CHAPTER 11

The Flex Developer

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Design and Construction Features

The Flex Developer (FD) is a most powerful and indestructible noncompliance intermaxillary Class II mechanism (Fig. 11.1). The force of the FD arises from a 3.0 mm diameter (D) elastic polyamide minirod that is clipped on to a standard fixed appliance. The unique anterior hooklet module makes the FD adaptable to any length. The hooklet is relockable and allows the orthodontist to take the device out easily for adjustments.

Because of its ability to produce high intermaxillary forces, the FD can be compared in some respects with the Herbst appliance. Only a few millimeters of mandibular protrusion will instantly reduce the force to zero. As the therapeutic force vector runs mainly parallel to the occlusal plane, there are only minimal vertical side effects in clinical use.

The FD is customarily combined with a prebent bypass arch, which allows delivery of forces up to 1000 cN and gives additional stability. This bypass arch also has an antirotational and antitipping effect on the attached molar. But using the FD does not necessarily mean only using high forces. The possibility to reduce the FD's minirod diameter and therefore achieve lower forces (as low as 50 cN) for single tooth movements or for periodontal reasons is another outstanding feature.

Observed clinically, the FD produces up to 1.0 mm tooth movement per month with no particular patient cooperation.

Pulling or Pushing Class II Mechanics?

At first it may not seem that the difference between these two types of mechanics is particularly relevant, since it is clear that both aim at the correction of Class II situations. However, the effects are different and important.

Pulling intermaxillary Class II mechanics, such as elastics or closed superelastic coil springs, may lead to open bite situations due to the extrusion of teeth and an increasing force when opening the mouth. As extrusion happens much faster than intrusion, this is a common threat.

In contrast, *pushing* intermaxillary Class II mechanics have an intruding side effect on upper molars and lower anterior teeth. As mentioned above, this vertical effect (intrusion) is much smaller than the extrusion created by *pulling* appliances. At the same time, it must be realized that the greatest force levels in the pushing devices are achieved in the final stages of mouth closing and include therefore a significant horizontal component. Taking this one stage further, it is interesting to contrast the effect of the Jasper Jumper™ and the FD. Experiments and clinical evidence show clearly that the effect of the FD is similar to that of the Herbst appliance, whereas the Jasper Jumper develops its maximum force while the force vector is in a less optimal (more vertical) direction.

Using rigid constructions such as the Herbst appliance or the FD, an immediate decrease of force is observed when the patient moves the mandible forward or opens the mouth only slightly. Therefore the FD can be applied even in high angle Class II or in open bite cases (see Figs 11.20–11.36).

More than 2000 orthodontists are now using the FD because of its simple insertion and outstanding durability.

Indications and Contraindications for Use of the Flex Developer

Indications

- Class II correction of dental arches (removable or fixed appliances)
- Mesial movement of lower molars and premolars after extraction or in cases of aplasia

