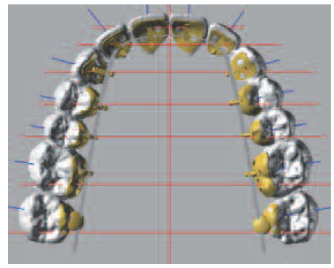
DOI: 10.1051/odfen/2011405

J Dentofacial Anom Orthod 2012;15:105

Customized brackets and the straight arch technique combined in one appliance to simplify lingual orthodontics



Pascal BARON, Christophe GUALANO

ABSTRACT

The concept of the appliance we describe in this article is based on a number of technological advances. The brackets, created in accordance with CAD/CAM are the product of an original process that makes them resistant to de-bonding providing a high resistance to bracket loss. They are also compatible with the use of a veritable straight wire enabling the use of prefabricated standard wires. The manufacturing process uses a maximum of digitized resources to elaborate a numerical set-up usable by the practitioners. A 3D computerised treatment control is performed from the beginning to the end of the assembly line and warrants a perfect precision of the bonding placement.

Appliances are completely personalized for each patient taking into account particular anatomic features as well as the prescriptions of practitioners. As a result practitioners will benefit from a number of theoretical advantages making treatment more pleasant and functionally smoother at every phase of therapy. Managing the Lingualjet appliance is simple and transforms straight wire lingual therapy into a procedure comparable in every way to traditional use of the straight wire in buccally bonded attachments.

KEY WORDS

Lingual orthodontics,

CAD,

CAM,

Straight wire,

Digital set-up,

3D imaging.

Conflicts of interest declared by author: cf. at end of article
Received: 08-2011
Accepted: 10-2011

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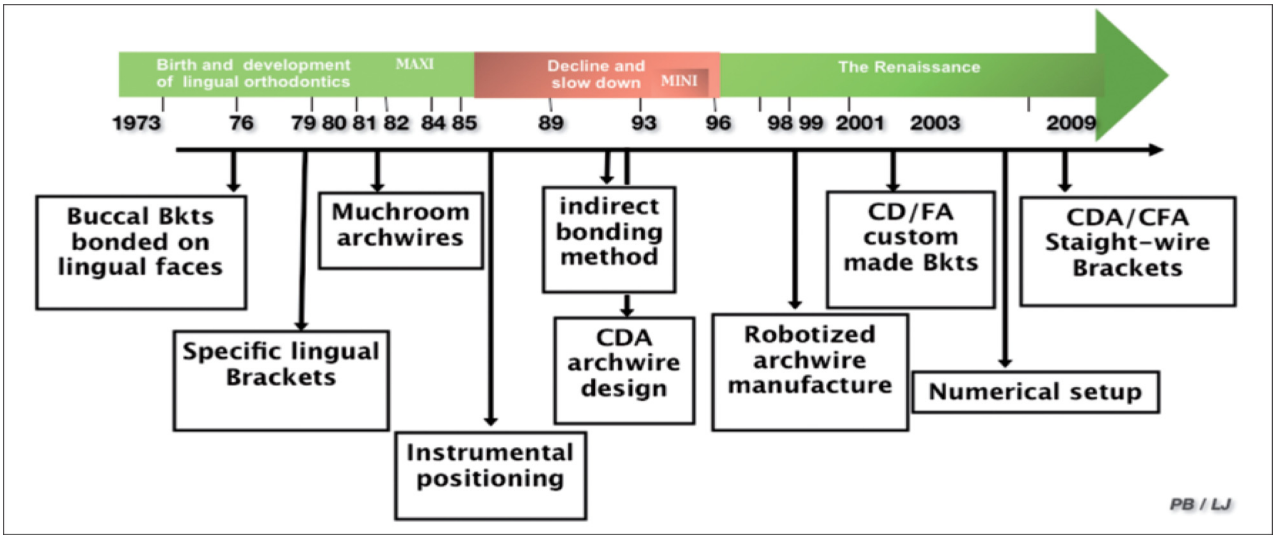
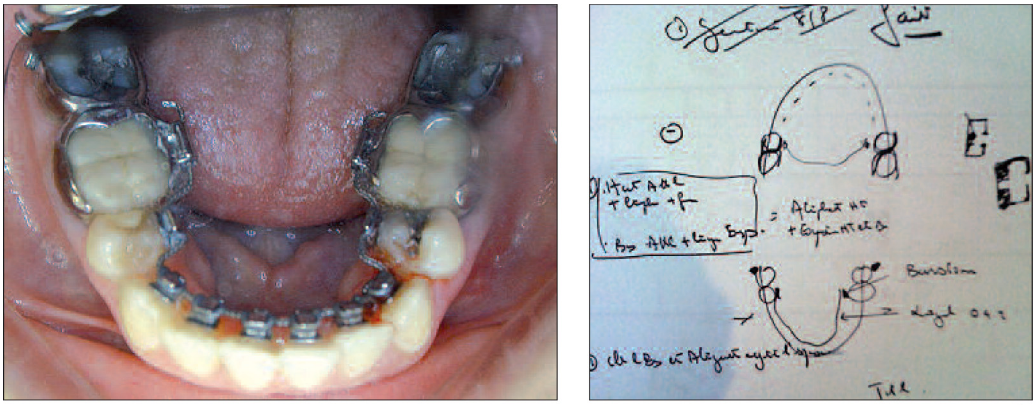


