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Biomechanics of mini-screws and adult treatment: two case reports

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ABSTRACT

Adult treatment is often hindered by the psychological, periodontal, articular and/or muscular context. Denture is often incomplete, and malocclusion is more varied.

Analysis of orthodontic mechanics is thus essential to reduce unwanted displacements and achieve treatment objectives. Mini-screws are often very useful here, ensuring rigid anchorage and enhancing treatment efficacy.

Benefit is discussed, based on two case reports: one using a slide mechanism and the other a frictionless mechanism.

KEY WORDS

Biomechanics, mini-screw, adult treatment, friction

Managing anchorage is a key issue in orthodontics, to anticipate and control the movements to be induced. During the 20th century, numerous authors (Tweed, Merrifield, Ricketts, etc.) described means of reinforcing anchorage so as to prevent unwanted displacement in some teeth due to the displacement of others; their solutions often required patient cooperation.

The spread of such treatment to adults has led to a growing wish for esthetically acceptable treatment requiring minimal cooperation. Mini-screws were therefore developed, and now allow correction of previously recalcitrant malocclusions: vertical asymmetry, with frontal tilt of the arcade planes and molar protrusion secondary to loss of the antagonist tooth, etc.

However, attractive as these systems seem, the mechanics needs to be well considered, to avoid side-effects; notably, the indications for direct versus indirect anchorage, with or without friction, need determining.

The present study, based on two case reports in adult orthodontics, one lingual, the other vestibular, describes well-considered use of mini-screws adapted to treatment objectives.

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CASE 1:
TREATMENT WITH FRICTION

(Case managed in the Pitié-Salpêtrière Hospital by Dr P. Tuil, in Dr P. Garrec's department.)[1-4]

Diagnosis

A 37 year-old woman consulted for esthetic (dental alignment) and functional reasons (replacement of 16 and 26, recently extracted for decay).

- Esthetically, the profile was slightly convex, with normal nasolingual angle. Skeletally, the case was class II, non-confirmed by the AoBo orthodontic association (trend toward class III) with normally divergent facial pattern.
- Dentally, dental formula lacked 16, 26, 38 and 48; class I right canine angle, class II left canine angle, 2mm leftward deviation of the median mandibular incisors, reduced cover, incisor vestibular version, dento-maxillary disharmony in the form of 11mm crowding.
- Functionally, lingual dysfunction with atypical swallowing and phonation (Fig. 1).

Treatment plan

- Closure of maxillary arcade spaces by mini-screw anchorages, positioned mesially to 17 and 27 so as to draw back the anterior maxilla. Reciprocal anchorage between anterior sector and the two molars once class I is achieved. As 18 and 28 were dwarf teeth, they were not included in the treatment plan.
- Extraction of 34 and 44 in the mandibular arcade, to correct dento-maxillary disharmony.

Photographs at 1 year

A vertical bowing effect could be observed. Traction was applied directly from the mini-screw (mesial to 17 and 27) to the canine so as to pull back the anterior 15-25 teeth as a block. This mechanism led to a lateral gap and loss of torque, as the pull-back was applied on an arch that was insufficiently rigid at the incisors (.018 .025 steel in .022 .028 grooves). As the motor system was applied directly on the canine attachment, a vertical component and stronger moment were applied on this tooth. Coronary distal version effects can be seen, due to the force system acting on the canine, inducing lingual version at the incisors and a premolar gap. As 17 and 27 intrusion is a very difficult movement, few molar side-effects were caused by this mechanism (Figs. 2, 3).

The same analysis applies to the superimposition on the maxillary arcade, with a shift in the occlusion plane.

