatment was accomplished with or without tooth extractions[4,5].
Retainers offer different advantages as they guarantee optimal teeth stability. These include: they do not interfere in patients' phonetics[6], they are not visible, only a little more accurate oral hygiene is required, as well as a follow-up every 6/12 months[7-10]. These advantages[11] justify the wide diffusion retainers have had.
Several[12-22] articles have described the clinical procedures of modelling and applying retainers as well as the management of chairside emergencies.

Different authors have suggested differing materials, such as wires and composite resins[23-27].

Although the standard procedures of modelling and bonding passive retainers has been correctly performed, the clinical follow-up for a whole period of 7 to 10 years of patients wearing post-orthodontic retainers showed movement of some teeth still bonded. Such movements were evident in short-term (i.e. 4-5 months) as well as in long-term periods (i.e. 4-6 years) after the retainers had been bonded. On the basis of my clinical experience, several hypotheses could be formulated to explain such phenomenon, such as the following:

- activation of bent retainers due to chewing of hard food;
- memory effect of wires;
- untwisting of wires;
- elastic deformation of wires during bonding (probably due to a non-passive fit to the lingual aspect of teeth).

Whatever the cause, movements of teeth bonded to previously passive retainers may happen. Consequently, I formulated a few questions:

- Is it possible to model an active wire bonded like a retainer on the lingual aspect of crowded teeth to achieve controlled and predictable movements?
- Is it possible to preactivate those wires according to current biomechanical statements[28-30] in order to increase the effectiveness and predictability of induced dental movements?
- If so, which kind of malocclusion can we successfully treat using those kind of preactivated e bonded wires?

To answer these questions, in the late 1998 I started a clinical experimentation with the Bracketless Fixed Orthodontics (BFO). These wires were modelled to passively fit on the lingual aspect of the teeth and then preactived before to be bonded. For this reason, the first time it was named: Preactivated Retainer. However, as time passed, I decided to change the name. Although the term retainer could be useful to image the device, both the terms together were in clear contrast.

I started from easy situations, such as the closure of small diastema, to complicated clinical cases, such as root movements.

Showing some clinical cases, the present study aims at explaining which kind of dental movements are achievable using BFO. Furthermore, we will analyse activation procedures, treatment time, chairside appointments time, the

L'ortodonzia fissa senza attacchi (BFO) è una terapia innovativa realizzata con un dispositivo costituito da fili ortodontici e resina composita. L'idea nasce sia dall'osservazione di modifiche dell'allineamento post terapia ortodontica dei denti anteriori, verificatesi nonostante la presenza di un retainer ben adeso, che da una sperimentazione clinica di nove anni circa la possibilità di pre attivare gli stessi fili ortodontici in modo da ottenere i movimenti dentari desiderati senza l'uso degli attacchi. Per questo motivo storico il primo nome provvisorio è stato quello di Retiners Preattivati. Questo dispositivo può essere usato per allineare i denti in caso di recidiva ortodontica oppure per finalizzare i pazienti in corso di terapia standard, rimuovendo anzitempo gli attacchi. Inoltre può essere usato in modo assoluto in situazioni cliniche più complesse, in pazienti non trattati precedentemente con terapie ortodontiche, oppure in associazione con altri dispositivi. In questo articolo sono presentati alcuni casi esemplificativi: la risoluzione di un affollamento, la correzione di una alterazione del torque e la chiusura di diastemi. Questo dispositivo, sia che venga applicato sulla superficie vestibolare che sulla superficie linguale dei denti, offre diversi vantaggi, come un buon controllo del movimento dentario (anche nel movimento radicolare), non interferisce con la fonetica e con l'igiene orale del paziente. Dal momento che non esiste alcun riferimento preciso, come potrebbero essere gli attacchi, oppure una sequenza terapeutica ben codificata, un buon risultato può essere ottenuto soltanto applicando i principi di biomeccanica descritti da Burstone e Melsen nel loro approccio segmentato.

Key words: Bracketless therapy, biomechanics, Preactivated retainers

materials to be used, and the therapeutic strategies and their biomechanical concepts.

Materials and Methods

The adopted composite is a flowable resin characterized by an optimal adhesion and optimal adaptability to both the dental surfaces and the wire; so that the clinician does not have to change its position before polymerization. Nowadays, several different flowable composites are available on the market but the clinical choice should be made on the basis of fluidity. If the composite is too flowable, it is prone to flow away (i.e.: into the gingival sulcus) before the clinician is ready to start with the polymerization. On the contrary, if the flowable composite is too dense, it does not easily flow, obliging the operator to spread down the composite, while he is keeping the wire in situ.

The adopted wires are the most common wires used in orthodontics: twisted stainless steel, **β**-titanium, Ni-Ti and stainless steel wires. The choice of the wire and its section should be made on the basis of the movement to be performed. The most frequently used wire is a 0.0175 inch twisted stainless steel wire made up of five threads. Due to the good mouldability and the proper Load/Deflection ratio, such wire is optimal to achieve alignment and/or levelling. The possibility of shaping loops allows the clinician to easily manage the opening and closing of spaces, derotations, as well as little intrusions/extrusions. Due to the low Load/ Deflection ratio, preactivations by means of V-shaped bends and/or steps allow to exert loads in between the range of forces controlled by the occlusion, in order to achieve difficult asymmetric movements. Finally, the composite strongly grips the wire which is very difficult to obtain when wire/bracket systems are used, as in other kinds of mechanics.

A 0.016x0.022 inch **β**-titanium wire was used to create uprighting and torque springs as well as levers, which were bonded directly on the teeth. A 0.014, 0.016 or 0.018 inch. round Ni-Ti wire was chosen to accomplish little levelling movements, or sliding mechanics, due to its lower mouldability. Stainless steel wires were used to stabilize previously aligned regions or to overlay other wires. Moreover, such wires were chosen to improve the natural anchorage, or to create dental segment, where we can apply class and/or vertical elastic bands. A 0.195 inch twisted steel wire made up of three threads was usually

Le orthodontie fixe sans brackets, Bracketless Fixed Orthodontics (BFO) (BFO) est un appareil innovateur composé des fils et de la résine. Elle vient de l'observation de la position instable des dents frontales toujours collées sur un reatiner fixe et d'une période de neuf ans d'expérimentation clinique sur un chemin sur preactiver un fil et obtenir les mouvements dentaires souhaités sans brackets. Pour ces raisons historiques le premier nom expérimental étaient: Preactivated Retainer Il peut être employé à niveler des dents, comme en cas de rechute, ou enlever les brackets avant la fin de la thérapie. Mais il peut être employé également dans la clinique plus compliquée de cas qui ont été traités avec la thérapie orthodontique, seulement ou jamais pas associés à d'autres appareils. Dans cet article sont montrés seulement quelques formes cliniques exemplificative. La résolution des dents encombrés, la correction du torque et la fermeture du diastema. Cet appareil est appliqué si sur la surface buccale ou linguale et offre des avantages: offre une bonne commande du mouvement dentaire, aussi dans le mouvement de racine, n'interfère pas en phonétique des patients et n'interfère pas dans l'hygiène orale. Puisque n'existent ni des références précises, comme des brackets, ni des ordres thérapeutiques codifiés, les meilleurs résultats pourraient être réalisés exactement appliquant les principes de la biomécanique décrits par Burstone et Melsen dans leur approche segmentée.