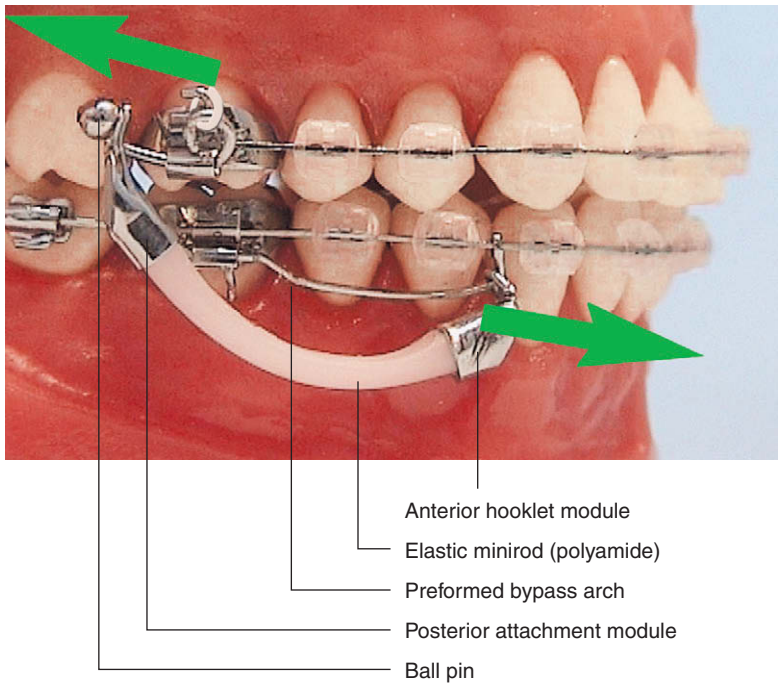


Figure 11.1 The general design and components of the FD system. The FD itself is attached to the bypass arch in the lower anterior region and the posterior part is attached from the distal side of the headgear tube on the maxillary first molar.

- Distalization of upper molars (headgear effect)
- Retraction of anterior teeth (upper molar anchorage)
- Protrusion of lower teeth (presurgical decompensation of Class III cases)
- Mandibular development (orthopedic effect)
- Midline correction (asymmetric use of FD)
- Unilateral dental Class II correction (unilateral FD)

Contraindications

- Proclination of lower incisors
- Steep occlusal plane
- Gummy smile
- Extreme anterior open bite

Excessive protrusion of the lower incisors will probably lead to loss of alveolar bone and gingival recessions. Especially in patients in whom these teeth are protruded prior to treatment, a further proclination represents a risk of instability and iatrogenic damage. In this context the thickness of the symphyseal area can give information as to how much the lower incisors may be protruded during treatment.[1–3]

Like any other intermaxillary treatment mechanism, the FD produces a slight tipping of the occlusal plane which could worsen a gummy smile. Nevertheless, worsening of these situations should be avoided.

History

The concept of jumping the bite is not new in Class II correction; in fact, it is nearly as old as orthodontics itself. The Herbst appliance was first presented by Emil Herbst at the International Dental Congress in Berlin in 1905 and reviewed in a later article.[4] After a long period of relative anonymity, the Herbst appliance experienced a revival in the 1970s[5] and, because of exhaustive research studies concerning its skeletal and dentoalveolar effects, is probably one of the most investigated and documented mechanisms in orthodontics. The original design of the Herbst appliance involved the creation of a strong, stable framework on which the telescopes, the active part of the appliance, were mounted. One of the disadvantages of the Herbst appliance is a relatively limited lateral movement, which results from the stiff telescopic system.

The Jasper Jumper was introduced as a flexible alternative, allowing better lateral movement and at the same time being used in conjunction with a standard fixed appliance. There is some discussion about the relationship of skeletal and dentoalveolar effects. An investigation by Weiland & Bantleon described a 40% skeletal and 60% dentoalveolar effect for the Jasper Jumper.[6] One of the drawbacks most frequently observed with this appliance was the risk of fracture. The soldered connection between the eyelets and the open coil represents a weak point where fracture is most likely to occur.[7] The need to stock various lengths, both for the left and right side, increases the risk of not having the right size available when needed. The applicable force is limited to approximately 250 cN (38 mm JJ) and cannot be reduced much.

In 1995, Dr Williams from the Royal Dental College, University of Aarhus, Denmark, presented for the first time an alternative device for jumping the bite (the Sagittal Developer), in which the rubber-coated spring of the Jasper Jumper was replaced by a polyamide minirod, eliminating the risk of fracture (S Williams, personal communication, 1995). The polyamide minirod was unbreakable, stable, and found to deliver a constant force. Williams also developed an adjustable anterior hooklet module to shorten the polyamide minirod to the patient's individual need. For easier insertion, this hooklet could be opened and relocked by the orthodontist. It was suggested that the appliance slid on a bypass arch as published earlier by Blackwood.[8] The anterior hooklet module of the Sagittal Developer at that time was not able to withstand the power development, often causing unexpected repair appointments. In spite of numerous successful clinical results, the reliability of the metal components was difficult to predict. The Williams sagittal developer was the first appliance on the market that could be shortened to any individual length and was able to deliver a high and continuous force.