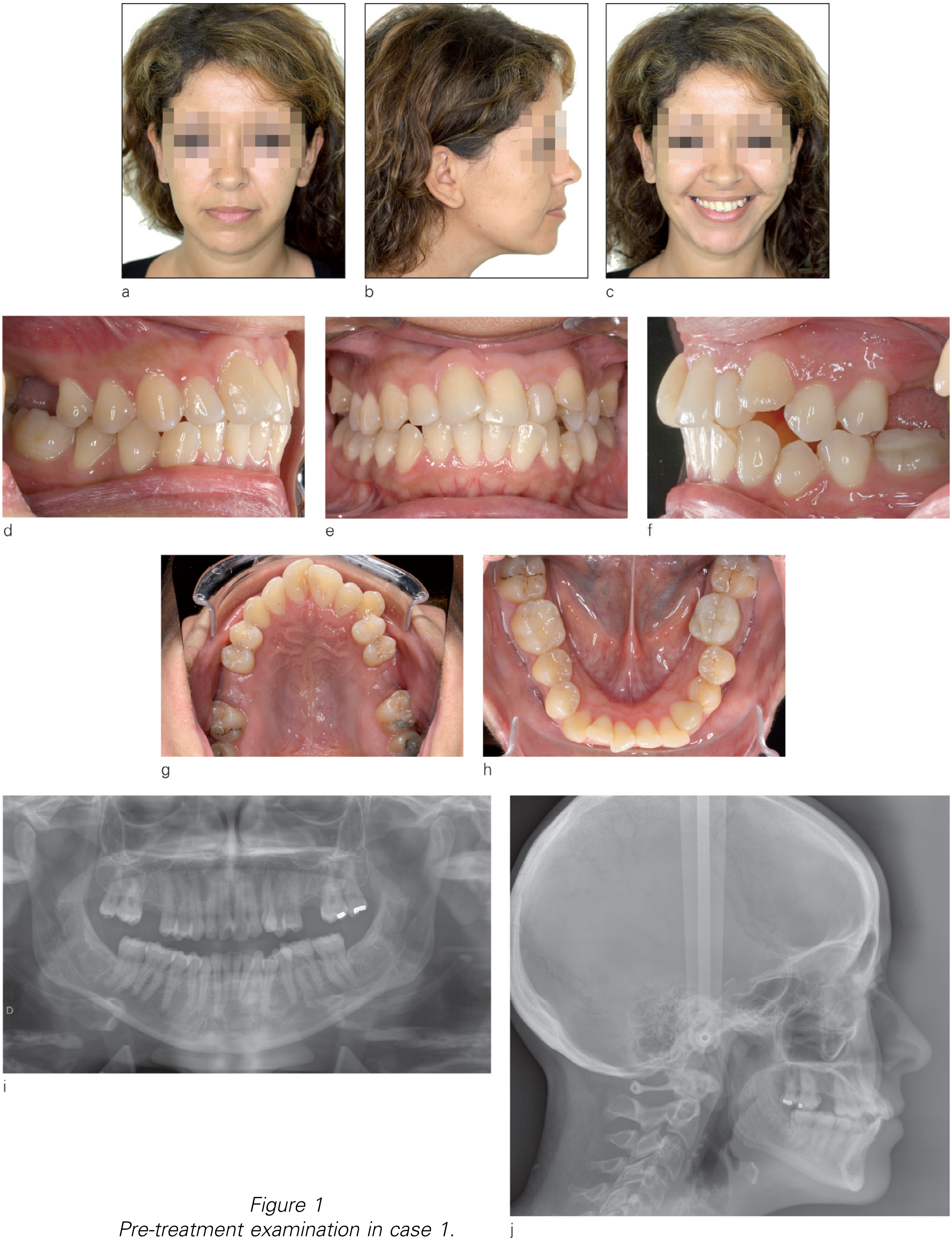


Figure 1
Pre-treatment examination in case 1.