Figure 1
Technological forward leaps in lingual orthodontics (sources < 2010 patents and publications).

If one reviews the history of the lingual orthodontic technique since it was introduced about 1982 and after Fujita presented the mushroom arch, one notices that most technical and technological advances adopted in the field of orthodontics were first designed for use in lingual therapy. This can be seen as a result of lingual practitioners being by nature receptive to innovation or, perhaps more accurately, because lingual orthodontics is a discipline that is never perfected and whose adepts are perpetually searching for solutions to its reliability problems. Such a review would also indicate that until about 2005 almost all articles were devoted to techniques, proposing new appliance systems or laboratory methods.

In this orthodontic arms race computers will be playing an increasingly prominent role propelled by the rapid rise of use and power of information technology throughout our society. And, it should be noted, these developments coincide with a revival of interest in lingual orthodontics, which, until very recently, had been gravely weakened by a loss in the already small number of its adherents. So the time is ripe for conception assisted by computer, CAC, to take its place in the formation, first of all of arch design promoted by systems like BEST (Bonding with Equal Specific Thickness); DALI (Dessin d'Arcs Lingual Informatisé) (1989); TOP (Transfer Optimized Positioning) (1998). Next came the concept of customized bracket with Incognito (2003) and digitalized set-up with Orapix (2005). Finally, in 2009 Lingualjet introduced an appliance that is created in every step of its construction and application by computer programs (fig. 1).

Takemoto and Scuzzo[8] proposed a lingual version of the straight wire



a b

Figures 2a and 2b
a: customized brackets on first and second molars;
b: production notes on the author's manuscript.

technique in 2001 but this technique remained unused in the conceptual stage for many years because technologies of the time were not capable of implementing it. However these two orthodontists[9] were able to partially overcome the compatibility problems that industrially produced brackets posed for execution of their straight wire lingual concept by fabricating a series of brackets of smaller size with a re-designed profile.

Customized brackets had, however, already been introduced in 2003 in conformity with a conservative philosophy where the arch wires remained under the control of a robot. Fontanelle had devised in 1983, long before the era of widespread computer technology applications, the original scheme for personalized lingual attachments provided by metal casting method to perform the first customized lingual orthodontic treatments in France (fig. 2). Much later, Weichmann[10] proposed a process consisting of the fabrication of made-to-measure computerized three-dimensional brackets cast in a gold alloy to receive a sequence of arch wires also computerized. This apparently user-friendly appliance made a major contribution to the development of lingual orthodontics by enticing a great number of orthodontists to employ lingual techniques.

So by 2007 orthodontists could choose to work with a straight wire and commercial brackets constructed with limited capability of adapting to conditions of anatomic variations of arch forms and of the lingual surfaces of teeth or of using 3D brackets coupled with robotized arch wires incorporating bicuspid insets that gave them an initial mushroom shape. In 2008 the first beta version of the Lingualjet appliance was introduced and presented at the European Society of Lingual Orthodontics (ESLO) convention. With it, for the first time orthodontists would be able to use a standard form straight arch wire in computer generated brackets