Traduit par Maria Giacinta Paolone

used as final constriction retainer after it was softened on fire. Where as it could be used without softening on fire as active wire during the finishing procedures, to change the curve of dental arches, or to modify the frontal inclination of the occlusal plane.
In regard to the methods and the technical approach, the given examples show that the best results could be achieved by accurately applying the principles of biomechanics described by Burstone and Melsen[28-30] in their segmented approach. Nevertheless, the manual ability and the sensitivity of the clinician in catching the patient's sensations are paramount to understand if the system is working correctly and the forces are proper for the occlusion.
Simple rules to be codified do not exist. Rules from the various previously described six geometries, V-bends, step-bends and segmented technique are used. The most effective system of forces to move teeth has to be designed for each patient. The following steps are the choice of the wires, their modelling according to the preactivations and further reactivations needed by each clinical situation, in order not to debond the whole wire at each follow-up.

Los Brackets ortodonticos fijos (BFO) son un sistema innovador conformado por alambres y resina. Proviene de la observación de la inestabilidad de los incisivos después de un tratamiento ortodontico, aunque si estos por un periodo de tiempo hayan sido bloqueados con retenedor fijo. Una experimentación clínica por un período de nueve años han dado la posibilidad de obtener movimientos dentales sin brackets. Por estas razones históricas el primer nombre experimental fue: Preactivated Retainers. Se puede utilizar para nivelar los dientes, en caso de recidivas y también en casos de retirar los brackets antes de terminar el tratamiento. También pueden ser utilizado en casos más complicados o en pacientes que nunca hayan sido tratados ortodonticamente. En este artículo se muestran sólo algunos casos clínicos con apiñamiento, corrección del torque y sierre de diastemas. Este sistema se puede utilizar por vestibular o por lingual ofreciendo diferentes ventajas, ya que garantiza un buen control del movimiento dental y radicular, no crea problemas de tipo fonética y además no interfiere en la higiene oral.
Dado que no existen referencias precisas, como con los brackets , ni una secuencia terapéutica, los mejores resultados se logran con la aplicación de los principios de la biomecánica descritos por Burstone y Melsen con arcos segmentados.

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Clinical Cases

a) General clinical procedures

The Bracketless Fixed Orthodontics (BFO) used in the following cases were modelled to passively fit on the lingual aspect of the teeth and pre-activated before to be bonded (see later in Specific clinical procedure about the preactivations). Oral hygiene was accomplished, oral fluids were isolated and the lingual aspects of mandibular or of maxillary front teeth were etched, following the standard protocol to bond passive retainers. The bonding agent was gently applied on etched surfaces and light cured. The BFO was keep on such surfaces using an utility probe and an amount of flowable composite resin (Filtek Flow, 3M ESPE), enough to cover the wire for at least 1 mm. was applied, being careful not to fill the interproximal spaces. 30 sec polymerization was performed on each tooth. A small amount of composite was added where a void had been left by the tip of the utility instrument.
Possible roughness of the composite was eliminated with a football diamond bur under water irrigation and polished with a silicon rubber, mounted on a low-speed

handpiece.
Next, activation was performed debonding the wire in the areas where the activation was required. The wire was debonded without any damage, just the thinning of the composite by means of a cylindrical diamond bur mounted on a high-speed handpiece under water irrigation first. Then without any irrigation, check the removal of the layers of composite nearest to the wire. The last layer of composite was removed manually using a dental explorer as a lever. After debonding the wire the layer of composite still bonded to the teeth was not removed, in order to bond again, the wire after the new activation without any further application of etchant on enamel. In the mean time, the wire was carefully kept apart from the bur, not to damage it. After cleaning, drying and roughening the composite with a football diamond bur at low speed, without water irrigation to create microporosities required for the bonding procedures; oral fluids were isolated and the activated segments were bonded on the teeth. The bonding agent was applied on the polymerized residual composite and was light cured; an amount of flowable composite resin (Filtek Flow, 3M ESPE) sufficient to cover the wire for at least 1 mm. was applied, being careful not to fill the interproximal spaces .30 sec polymerization was performed on each tooth.

b) Specific clinical procedures

There are two important chapters about the specific clinical procedures:

- one is: How to preactivate the passive shape in order to develop the right force system to move the teeth toward the final position;
- the other one is: How to bond a preactivated wire on crowded teeth and how to keep this wire on the teeth during the bonding steps, because this shape is very different from the lingual aspect of the teeth we want to bond.

Regarding the first topic, we can preactivate the wire from the passive shape by using loops, step bends and "V" bends[29]. The loops help us to give the force we need and to increase/decrease the space between the teeth (if needed) by dental arch form expansion/contraction.
In concern to the second topic, it is very important to bond the wire in a correct way, in order to develop the proper force system. Of course, the final preactivated shape doesn't fit on the teeth, and we can later see inside the single preactivations, on how it's done.

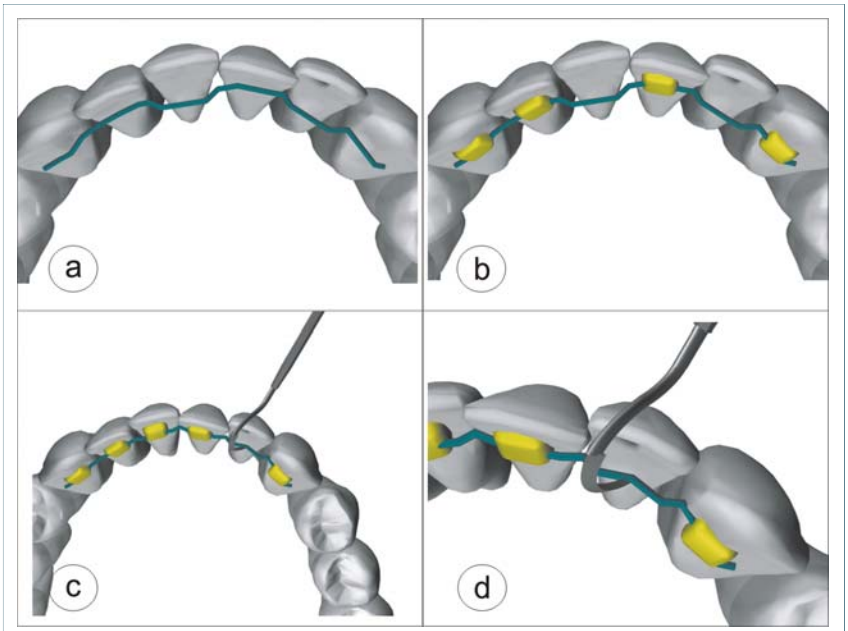

Fig. 1 Horizontal levelling by means of step bends.
a) The wire is modelled to passively fit to the lingual aspect of the teeth and two step bends are added to level.
b) The wire is bonded on the teeth closer to the wire.
c, d) The wire is pushed on the buccal teeth by means of an utility probe before to be bonded.