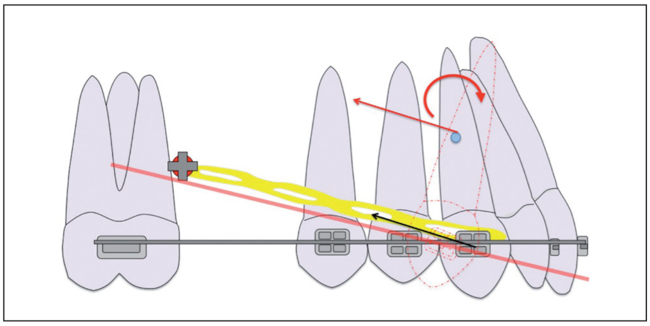
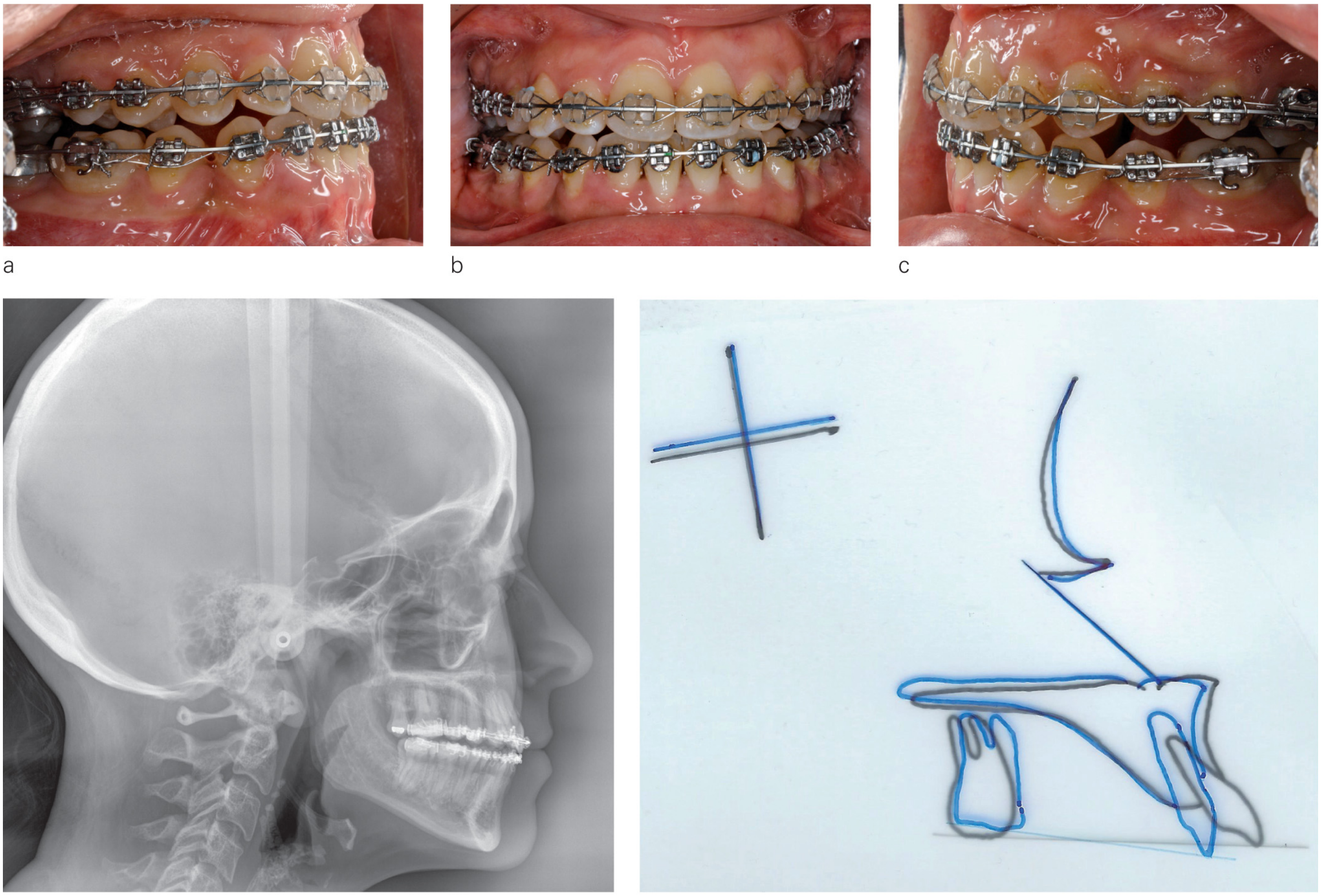


Figure 2
Diagram of the biomechanical system. Red force line and moment: equivalent system applied to canine; black force line: motor system.



a b c d e

Figure 3
1-year examinations in case 1.