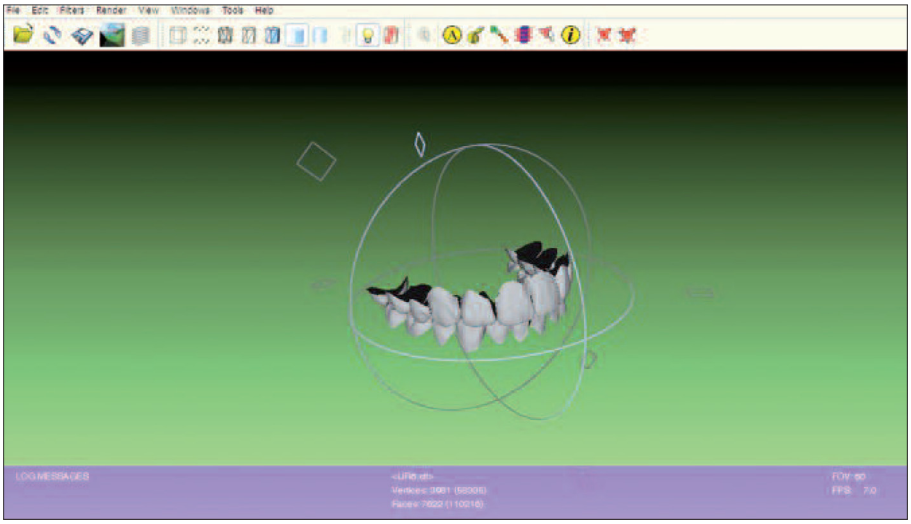


Figure 3
Digitized set-up of a four second bicuspid extraction case performed and filmed by MeshLab@ that can be viewed in 3D from every angle and at any desired enlargement.

totally adaptable to accommodating themselves perfectly to the exigencies imposed by variations in dental surfaces and the special needs of the straight wire technique.

1 – SPECIAL FEATURES OF THE LINGUALJET TECHNIQUE

The basic conceptions of the Lingualjet appliance are drawn from a number of technological advancements[3].

1 – 1 – A digitized setup

Without being, as yet, able to employ the optical impression techniques that will soon be available, we digitize plaster models of a patient's dentition with a very high-resolution optical scanner. Then a digitized set-up is constructed for the finished case including anticipated inter and intra-arch relationships as well as any specific prescriptions such as over-correction, augmented torque or tipping, anchorage preparation, and others. These operations are accomplished on the computer screen by means of special programs. The practitioner validates this working model that can, when desired, import the set-up computer file into any desired 3D program (fig. 3). The conventional views that thus become available are frontal, profile, and occlusal constitute an alternative means for practitioners to validate the quality of the virtual occlusion .Once validated the setup will be the working model used for the assembly line.

1 – 2 – Customized brackets

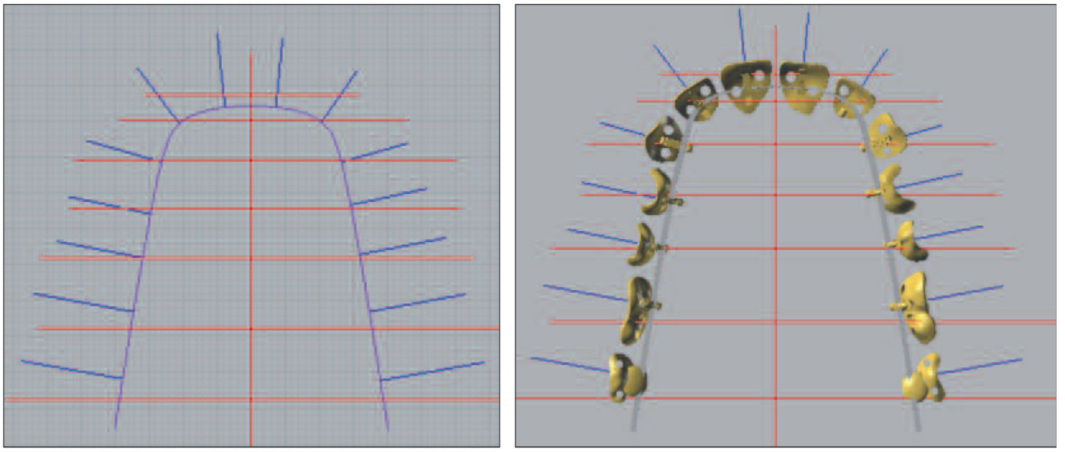
All attachments, constructed virtually with computer assisted technology, are individualized to fit the teeth to which they will be bonded. Their bases present a large extended surface adapted to fit intimately with

Figure 4
Size comparison between an STb social-6 bracket and a Lingual-Jet LJ bracket. Note that the placement of bonding material on pre-fabricated brackets necessitates placement of additional composite material when it is mounted in the laboratory.

the anatomy of the teeth they are joined to. All bracket slots accept edgewise arch wires and are aligned on a virtual straight arch wire that passes as closely as possible along the lingual bulges of the ensemble of teeth in the arch. The positioning of the body of the bracket on its bases can vary in all directions to allow wide latitude of adaption to initial conditions. The individualized brackets all have rounded forms and less pronounced contours (fig. 4). When all the virtual attachments are completed they are exported to be converted into a plastic physical reality that can be burned out when castings of them are made in an alloy of gold, essentially Au + Pd +Ag, which has remarkable properties with coefficients of elasticity (Young's Modulus = 75 GPa) that are very close to that of enamel (Young's Modulus = 82 Gpa). To give an idea of how effective they are, composites that allow on the average a compensatory heel during the positioning of pre-fabricated attachments are much more vulnerable to deformation (E << 10 Gpa) and, as a direct consequence, to becoming detached. Moreover, the bases of LJbrackets are pierced with special perforations made by an original fabrication procedure that increases resistance to debonding by improving retention thanks to better photo-polymerization of the bonding material[2]. Finally, the size of the LJbracket has been reduced enough to make it comparable in size to the most diminutive commercial brackets available today (fig. 4).