Step bend for minor alignments

When there is very small crowding (superimposition of the interproximal border until .25 mm) on the frontal teeth and it is required to move the interproximal border of the teeth until 1mm toward the buccal or lingual side. We can use a .0175'' multi strand wire with 5 or 6 strands or NiTi .014'' and then preactivate the wire using small step bends (in and out steps) (Fig. 1).

In this case it is still easy to correctly bond the wire; it is needed to bond with the composite. First the segments of the wire that are closer to the enamel surface (Fig. 1b), then I can push one by one the remaining wire segments toward the teeth by using a utility probe in order to bond them (Figs. 1 c, d).

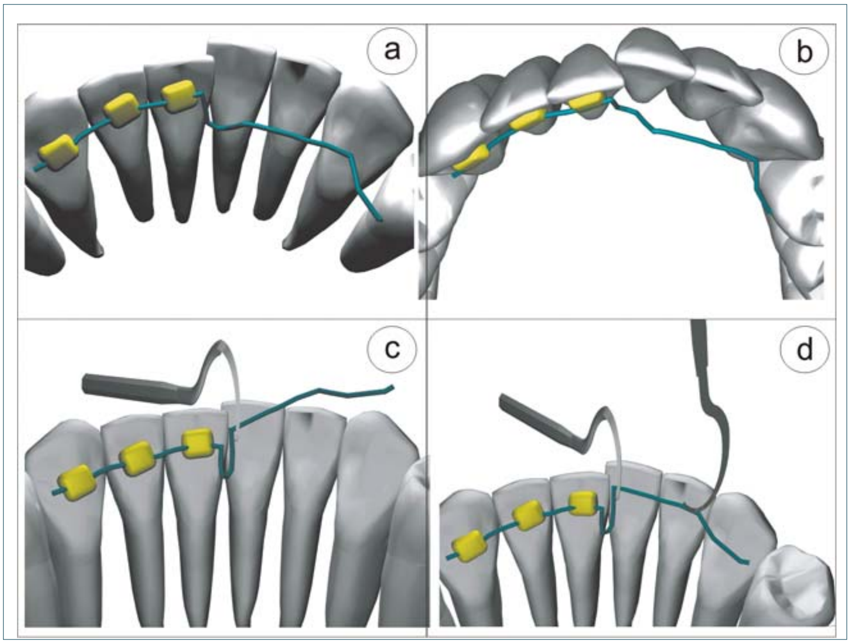

Fig. 2 Horizontal levelling by means of U Loops.
a,b) The wire is modelled to passively fit to the lingual aspect of the teeth and with an U Loop between the crowded teeth, 31 and 41. Then the retainer is preactivated widening such loop and bending this loop so that the horizontal segment to be bonded to mandibular central right incisors was pushed 2.5 mm lingually.
c, d) The U loop is loaded and bonded on tooth 41 by means of a pushing utility probe, keeping the horizontal plane with the use of a dental explorer.

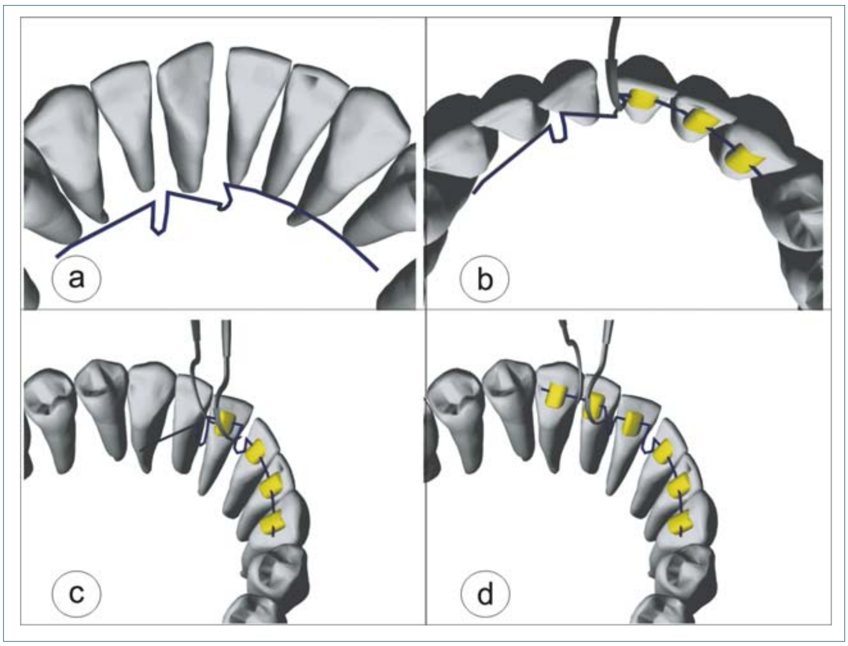

Fig. 3 Closure of diastemata by means of U Loops.
a) The wire (0.0175 inch twisted wire with round section made up of five threads) is modelled to passively fit to the lingual aspect of the teeth and with U Loops at level of the diastemata. To derotate the right lower central incisor the segments of the U loops near this tooth is bent lingually between teeth 31 and 41 and is bent buccally between teeth 31 and 32.
b) The wire is bonded keeping the horizontal plane.
c) The first U loop is opened and bonded by means of an utility probe keeping the horizontal plane with the help of a dental explorer.
d) The second loop is opened and bonded like the first. The elastically return of these opened U loops allows the closure of diastemata.

The sliding mechanics

When there are spaces to close and the teeth without any distortions, an easy sliding mechanic is created Fig. 4).

I realized this by using a round .018'' or rectangular .016" x .022" Stainless Steel wire or .018'' Ni Ti wire, shaped to the individual lingual arch form of the patient, without any evident bend. Before bonding this segment arch onto the teeth, a little bit of dental wax (i.e. Tenatex) is applied to the wire with a hot spatula, to avoid the grip between the composite and the wire during the bonding step (Fig. 4 b). Thus creating a kind of tube with the composite around the wire to allow the sliding mechanic.

In this case it is easy to bond the wire, because the shape fits perfectly to the teeth. Then the bonding step is performed and the activation is done by the elastic chain. The elastic chain is tied to the wire with a ligature wire (Fig. 4 d) to move the teeth along the wire. After the space between two teeth is closed the sliding is blocked with an 8-shaped ligature wire, or create some notches. In the latter case, some notches are done on each tooth with a diamond bur under water irrigation on the composite and the wire (Fig. 5 a). Then these notches are filled with composite (Fig. 5 b). After these procedures I begin closing another space.

"U" loop for major alignments

If the frontal teeth are much more crowded and/or it is needed to move toward the buccal or lingual side more than 2 mm. It is better to use a small vertical loop, such as the "U" loop (Fig. 2). In this way, a step bend is created a with much more wire (the "U" shape) in the region of the step; in order to decrease the load/deflection ratio, resulting in a good activation for a long time (3-4 weeks).