It would have been preferable to add a bracket at the canine and use a larger steel bow to limit anterior information loss and reduce the moment exerted on the canine. This would have made treatment faster, as it took a long time to restore correct torque, with resultant jiggling of the incisors, liable to lead to dental resorption.

Photographs at 2 years (end of treatment)

By end of treatment, correct torque had been restored. Results were class III. Right and left laterality was carefully checked, to eliminate any non-working contact (Fig. 4).

CASE 2: NON-FRICTION TREATMENT

(Case managed by Dr G. Bourgoin.)[5]

Initial photographs

- External views: anterior occlusion plane tilt seen in Figure 4: tilting downward from right to left (Fig. 5a, b).
- Intra-oral views: premolar missing in sector 2;
- sector 1: maxillary endo-occlusion;
- intermaxillary centers shifted by 7 mm;
- left: class III canine; right: class II canine (Fig. 6).

The classic recentering solution consists in extracting 1 premolar from the side opposite to the deviation (15, as it was crowned).

If a sliding technique is used to close the spaces, the teeth have to be slid one by one along a continuous arc. With a mini-screw, several teeth can be slid together at the same time, but this has the major drawback of having to position the middle of the arch off-center with respect to the middle of the dental arcade so that the two arcade centers match at end of movement. Resistance to sliding along the arch would hamper movement and could result in a flattening of the arcade. It is very difficult to protect the shape of the anterior curve of the arcade against friction in case of asymmetry. Moreover, treatment risks being lengthy.

The interest here of Burstone's segmented arch technique is that movement is easily foreseeable and displacement is faster, being frictionless. One principle of the technique is to divide the arcade in 3 segments: 1 anterior, from canine to canine, and 2 lateral. The teeth are aligned in the interior of each segment, then the segments are displaced with respect to one another using calibrated springs.

Before starting treatment, it is important to:

- set objectives:
  - displace the anterior segment together, so that the maxillary and mandibular centers coincide;
  - conserve arcade shape by avoiding friction;
  - conserve anchorage, as there is class II on the right;
- choose the most well-adapted means:

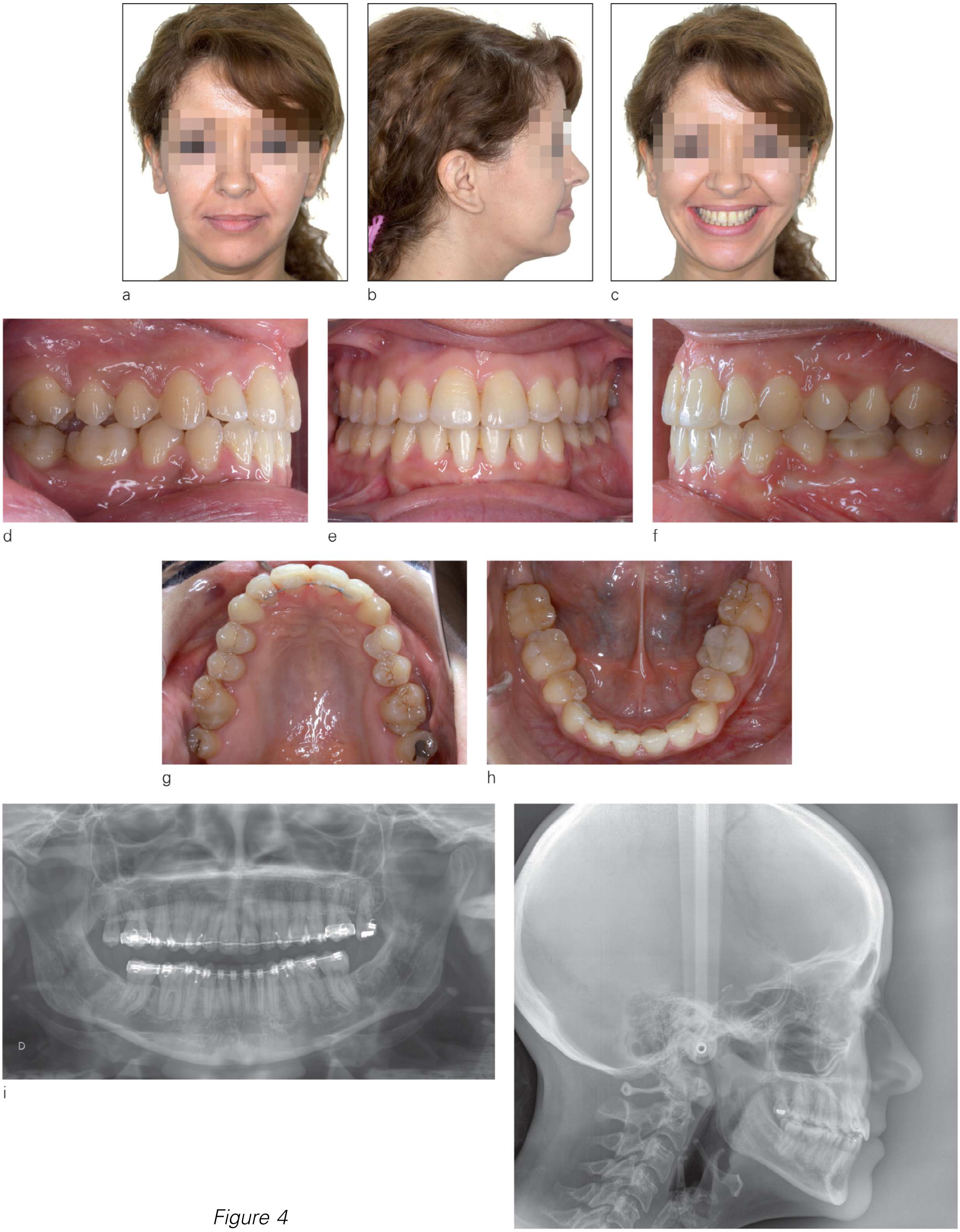
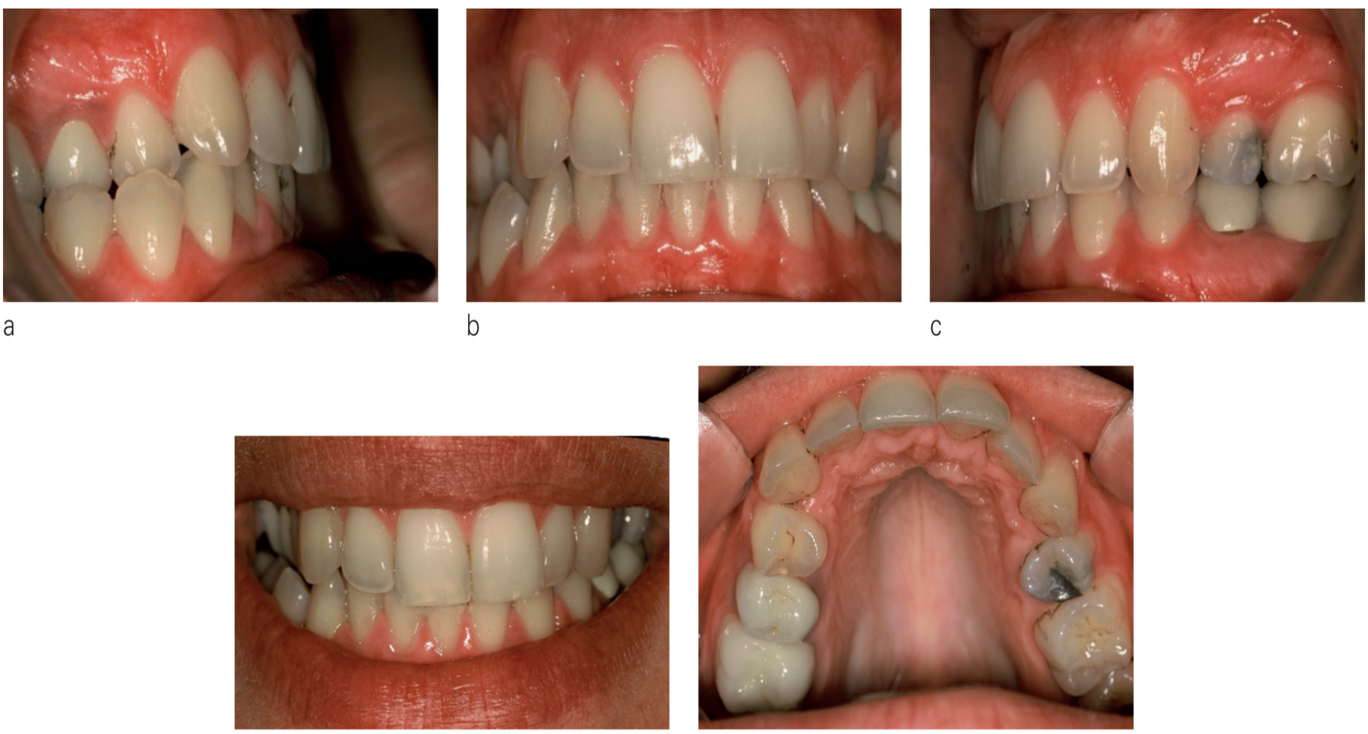