1 – 3 – The straight arch

The system's straight wire can be adjusted slightly in the sagittal plane and its horizontal plane positioned more gingivally so that the difference between the canine cingulum and the lingual surface of the premolar will be in continuity without placement of the slightest arch wire in-set. The arch wire is placed as close as possible to tooth surfaces and it is formed in accordance with the disposition of the crown lingual surfaces at its level. This is re-transcribed on a chart that describes the intersection of the arch with the center of each bracket slot (fig. 5).



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Figures 5a and 5b

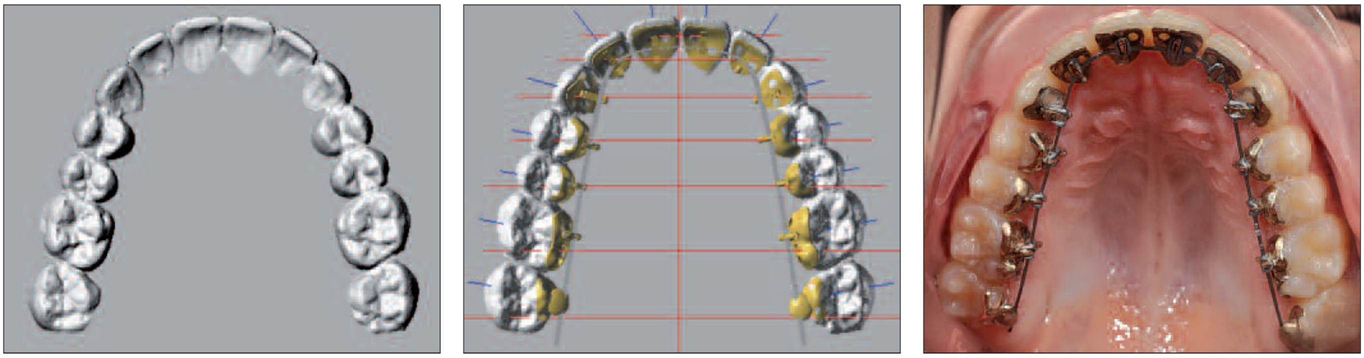
a: LJ arch chart;
b: design of the straight wire arch: for each bracket the center of the slot is represented on the chart by its intersection by the line of the arch.

The use of the made-to-measure 3D bracket makes arch wire standardization in a single form possible. From this standardized start, practitioners are free to select any type of arch wire needed in the material and size desired for the phase of treatment in progress, just as they would in any veritable straight wire technique.

Its one-piece bracket design with a widely distributed bonding surface, its capability of varying slot height to suit needs, and its allowance for adjustments of position between body and base allow the LJ bracket to adjust to the geometric exigencies demanded by the lingual straight wire technique. In doing so, the arch wire is closer to the center of resistance of the tooth, which gives orthodontists a highly desirable increase in therapeutic control. Obtaining the anticipated result depends on the precision of the fabrication, which, if it is optimum, will reproduce in the patient the exact changes made in the setup (fig. 6).

1 – 4 – 3D dentofacial imaging

If it seems desirable to extend the parameters of the LJ appliance, orthodontists have the option of assembling supplementary data. Today, Cone Beam, computed axial tomography, technology makes volumetric radiological assessments readily available, giving orthodontists three-dimensional films and producing diagnostic and treatment aids like, for example the Cepha3DT view and analysis portrayed in figure 7. It is now also possible to enrich the precision of the setup by including the roots in the working space and to assure, with certainty, intra-arch root parallelism as well as the angular re-



a b c

Figures 6a to 6c

a: digital setup;
b: appliance design;
c: result in the mouth after alignment and leveling.