When spaces need to be closed, the same vertical loops can be

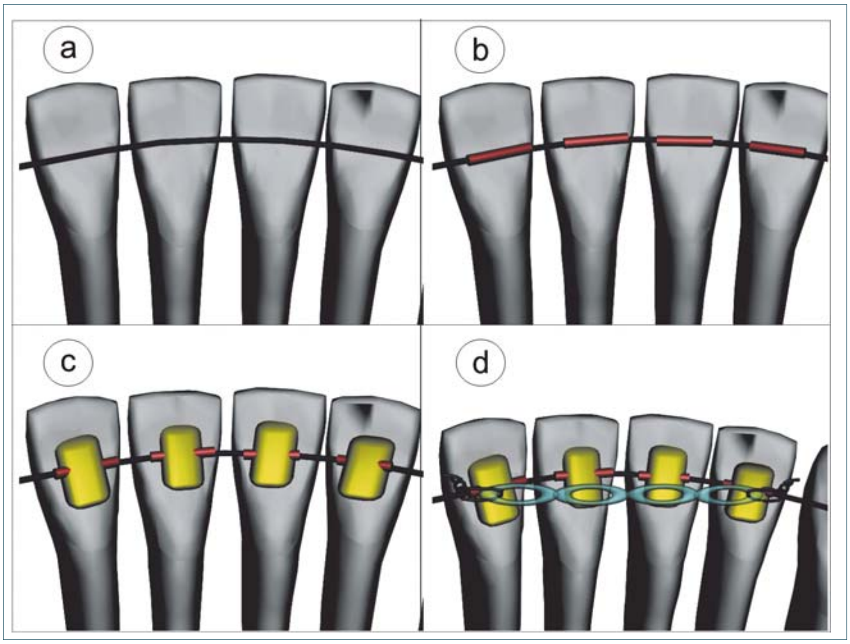

Fig. 4 Closure of diastemata by means of sliding mechanic.
a) The wire (0.016 inch round mouldable Ni-Ti wire) is modelled without shaping any sharp fold that could prevent the sliding, following the curve of the lingual surfaces of front teeth.
b) The wire is covered with a little bit of dental wax to avoid the grip between the composite and the wire.
c) Such procedure allows to create a tubular of composite around the wire to achieve the sliding mechanics.
d) Closure of the diastemata by means of an elastic chain actived with a force of 50 g and tied with ligature wires on both sides.

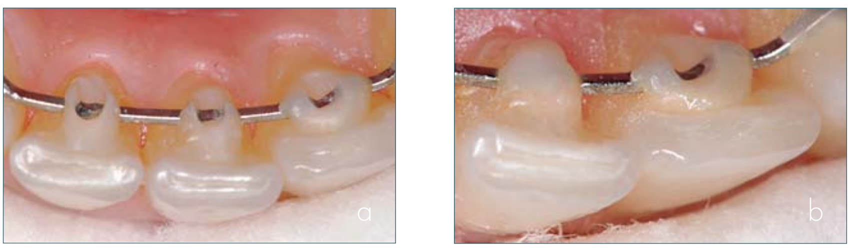

Fig. 5 Notches on wire and resine.
a) To stop the sliding mechanic with a diamond bur under water irrigation were done some notches from the composite until the wire on each teeth.
b) These notches were filled with composite and polimerizated.

used, if there are spaces between the teeth, which are not on a regular dental arch form. In this way I am able to close the spaces and give small derotations to the teeth at the same time (Fig. 3).
Of course, the bonding procedure is much more difficult with "U" loops, because I need to open or close the loops and load in and/or out bend in the same place and at the same time, in an elastic way.
As general rules, in case of crowded teeth, first, I will bond the wire on the teeth that I want less movement from and/or closer to the wire. Then, the bonding of the remaining part of the wire (Fig.1c, d; 3c, d; 6c).
During such procedures much attention is needed to a variety of things.

- To load the preactivated loop and hold on it close to the teeth with an utility probe (Figs. 2c-d; 3c-d).
- To avoid the overturning (fig. 2c) of the remaining part of the wire, by using a second dental explorer.
- To place the flowable composite on enamel (pre treated with the standard bonding liquid) and on the active segment of the wire held on by the utility probe and the dental explorer (Figs. 1d; 2d; 3c,d; 6c).
- To avoid resin flows into the gingival sulcus and on the loops.
- To be careful not to fill the interproximal spaces with the resin.

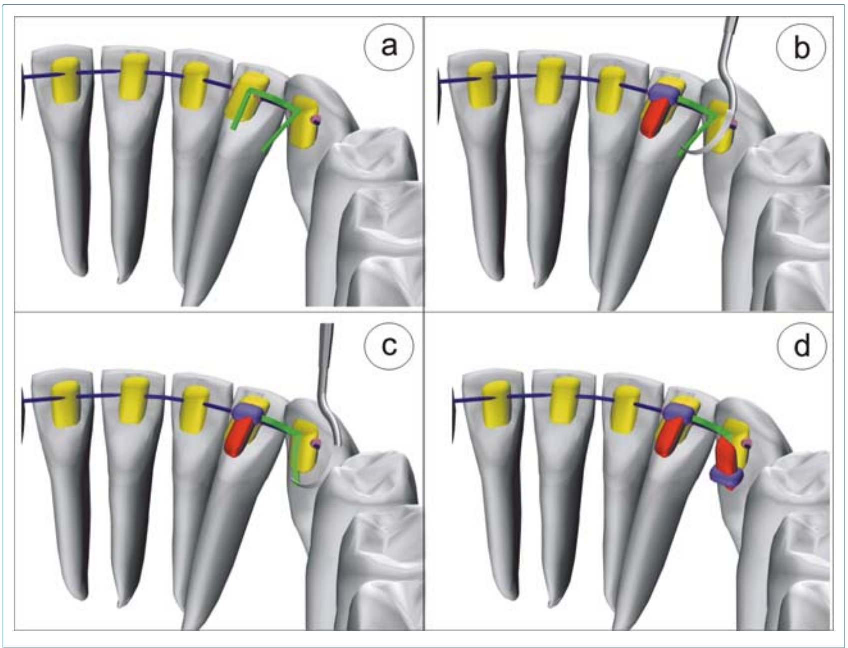

Fig. 6 Correction of torque by means of radicular movements.
a) A passive retainer build up by a round wire is bonded on the tooth we want to realize the root movement and on the near teeth as anchorage. This wire in the segment that is bonded on the tooth we want to move is covered with a little bit of dental wax to avoid the grip between the composite and the wire because it will work as an hinge system for the torque movement. The TMA spring is preactived with a torsion of about 30° on its horizontal segment.
b) The vertical side of the TMA spring closer to the tooth is bonded, while the horizontal segment goes parallel and closer to the passive retainer. Flowable composite in excess is applied to cover the wire for at least 3 mm, particularly in the most occlusal part of this vertical segment.
c) The other vertical segment is pushed from the apical-lingual direction to the enamel by means of an utility probe.
d) Flowable composite in excess is applied to cover the wire for at least 3 mm, particularly in the most apical part of this vertical segment.