Figure 4
End-of-treatment examinations in case 1.

a b

Figure 5
a,b Photographs showing frontal tilt of the occlusion plane.



a b c

d e

Figure 6
Start-of-treatment examinations in case 2.

- segment the arcade, to isolate the teeth to be displaced;
- use traction mini-screws to create forces with optimal lines of action, avoiding all friction, and to conserve molar anchorage;

- draw up a treatment plan:
  - extraction of 15;
  - distalization and vestibular version of 14;
  - transverse recentering and unilateral distalization of the incisor-canine group.

First step of treatment: distalization and vestibular version of 14 in the 15 extraction space

A rigid arch connects 14 and 16, guiding the distalization of 14, which is performed by sliding the arch in the tube of 16. Force is applied between the mini-screw and 14 on a bracket, so as to approach the vertical level of the center of resistance of 14. A slight counterforce is applied to the palate, to prevent rotation. A transpalatine arch connects 16 to 26, to prevent any transverse movement of 16 (Figs. 7 to 10).

Once distal translation of 14 is achieved, the incisor-canine group has to be recentered rightward; this should be associated to correction of the occlusion plane tilt.

Figure 7
Lateral view of the premolar translation system at initiation of movement.

Figure 8
Occlusal view of the premolar translation system at initiation of movement.

Figure 9
Lateral view of the premolar translation system at end of distal translation.

Figure 10
Occlusal view of the premolar translation system at end of distal translation.

Second step: transverse recentering and unilateral distalization of the incisor-canine group

The six anterior teeth first have to be aligned and made level, using flexible arches. Intercanine width should be planned, to allow for the future shape of the arcade. Then the anterior sector needs not only to be drawn back unilaterally but also re-centered; two mini-screws are used to achieve this. The lingual attachments dimensions are .018 x .025; the .016 x .022 rigid steel arch holding the anterior segment allows very little play inside the attachments, thus avoiding individual tooth movement within the anterior segment; interbracket distance being shorter lingually, the load/flexion ratio of the wire is greater than if it had been applied to the vestibular facets. The anterior segment is connected to the posterior segments only via a metal ligature between the left maxillary premolar and 23, thus avoiding any space opening up between the two segments.

- 1st mini-screw: This is placed in palatine position between 12 and 13, at the level of the center of resistance of the anterior segment. The motor system consists of a chain between the mini-screw and a bracket approaching the center of resistance of the anterior segment, slightly toward the palate.