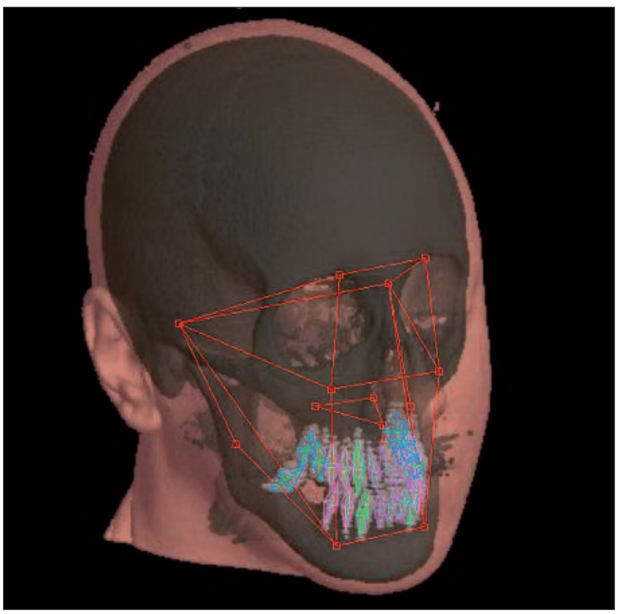


Figure 7
This Cone Beam imaging technique gives orthodontists the capability of reproducing virtual facial, skeletal, and dental structures and utilizing biometric analysis tools like Cepha3DT.

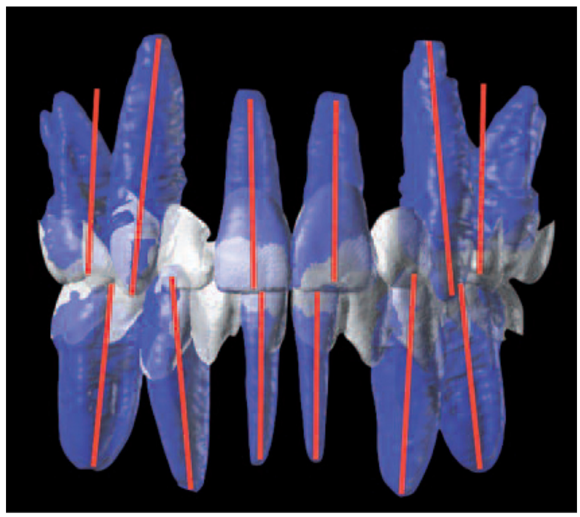


Figure 8
Roots can be reattached to their crowns in a virtual setup of the entire dentition. In this view, to make the image more readable, only every other tooth is pictured with its crown-root axis.

lationships between antagonistic teeth in the two arches (fig. 8). This option allows orthodontists to push the envelope still further in the direction of accurate individualization of the appliance by incorporating supplementary anatomic data.

2 – TRANSFERRING THE ATTACHMENTS TO THE MOUTH AND BONDING THEM

In any transfer of orthodontic attachments to the mouth the orthodontist's primary goals are to assure both maximal precision in their placement and optimal quality of their bonding to make them highly resistant to detachment. These principles apply with, perhaps, greater vigor to lingual than to buccal appliances. Lingually, difficulties are aggravated and every instance of imprecision of placement or loss of a bracket will result in a mal-positioning tooth that will have to be corrected in finishing procedures[7].

Many details of the conformation of the LJbracket base increase the efficacy of their bonding:

- absence of a composite mounting heel;
- an enlarged surface constructed to fit the surface contours of the tooth to which it will be attached;
- intimate juxtaposition of tooth surface and bracket base, augmenting stability;
- presence of LJ pores that both improve retention in leaving extruded composite buttons (fig. 9) and facilitate better polymerization of the bonding agent by letting light penetrate to the bracket base.
- One of the advantages customized attachments is that they give orthodontists the option of bonding them directly. Because their bases are designed to perfectly fit the dental surface they are destined to join in an exactly specified position, orthodontists can bond directly to the last molar in an arch when access to it has improved or rebond a detached bracket as easily as they would a detached buccal bracket.

However, as a rule bonding of attachments lingually to an entire arch is carried out in a single procedure with a two-layer transfer tray that provides all the needed capabilities. The first layer, contacting tooth surfaces, carries the brackets to be bonded firmly in the material, which is translucent and supple enough to allow easy and non-aggressive removal after brackets have been attached to teeth. On top, a 0.5 mm thick transparent acrylic envelope confers to the full arch assembly the rigidity needed for the tray's introduction into the mouth, its correct application to the teeth, and ease of its maintenance in place during the full period of polymerization.