Design and Use

In 1997, Winsauer optimized this concept by adding more than 18 improvements (Fig. 11.2). He redesigned the metal components

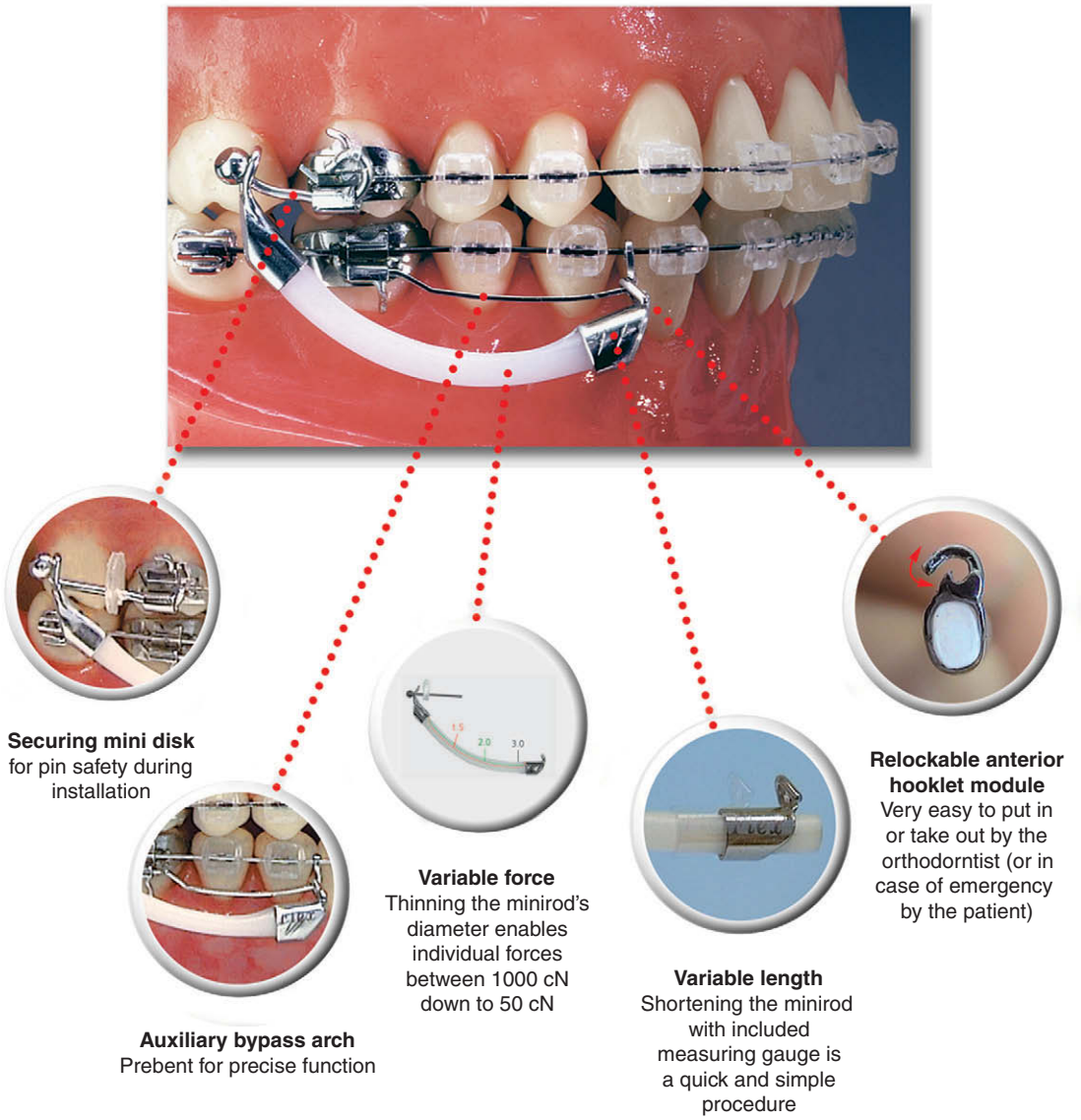


Figure 11.2 Features of the FD also have an antirotational effect on the attached molar.

and made them more reliable and functional. Plasma welding (no solder) guarantees long-lasting robustness along with inert quality. A *starterkit* for standardized and simplified insertion was added (Fig. 11.3). The adjustability of the appliance length was maintained, in that the anterior hooklet module could slide along the polyamide minirod and be fixed at an appropriate length. Moreover, Winsauer introduced the possibility of *reducing the minirod's diameter* in order to obtain an individually adjusted power range.