The force applied between the mini-screw and the bracket is shown in the diagram (Fig. 13) as the blue force line in the anterior segment. The equivalent system applied to the center of resistance comprises the red force line and a weak moment of anterior segment rotation, as the force passes slightly toward the palate from the center of resistance of the anterior segment (Fig. 13, red moment). This moment tends to worsen arcade asymmetry (Figs. 11 to 13).

Figure 11
Occlusal view showing use of 1st mini-screw.

Figure 12
Photograph of the .016 .022 steel arch positioned anteriorly.

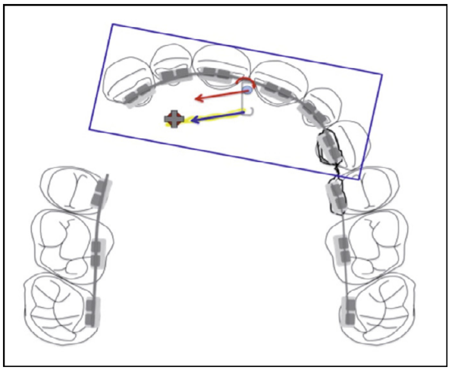


Figure 13
Diagram of the biomechanical system implemented, on occlusal view, by the force applied to the first mini-screw. The blue force line models the motor system, and the red force line and moment model the equivalent system applied to the center of resistance of the anterior segment.

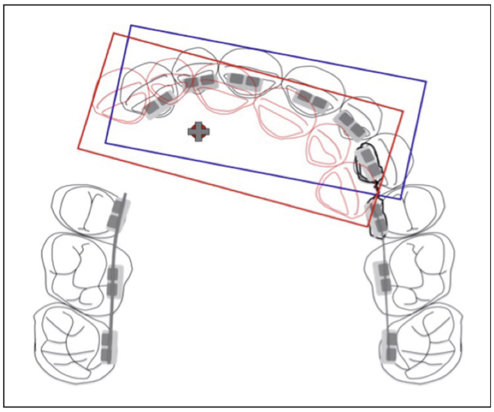


Figure 14
Movement of the anterior segment under the force applied to the first mini-screw. In blue, initial anterior segment position; in red, final position if only this force is applied

The movement obtained with the palatine mini-screw consists in a transverse movement of the anterior segment associated with slight rotation of the segment (Fig. 14).

- 2nd mini-screw: This is placed in vestibular position between 15 and 16. The motor system consists of a chain between the mini-screw and a bracket on 13 in vestibular position, at the level of the vertical of the center of resistance of the anterior segment, to prevent distal version. The force applied between the mini-screw and the bracket is shown in the diagram (Fig. 16) as the blue force line in the anterior segment. The equivalent system applied to the center of resistance comprises the red force line and a strong moment of anterior segment rotation, as the line of force is remote from the center of resistance of the anterior segment (Fig. 16, red moment) (Figs. 15, 16).

Figure 15
Lateral view showing use of 2nd mini-screw.

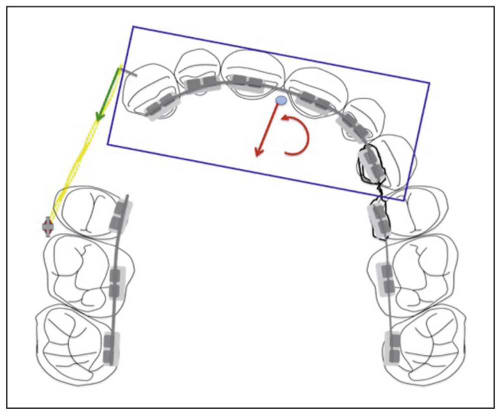


Figure 16
Diagram of the biomechanical system implemented, on occlusal view, by the force applied to the second mini-screw. The green force line models the motor system, and the red force line and moment model the equivalent system applied to the center of resistance of the anterior segment.