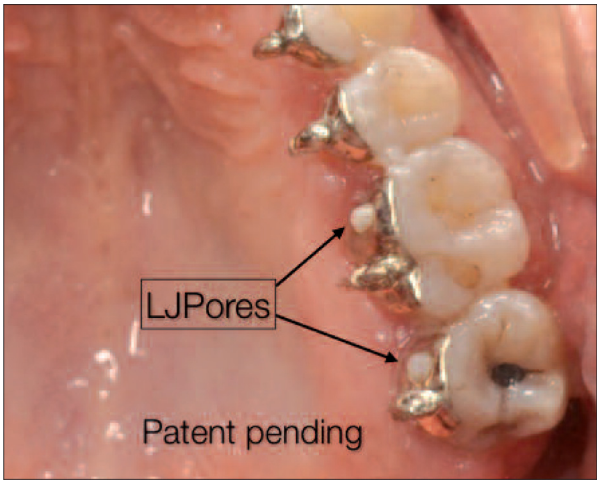
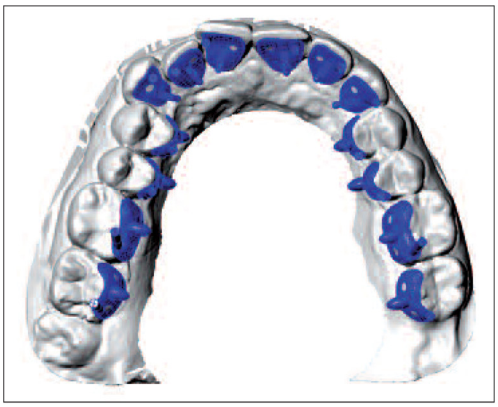


Figure 9
The LJpores significantly increase the quality of the bonding process.

The final position of the brackets, which have themselves been digitally designed on the digital setup, in the transfer tray is controlled by a digital CDA program (fig. 10 through 12). Once created, these virtual brackets will again be attached to the digital model representing the initial planned alteration of the arch. This file will then be exported via a rapid prototype that will reconstitute in plastic the three dimensional impression of the original model with the brackets. It will constitute the working model for the transfer tray that will be fabricated on it. The brackets, cast in metal, will be carefully placed in their respective tray slots, ready for bonding.



a

b

Figures 10a and 10b
a: virtual brackets attached to initial virtual model;
b: plastic working model made from virtual model.

a

b

Figures 11a and 11b
a: real brackets set in transfer tray;
b: bonding by polymerization.

a b c

Figures 12a to 12c

a: removal of the acrylic cover
b: peeling off the elastic layer
c: result of the transfer tray's having been held rigorously in position – brackets will be attached to the four bicuspids later when they will be included in the treatment.

3 – CLINICAL CASE (fig. 13 to 21)

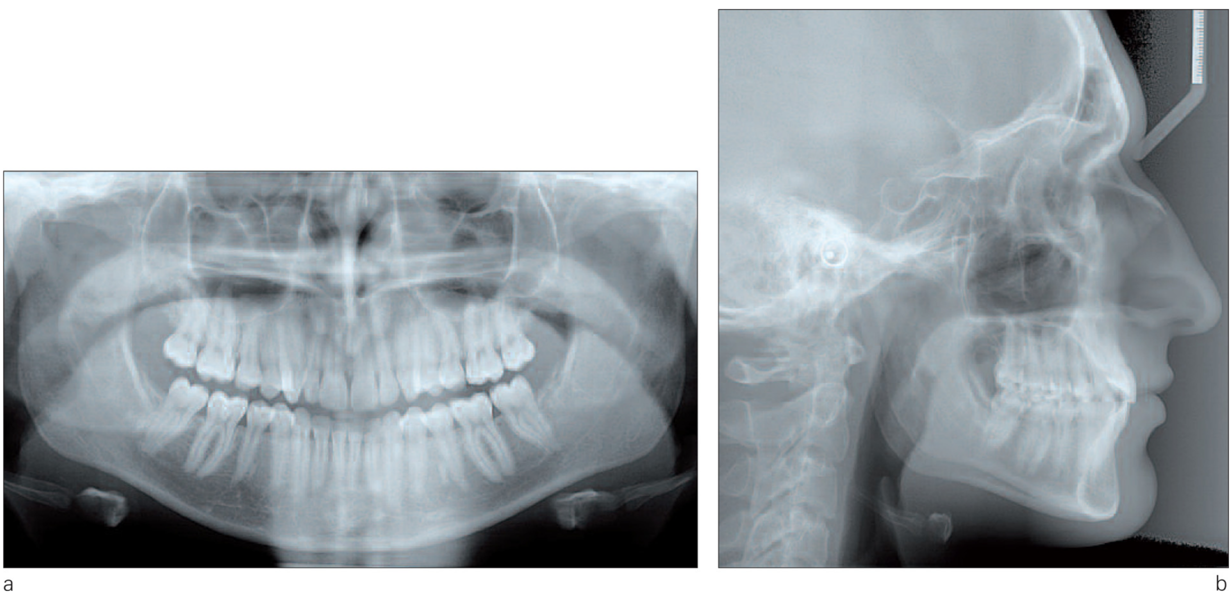
Mr. Alexandre C. is a 24 year-old professional who had no previous orthodontic treatment. He consulted us because of his ''crooked teeth'' and uncomfortable occlusion, desiring treatment with an appliance that would not be visible.