Root movements

When it is necessary to realize a root movement, like a torque or tip movement on a single tooth, a simple mechanic is used: a passive retainer and a **β**-titanium spring (Fig. 6).
The passive retainer is built up by a round wire (Fig. 6a), bonded on the tooth I want to realize the root movement and on the near teeth as anchorage. This wire, the segment that is bonded on the tooth I want to move, is covered with a little bit of dental wax to avoid the grip between the composite and the wire, resulting in a hinge system for the torque movement. For this passive retainer, different kinds of wires can be used: Stainless steel, multi strand or NiTi from .014" to .018" However, it depends on the control of the crown position I want. An elastic wire allows small buccal or lingual movement of the crown.
The active unit is made by **β**-titanium wire .016'' x .022'' (TMA Ormco) modelled with a box sha-

pe. This box is made up of two vertical segments connected by an horizontal segment.
The two vertical segments are modelled to passively fit on the teeth I want to realize the opposite root movement. The horizontal segment is placed close to and parallel to the passive retainer. In addition to the previous passive retainer, this horizontal segment gives the labial-lingual control to the crown of the teeth. This box is preactived with an amount of torque between 25° and 60° (depending on the distance between the teeth involved by the movement). To apply this special torque spring, first, a passive retainer is placed with a small amount of composite where the spring will be placed. Then the vertical side of the spring is bonded closer to the tooth (Fig. 6b), while the horizontal segment is placed parallel and closer to the passive retainer. Additional flowable composite is applied to cover the wire for at least 3 mm, particularly in the most occlusal part of this vertical segment.
Finally, the other vertical segment is pushed to the enamel by means of an utility probe (Fig. 6c). Additional flowable composite is applied to cover the wire for at least 3 mm, particularly in the most apical part of this vertical segment (Fig. 6d).
In fact, the most occlusal part of the first segment and the most apical part of the second segment are the more stressed by the activation of the wire.

As a general consideration, we can summarize that the different kind of wires help us to choose the right load/deflection ratio in order to distinguish the active unit from the passive unit, as is needed. Furthermore, if we don't want the grip between the composite and the wire, we can adapt a small amount of hot wax on the wire out of the mouth before the bonding step.
The most used wire is a 0.0175 inch twisted stainless steel wire made up of five threads. Due to the good mouldability and the proper load/deflection ratio, such wire is optimal to achieve alignment and/or levelling. Nevertheless, in many clinical cases, other kinds of wires are used, such as a 0.014, 0.016 or 0.018 inch round Ni-Ti wire, to accomplish little levelling movements or sliding mechanics. A 0.016x0.022 inch **β**-titanium wire is used to realize torque or tip springs. Stainless steel wires are used to stabilize previously aligned regions. A 0.195 inch twisted steel wire, made up of three threads, is used during the finishing procedure, or if softened on fire, is good as final constriction retainer.

Patient 1

Treatment of crowding by means of expansion of dental arches using U-shaped loops associated to asymmetric intrusion of the frontal group using V-bends.

The patient E.V. presented the following clinical situation to the visual inspection (Figs. 7-13):

- presence of all teeth in good health;
- molar and canine first class on both sides;
- no crowding in the maxillary arch;
- slightly increased OVJ;
- slightly increased OVB related to teeth 32 and 33 (Fig. 9);
- reduced intercanine width and absence of contacts between canines in occlusion (Fig. 7);
- limited crowding of mandibular front teeth (Fig. 12);

Fig. 7 Frontal view and apparently normal OVB.

Fig. 8 OVJ view, slightly increased.

Fig. 9 Frontal view in slight disclusion, vertical disalignment with extrusion of tooth 32.

Fig. 10 Lateral right view, molar and canine first class.

Fig. 11 Lateral left view, molar and canine first class.

Fig. 12 A particular of the occlusal lower view. We can see moderate crowding and reduced intercanine width.

Fig. 13 Intraoral radiograph of the lower frontal teeth at the beginning. Optimal periodontal health with absence of pockets.

Fig. 15 Lingual lower view of the of the preactived retainer bonded at the beginning.

Fig. 14 Occlusal lower view of the preactived retainer bonded at the beginning. A force pulling the mandibular central incisors lingually was created, which would have acted as soon as the opening loops have created a proper space.

- slightly abraded surfaces related to maxillary and mandibular front teeth due to forced mandibular lateral movements on both sides;
- optimal periodontal health (Fig. 13) with absence of pockets.

Requested about his subjective evidences, the patient lamented the following situations:

- no evidence of crowding until 8-9 months ago, as documented by intraoral photographs taken a few years ago while he was a student at the Dental School;
- for about 16 months, due to job changes, he felt more stressed and became bruxist at day and night time, as reported by his relatives and coworkers;
- since crowding increased pushing it lingually, tooth 32 extruded (probably to get occlusal contacts).

Therapy

Lingual therapy by means of BFO was proposed to the patient, in order to expand the mandibular frontal region at level of the intercanine width as well as the contour of incisors (Figs. 14, 15). In order to restore a correct curve to the entire dental arch, the same device would then have been activated to vertically align the frontal teeth.

Procedure

During the first appointment, in which the initial records were achieved, the application and modelling of the active wire lasted almost an hour.
A 0.0175 inch twisted Stainless Steel wire with a round section made up of five threads was used. Such wire was modelled so as to passively fit to the lingual aspects of the mandibular front teeth. Two U-shaped loops with height and width of about 3 mm, respectively, were added (Fig. 15).

The preactivated shape

Before bonding to the lingual surface of the mandibular front teeth, the wire was preactivated by widening such loops to about 1.5 mm each. Such a procedure was accomplished by keeping the horizontal plane of the wire in order to apply an expanding force on this sector of the dental arch, particularly at the level of the interproximal spaces between the central and lateral incisors. To begin levelling such elements, two step bends of about 1 mm were created between teeth 32 and 33 and between teeth 31 and 41, respectively.

The beginning bonding step

First, the activated wire was bonded to the lingual aspects of teeth 32 and 33. The wire in this zone was preactivated with a V bend placed in between teeth 32 and 33 in order to give a small derotation. A step bend had been added to facilitate the derotation of tooth 32 itself. During the bonding procedure, in order to accentuate the V bend and to give a small derotation to 32 and 33, the wire was pushed with a tip of the utility probe in the area of the inter proximal space between 32 and 33. Therefore the V bend placed in between those teeth had a shape more evident than it appears in fig. 14. Being that tooth 33 has a greater anchorage it will move less. The wire bonded as such had a length greater than the intercanine distance, because it was preactived widening the U loops. It was extended until the distal surface of tooth 44.
Then, with the help of an utility probe the U loop between teeth

Fig.16 Reduction of the crowding between central and lateral incisors one month later.