The movement obtained with the vestibular mini-screw is an anteroposterior movement of the anterior segment associated with strong rotation, as the distance between the point of application of the force and the

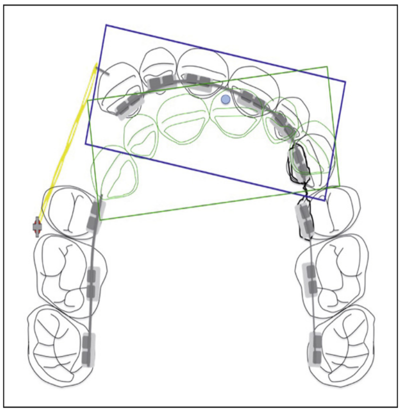


Figure 17
Movement of the anterior segment under the force applied to the second mini-screw. In blue, initial anterior segment position; in green, final position if only this force is applied

center of resistance of the anterior segment is great (Fig. 17).

The mini-screw is positioned higher than the point of application of the force on the bracket. The resulting force in the vertical direction thus includes an intrusive component. As it is applied well away from the center of resistance of the anterior segment, this intrusion force induces a moment that corrects the vertical obliqueness of the line of force (and thus the intensity of the vertical component), modifying the height of the bracket.

The vestibular mini-screw is thus intended to prevent undue transverse movement while at the same time closing the extraction space and correcting the obliqueness of the anterior occlusion.

The combination of the two forces thereby corrects the malocclusion (Fig. 18).

The force system is coherent: it allows improvement in both the transverse and vertical planes. The anterior occlusion plane obliqueness and non-concordance of the two centers were corrected in 4 months' treatment (Figs. 19 to 23).

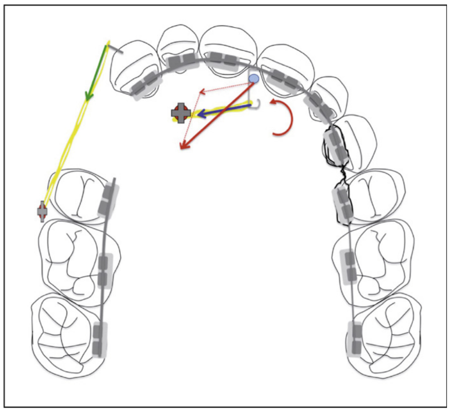


Figure 18
Blue force line: motor system induced by traction on palatine mini-screw. Green force line: motor system induced by traction on vestibular mini-screw. Red force line and moment: equivalent system art center of resistance. Dotted force lines: equivalent decomposed force at center of resistance.

The present clinical case highlights the advantage of using mini-screws: firstly, it avoided having to fit an apparatus to the anterior teeth. The correction time for incisor-canine

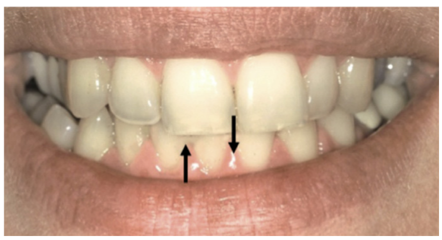


Figure 19
Photograph of smile at start of treatment, showing discrepancy between centers, of maxillary origin.

Figure 20
Photograph at end of treatment, showing concordance of incisor centers.

recentering and occlusion plane straightening (4 months) was also less than with a classic approach, thanks to the friction-free technique. And finally, the mini-screws prevented sector-1 posterior anchorage loss.

Precise biomechanical analysis of the forces deployed enabled side-effects to be made use of so as to obtain two simultaneous movements

a b

Figure 21
a) Frontal view showing frontal occlusion plane tilt at start of treatment. b) Frontal view showing frontal correction of occlusion plane tilt at end of treatment.

Figure 22
Photograph of smile at start of treatment.

Figure 23
Photograph of smile at end of treatment.

(coherent force system), considerably shortening treatment. Patient cooperation was at no point required.

It is clear that this kind of treatment plan depends on selecting a well-considered force system. The treatment plan has to be personalized and not automatic, which would inevitably limit treatment objectives in complex cases such as the present.

Conflicts of interest: The author declares no conflict of interest.

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