Our most salient clinical findings were his asymmetrical occlusal relationships, Class III on the right and

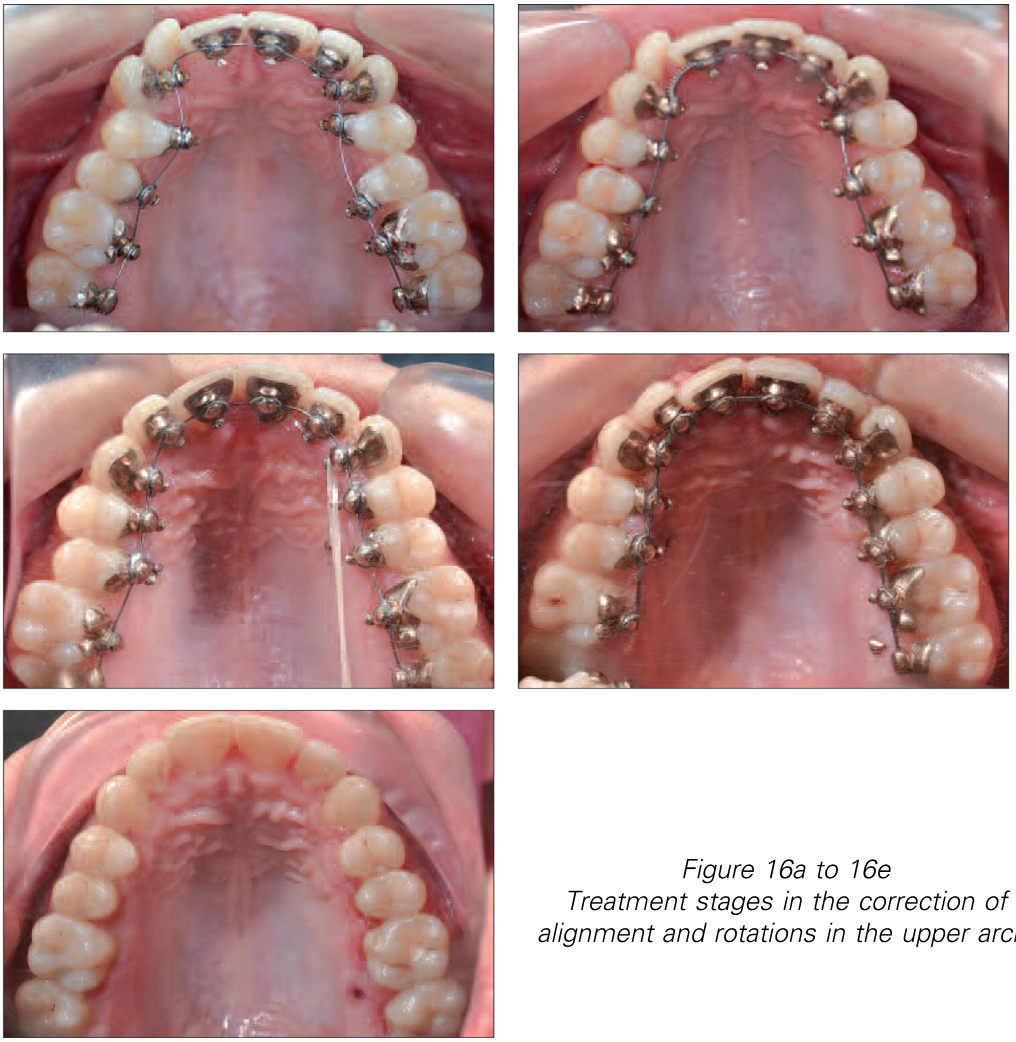
a b c

Figures 13a to 13c
Pre-treatment facial views.

Figures 14a to 14c
Intra-oral views showing the occlusal asymmetry and the anterior crowding in both arches.



Figures 15a and 15b
Pre-treatment radiographs.