41 and 42 was closed until the horizontal segment of the wire was in contact with the lingual aspect of teeth 42 and 43. This segment was bonded on teeth 43 and 42 keeping the horizontal plane with a dental explorer (as shown in the schematic fig. 2d).
Due to the position of the teeth themselves, as well as to the preactivation of the wire, the central unbonded segment of the wire, in correspondence to the lingual aspects of the mandibular central incisors, was 2.5 mm more lingual than the teeth. The unbonded segment was brought near the incisors by means of the tip of an utility probe, pushing the wire towards the interincisive area at the level of the more lingual part of the step bend, so that the wire approached the surface of tooth 31. Besides lingually pulling tooth 31, a force to derotate tooth 41 was exerted by means of the step bend. This elastically preactivated wire was bonded.
The pulling force on the mandibular central incisors will begin movement as soon as the opening loops have created a proper space. At the same time, a side force pushing the lateral incisors labially was introduced in the system; such teeth would likely be the first to move, because the lingual movement of the central incisors is prevented by the impact to the adjacent teeth, as well as by the possible crowding.

First Reactivation

One month later, reduction of the crowding between the central and lateral incisors was noticed, due to the expanding loops which labially moved the lateral incisors and canines. The central incisors were moved lingually by the wire as soon as space was recovered in the dental arch (Fig. 16).
The next activation was performed debonding the wire just from teeth 32 and 33. This second appointment had a duration of fifteen minutes.
A traction was applied on the debonded segment of the wire by means of Weingart's pliers. The force was applied tangentially to the lingual aspect of tooth 32, keeping the plane of the wire. To avoid stress to the tooth and to prevent debonding of the composite during activation, a light pressure was exerted to the composite on tooth 31 by using an utility probe to balance the applied forces. If performed correctly, such a procedure leads to a further widening of the U-shaped loop, which will be used to expand the treated region again, without modifying the occlusal plane of the wire with a V-bend. At this step, the treatment goal is the recovery of space in the dental arch.

Follow-up

After one month, the alignment of the incisors was improved on the occlusal plane, but they were slightly inclined counterclockwise from the frontal point of view. This was likely due to a vertical alignment with predominant extrusion of tooth 32. Moreover, the region of teeth 31, 32 and 33 showed a contour flattening in relation to the contralateral teeth.

Further Reactivations

After 3 months from the beginning of the treatment, and several reactivations of the step bends, good alignment was achieved. During an appointment of 30 minutes, the wire was substituted with a 0.0195 inch twisted wire made up of three threads. Such wire was modelled to passively fit on the lingual aspects of teeth 43, 42, 41 and 31. A V-shaped bend with the top towards the apex was created on the frontal plane at the level of tooth 32. The residual portion of the wire was modelled to passively adapt to the lingual aspects of teeth 33 and 34, up to the mesial fossa of the latter. Consequently due to its occlusion with the antagonist tooth, tooth 34 is involved in the anchorage and it is prevented from extrusion. Occlusally, the wire ends on the mesial fossa of tooth 34, do to the fact that this area is not in contact with the antagonist in Angle's Class I.. Therefore, it is easier to also have a correct design of the wire involving this tooth, without any occlusal interference. The V-bend activates a tip that moves the roots of teeth 31 and 33 away and applies an intrusive force on 32 and an extrusive one on 34. Because it is in a sufficiently long sectional, the V-bend has to act for a very long time to determine the tip, until it reaches the shape modelled during the wire activation. Because it is a radicular movement, the tip is very slow in coming off, but at the same time it allows vertical forces to act. Intrusive vertical forces are highest at the top of the V-bend, while extrusive vertical forces progressively decrease as far as they move away from such top. If extrusive vertical forces exerted at level of tooth 34 are included in the range of forces checkable by the occlusion, an intrusion of tooth 32, rather than an extrusion of tooth 34 would be achievable. Furthermore, if the intrusive force in region 32 is slightly ahead of the C.R. (centre of resistance) of the group of teeth it acts on, it will contribute pushing towards tooth 32 in the buccal direction, levelling this area of the dental arch, which is less contoured than the contralateral sector.

The bonding step

The former active wire is removed.

A new wire is modelled using a 0.0195 inch twisted wire with round section made up of three threads. Preactivated as previously described, such wire will be bonded to teeth from 43 to 34. It is bonded before on teeth 43, 42, 41 and 31 and then on teeth 32, 33 and 34.

A certain amount of composite is placed on tooth 32 more gingivally than the V-bend, so that it does not completely cover the wire but at the same time it is thick enough to withstand the intrusive vertical force that will be applied in this area once the wire is com-

Table 1 Measurements on the dental casts of the intercanine width, arch length and arch depth before and after treatment.

	Pre-treatment	Post-treatment
Intercanine Width	20,24	21,56
Arch Length	51,48	55,88
Arch Depth	19,8	21,56

Figs. 17-21 Intraoral photographs at the end of treatment. Frontal view (Fig. 17); OVJ view (Fig. 18); Frontal view in slight disclusion (Fig. 19); Lateral right view (Fig. 20); Lateral left view (Fig. 21).

Fig. 22 Occlusal lower view at the treatment end with the passive retainer.

Fig. 23 Lingual lower view of the passive retainer.

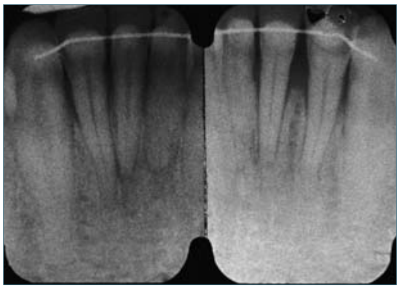

Fig. 24 Intraoral radiographs of the lower frontal teeth at the treatment end.

Fig.25 Intraoral anterior apical radiograph two months later the treatment end.

Fig. 26 Frontal view, slightly deviated mandibular middle line towards the right side and marked torque alteration of teeth 43 and 42.

Fig. 27 A particular of the occlusal lower view, it was removed the segment on the old retainer on tooth 43.

pletely bonded.
The wire is bonded and pushed towards the crowns of teeth 33 and 34 by means of a utility instrument; consequently, the wire will be moved occlusally due to the activation.

Final step

Three months later, after accomplishing the procedures previously described, good alignment of the mandibular arch and good levelling of the frontal plane were achieved (Figs. 17-21; 24-25). The active wire was substituted by a traditional passive retainer by means of a 0.0195 inch twisted rounded wire made up of three threads (Figs. 22-23).
All arch dimensions 31-32 are slightly increased with the therapy (table 1). The intercanine width increased of 1,32 mm, the arch length increased of 4,4 mm and the arch depth of 1,76 mm. So there was a slight increase of the intercanine width, and an expansion of the arch approximately of 2 mm.

Patient 2

Correction of torque by means of radicular movements with a **β**-titanium spring and relative considerations about the anchorage.