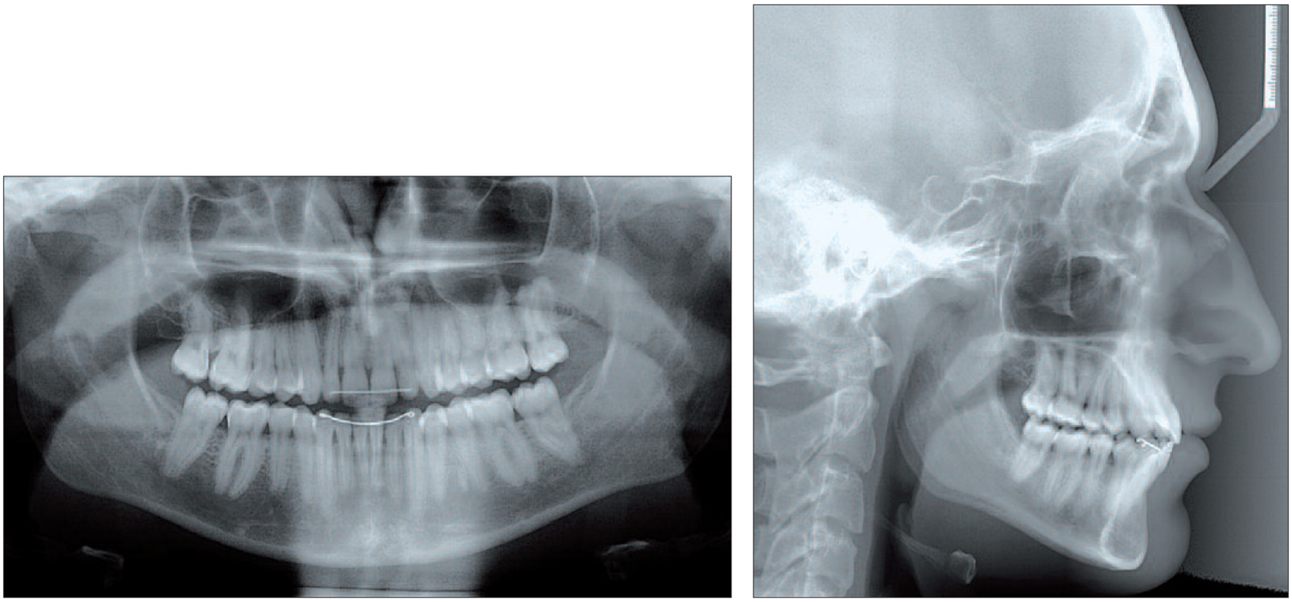


a b c d e

Figure 16a to 16e
Treatment stages in the correction of alignment and rotations in the upper arch.

a b c

Figure 17a to 17c
Alignment of the lower arch.



a b

Figures 18a and 18b
Post-treatment radiographs.

a b c d e

Figures 19a to 19e
Post-treatment intra-oral views.

a b c

Figures 20a to 20c
Post-treatment facial views.

a b c

Figures 21a to 21c
The setup is a virtual duplicate of the result achieved in the mouth.

Class II on the left, a midline deviation, and upper and lower anterior crowding. The upper left buccal teeth were in a mesial position that extended to the right central incisor. The lateral sectors of both arches were compressed toward the lingual. Skeletally, his face is balanced but the upper right buccal teeth are in mesioversion.

Our treatment plan proposed an initial leveling and alignment of the teeth in both arches followed by asymmetrical mechanics supported by miniscrew anchorage to be completed by detailed intermaxillary finishing.

We constructed a Lingualjet version 1.3beta appliance and bonded it into both arches, differing bonding of the upper right lateral to a later point in treatment when its lingual surface would be more accessible. Figure 16 shows steps in the alignment and rotation correction of the upper arch achieved with the aid of an elastic worn on the left side only to a mini-screw anchor placed mesial to the upper left second molar.

A treatment time of 23 months was required for us to obtain satisfactory alignment of the crowns and parallelism of the roots.

The sequence of the arches we employed was limited to these: .016 NiTi/ .018 NiTi/.018 by .018 NiTi/.016 by.022 TMA.

We corrected antero-posterior arch relationships and brought the arches into transverse harmony by letting a succession of straight arch wires of progressively increasing size gradually express their corrective force on the teeth.

The result we obtained, with no bracket detachment throughout treatment, corresponds almost exactly to our original predictive (and working) setup. Today, Lingualjet 2.1, the latest version of our appliance, allows orthodontists to undertake treatment with a system of attachments that are smaller and more precise than any that were previously available. Orthodontists retain complete freedom of selecting options from the time they write the original prescription until they remove the appliance thanks to their use of a veritable straight arch wire supported by 3D digitized brackets that carry within them the totality of information needed for every treatment phase. The Lingualjet system is participating in the advancement of lingual orthodontic therapy by making it simpler, more comprehensible, and by not requiring orthodontists to modify their working methods or compromising their convictions. Practitioners today can achieve the same results by working ''inside'' that they have been accustomed to producing by concentrating on the ''outside.''

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DECLARATION OF CONFLICT OF INTEREST

I, the undersigned, Pascal Baron, that the authors of this article entitled:

''Customized brackets and the straight wire technique combined in one appliance to simplify lingual orthodontics''

Pascal Baron and Christopher Gualano

are participating owners of the Lingualjet Orthodontics Company that developed the Lingualjet appliance, which is described in this article submitted for publication to the Revue d'Orthopédie Dento-Faciale.

Toulouse 16/10/2011

P. Baron