The patient C.S. presented the following clinical situation to the visual inspection (Figs. 26, 27):
- presence of all teeth in good

health;
- molar and canine first class on the left side and tendency to molar and canine first class on the right side;
- slightly deviated mandibular middle line towards the right side (Fig. 26) and marked torque alteration of teeth 43 and 42 (Figs. 26, 27);
- presence of a retainer made up of a twisted wire on the mandibular front teeth;
- slightly abraded surfaces related to teeth 43 and 42.

Requested about his subjective evidences, the patient reported the following situation:
- previous orthodontic therapy, as suggested by the presence of a retainer, concluded 5 years ago;
- achieving of correct closure, with centered median lines and good position of teeth 43 and 44.

Diagnosis

In spite of the presence of the retainer extending from canine to canine, the presence of such a torque alteration of teeth 43 and 42 allow to formulate two hypotheses to explain such a phenomenon, since no interradicular bone pathology was evident:
- parafunctional and/or vitiated habits that could have pushed those teeth, while the retainer acted as fulcrum the teeth rotated on;
- slow and progressive unwinding of the twisted wire in that area, causing an opposite radicular-buccal torque movement over time on tooth 43 and a radicular-lingual torque movement of tooth 42.

Therapy and the application procedure

Apart from the reported considerations, the device to be used should correct the torque keeping the crowns in the position they already had. After removing the segment on the old retainer on tooth 43 (Fig. 27), a torque spring made up of a 0.016x0.022 inch rectangular TMA wire was designed with a squared and turned upside down "U" shape (or box shape). Before the bonding step, it was preactivated with a torsion of about 30° on its horizontal segment. The design, the preactivation and the bonding steps are described in the previous chapter Root movements, inside the Specific clinical procedures (see fig. 6a).

This first appointment, during which the initial records, the modelling and applying the TMA spring were achieved, lasted almost 30 minutes.

The excess of composite was removed from teeth 43 and 42 by means of a football diamond bur mounted on a high-speed handpiece under water irrigation. The composite was thinned to a thickness of 1.5-2 mm over TMA. Then, possible roughness of the composite was removed by means of a diamond bur mounted on a low-speed handpiece under water irrigation and polished with a silicon rubber.

Further reactivations

The patient was followed-up every 3-4 weeks to evaluate the treat-

Fig. 28 Frotal view at the end of torque movement.

Fig. 29 Occlusal view at the end of torque movement.

Fig. 30 Frontal view and apparently normal OVB.

Fig. 31 Lateral left view, molar and canine first class.

Fig. 32 Lateral right view, molar and canine first class.

Fig. 33 Occlusal upper view, no crowding in the maxillary arch.

Fig. 34 Occlusal lower view, limited crowding of mandibular front teeth.

Fig. 35 A particular of the occlusal lower view.

Fig. 36 An .016 inch rectangular wire was modelled without shaping any sharp fold from the 42 till the 33 where we need to create the sliding mechanic. In that segment the wire was covered with dental wax and tied at both ends to create a stop at canines level. The elastic chain exerted a force able to pull tooth 32 distally.

ment outcome. At each control, for a length of ten minutes, it was debonded just the portion of TMA on tooth 43 to check its activation. If necessary, the wire was reactivated by means of two pliers: thin bird-beak pliers positioned on the horizontal segment of the torque spring and Weingart's pliers positioned on the vertical segment lingually to tooth 43, in the interproximal space between teeth 43 and 42. While bird- beak pliers were used to keep the spring immobile in order to avoid possible stress. Weingart's pliers were used to deform the wire with a torsion applied on the horizontal segment of the spring, in order to make a 30° angle between lingual enamel of tooth 43 and the segment of the wire to be bonded. The wire was bonded once more.
After 4 mounts, the roots alignment of teeth 42 and 43 was achieved (Figs. 28, 29). The TMA spring and the old passive retainer were removed and a new passive retainer was applied.
The torque correction of tooth 43 was about 18°. This is evident, if we compare the angles formed by the tangents to the FA points of teeth 43 and 44 or 45 before and after treatment.

Patient 3

Treatment of closing diastema by means of elastic chain and sliding mechanics.

The patient E.F. presented the following clinical situation to the visual inspection (Figs. 30-35):

- molar and canine first class on both sides;
- no crowding in the maxillary arch;
- limited crowding of mandibular front teeth;
- a slightly increase of the Anterior Bolton Index (A.B.I. = 78%) because of the greater mesiodistal dimension of the lower frontal teeth in relation to the upper frontal teeth;
- slightly increased OVJ related to tooth 43;
- slightly increased OVB related to teeth 42;
- presence of all teeth in good health;
- optimal periodontal health with absence of pockets;

Requested about his subjective evidences, the patient reported the following situations:

- wish for solving the unesthetic situation due to frontal crowding.

Therapy

The alignment was achieved by means of stripping from the mesial surface of tooth 33 to the mesial surface of tooth 41, in order to decrease the A. B. I. (The A.B.I. decreased from 78% to 75%) and a sliding mechanic to distribuite the space to align tooth 42. The wire used to apply sliding mechanics was a S. S. 0.016 inch rectangular wire.

Application Procedure

The first appointment during which the initial records, the modelling and applying the BFO were achieved, lasted almost 40 minutes.
A .016 x .016 inch S.S. wire was modelled without shaping any sharp fold that could prevent the sliding, following the curve of the lingual surfaces of the frontal teeth. Consequently, the wire was not in continuous contact with the enamel of the mandibular frontal teeth 33, 32, 31, 41 (Fig. 36).
The wire was tied at both ends to create a stop at the canines' level, as not to change the position of these teeth.
In order to create a tubular of composite around the wire to achieve the sliding mechanics, this wire was pre-covered with soft wax and bonded to the teeth as described in the previous chapter The sliding mechanics, inside the Specific clinical procedures (see figs. 4 a-c). Although there is no grip between the composite and the wire, satisfactory antirotational and tip control are kept.
On one side of the wire, in position 33, one end of an elastic chain was tied by means of a ligature wire and the second end of the same chain, activated with a force of 50 g, was tied on the wire with another ligature wire (Figs. 36, 37) between teeth 32 and 31. Consequently, a force able to pull tooth 32 distally was exerted.

First follow-up and reactivation

Three weeks later, the diastema between teeth 33 and 32 was closed. The elastic ligature was

substituted with an 8-shaped tightened ligature wire (Fig. 38). It was placed between teeth 33 and 32, under the wire in the interproximal position between them.
A new elastic ligature with an exerting force of 50 g was activated to pull tooth 31 distally. As previously described, such elastic chain was secured by means of two ligature wires in the interproximal spaces between teeth 33 and 32 and between teeth 31 and 41.

Further Reactivations

The patient was followed-up every 3-4 weeks. If the space had not been completely closed, the chain was renewed. If so, the closed space was blocked by means of new ligature wires. After distally pulling tooth 31, the same procedure was adopted to mesially pull tooth 41. After mesially pulling tooth 41, a space located mesially to tooth 42 was available to align it. During a half an hour appointment, after 10 weeks from the beginning of the treatment, the rectangular wire was cut distally to tooth 41 and removed from teeth 42 and 43. To stop the sliding mechanics, some notches were made on the composite up to the wire on each tooth with a diamond bur under water irrigation (Fig. 5a). These notches were filled with composite and polimerized (Fig. 5b). A 0.0175 inch twisted wire with a round section made up of five threads was used. Such wire was modelled to passively fit to the lingual aspect of teeth 41, 42, 43 and 44 up to the mesial fossa of the latter. Two U-shaped loops with height and width of about 3 mm, respectively, were added in the space between 42 and 41 and between 43 and 42. In this last zone, a step bend had been added to facilitate the labial movement of tooth 43.
Before bonding, the wire was preactived by widening the loop between teeth 42 and 41 about 1.5 mm. The wire was also bent so that the segments to be bonded to teeth 43 and 41 were positioned lingually 2.5 mm in relation to the segment which would be bonded to tooth 42. First, the wire

Fig. 37 Lingual lower view of the sliding mechanic.

Fig. 38 Tree weeks later, the diastema between teeth 33 and 32 was closed. The elastic ligature was substituted with an 8-shaped ligature wires and a new elastic ligature with an exerting force of 50 g was activated to push tooth 31 distally.

Fig. 39 Occlusal view of the lower active retainer, tooth 42 is aligned with the others teeth.

Fig. 40 Lingual view of the lower active retainer, tooth 42 is aligned with the others teeth.

was bonded to tooth 42, because in this position, the wire was closer to the tooth. Then the wire was bonded to teeth 41 and 43, after maintaining the U loop closed between 42 and 43, by means of an utility probe, while simultaneously keeping the horizontal plane with the use of a dental explorer.

Consequently, a force pushing the mandibular right lateral incisor buccally was created, which would have acted as soon as the opening loop between teeth 42 and 43 have created a proper space pulling tooth 42 in the mesial space. Another force was created to pull lingually and derotate the mesial side of tooh 43. Actually another force pulling teeth 41 lingually was introduced in the system, but this movement was prevented by the rectangular wire on teeth 33, 32, 31 and 41 that acted as an anchorage.

After 3-4 weeks, during an appointment of a quart of an hour, the wire was debonded from teeth 43 and 44, and preactived widening the U loop and bent lingually the segment to be bond on tooth 43 and 44. Then was bonded closing this U loop and pushing the wire segment on tooth 43. Besides labially pushing tooth 42, a force to derotate tooth 43 was exerted by means of the step bend.

Such procedure was repeated about for 2 months until tooth 42 and 43 were aligned with the other teeth (Figs. 39, 40) and the wires were replaced with a passive retainer.

Results

Lingual therapy by means of BFO resolved the previously described clinical cases in a few months.

The first case: the resolution of crowded teeth by widening the dental arch applying U-shaped loops in association with asymmetric intrusion of the anterior group by means of V-bends, has been resolved in 6 months. The second case: the torque correction by means of root movement using a TMA spring, has been resolved in 4 months. The third case: treatment of closing diastema by means of an elastic chain and sliding mechanics, has been resolved in 5 months.

Discussion

Lingual therapy by means of BFO, allowed the resolution of most of the clinical cases alone or in association with other appliances.

In the years during which this clinical appliance was applied, only two authors have introduced something similar: Dr. Liou EJW et coll[33], in the year 2001, and Prof. Macchi A., in the year 2002. (SIDO Congress: Day of the others Italian Orthodontic Societies). In both cases the appliances are made up of NiTi wire, without specific pre-activation based on the principles of biomechanics.

During the first appointment, the initial records, the modelling and the application of the active wire are achieved. When the wire is applied on both dental arches, the first appointment lasts almost an hour. Otherwise, If the wire is applied on only one dental arch, the appointment lasts about thirty minutes.

During the following appointments, the re-activation of the wire takes place. These appointments have a duration of 5-10 minutes, due to the fact that in most cases it wasn't necessary to debond the whole wire or to etch the teeth again. In fact, in the planning phase I considered the force system necessary to align teeth and the respective activations. Moreover I considered the possible shape and bends able to produce the desirable force system, and the activation and the re-activation of the wire without replacing it. Finally, if we want the aligned teeth not to move, it is possible to de-activate a sector of the wire by overlaying a rigid wire.

The clinical cases showed in this article are exemplificative of the many orthodontic therapies available. Lingual therapy by means of BFO alone or in association to other appliances, allows for the resolution of most of the clinical cases. With the correct pre-activations, it is possible to achieve a good arch alignment (resolution of crowding, closing of diastemata, arch alignment, tip and torque control). If we want to expand the upper arch, it is possible to apply a Quad Helix prior to alignment by means of BFO. If it is necessary to open or to close the bite, we can associate BFO with mini-screws as anchorage. Otherwise, we can use BFO in combination with stainless steel sectional wire as anchorage and an intrusion or an extrusion lever. It is possible to associate BFO with vestibular resin buttons to apply vertical elastic bands. If we want to close symmetric or asymmetric extraction space, we can use the hinge mechanics planned by Dr. A. Fontenelle[34], or power arms, for the "en masse" retraction. If we want to correct the class relationship with intraoral elastic bands, we can use stabilization stainless wire bonded on posterior aligned teeth and another BFO on anterior teeth to control the torque during correction of the OVJ.

The BFO can be applied either on the lingual or on the labial aspect of the teeth, without interfering with the patients' phonetics. Patients prefer therapy with BFO bonded on the lingual aspect of the teeth rather than the labial therapy with brackets because the BFO are not visible if bonded on the lingual aspect of the teeth. Moreover, patients prefer therapy with BFO bonded on the lingual aspect of the teeth, rather than the lingual therapy with brackets, because the BFO are thinner and more comfortable than the lingual brackets. As for bracket therapy, slightly more accurate oral hygiene is required, and it is possible to protect the decubitus areas with orthodontic wax.

Obviously, it is a very complex technique both for the modelling and for the bonding phase. Since no precise references exist, as in bracket therapy, the best results could be achieved by applying the principles of biomechanics described by Burstone and Melsen[28-30] in their segmented approach. Moreover, greater patient collaboration is needed because it is necessary that oral fluids are isolated during each re-activation of the wire. So this appliance is not indicated for young patient.

Conclusions

The BFO (Bracketless Fixed Orthodontic) are appliances that, applied either on the labial aspect or on the lingual aspect of the teeth, guarantee a good control of the dental movement, and also in the root movement.

It can be used to level teeth, as in case of relapse, or to remove the brackets before the end of the therapy. But it can be used also in more complicated clinical cases where patients have never been treated with orthodontic therapy, especially in association with other appliances, as previously described.

Obviously it is a complex technique both for modelling and for bonding phases.

Since there aren't precise references, as for the bracket therapy, the best results could be achieved accurately applying the principles of biomechanics described by Burstone and Melsen[28-30] in their segmented approach.

The BFO offers different advantages, applied either on the labial aspect or on the lingual aspect of the teeth, because they guarantee a good control of the dental movement, they do not interfere in patients' phonetics, and or oral hygiene.

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