At this time a more powerful and color-stable polyamide material came into use. In order to avoid time-consuming and individual bending procedures, a *standardized prebent bypass arch* was added to each FD. The prebent auxiliary bypass arch has a precise form enabling optimal use. Besides letting the FD slide forward and backward, it also serves as an antirotational and antitipping device. Another well-liked feature of the FD is the *security disk* mounted on the posterior pin which eliminates the danger of a dropped pin during its insertion into the rear end of the headgear tube. Another security feature is the patient's ability to open the hooklet in case of emergency (claustrophobia, technical defect) and this way for convenience the FD can be hooked onto the upper archwire.

Due to the average insertion time being less than 4 minutes and the minirod being guaranteed to last a lifetime, the FD has become a widespread and highly accepted Class II intermaxillary treatment device. In addition to its high efficiency, the FD requires no compliance from the patient.

The appliance is offered for sale together with a starter kit of instruments, etc., which facilitates the fitting of the FD. Force adjustment is achieved by reducing the diameter of the polyamide rod (see Fig. 11.3). For this purpose a special Gyroform™ *grinding wheel* is included in the kit. This wheel is also able to produce a

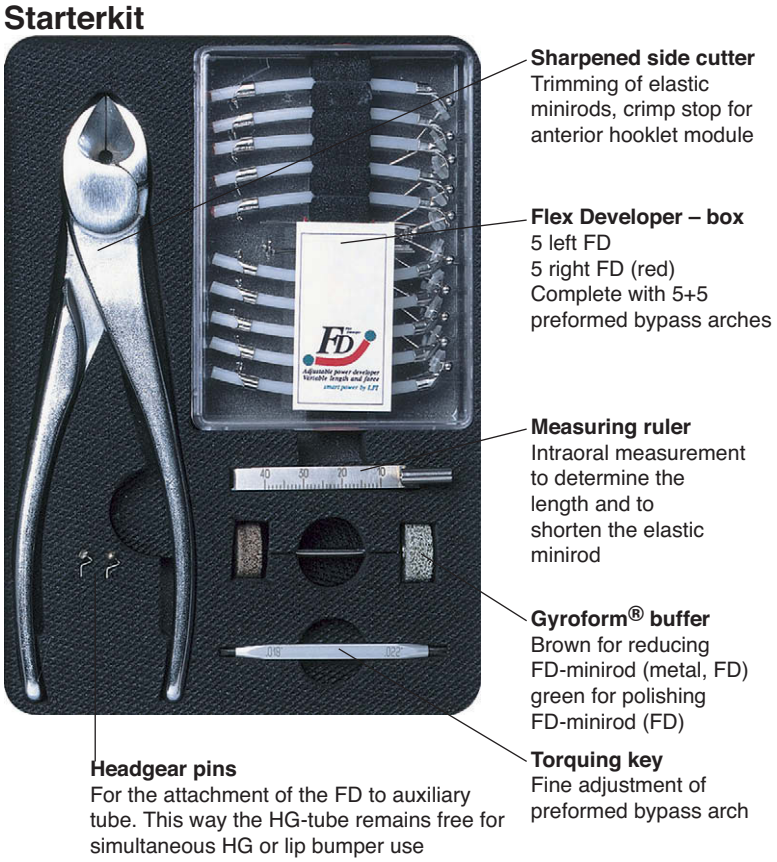


Figure 11.3 Toolbox with a set of FDs, cutter, ruler, gyroform grinding wheel, torquing wrench and headgear pins.

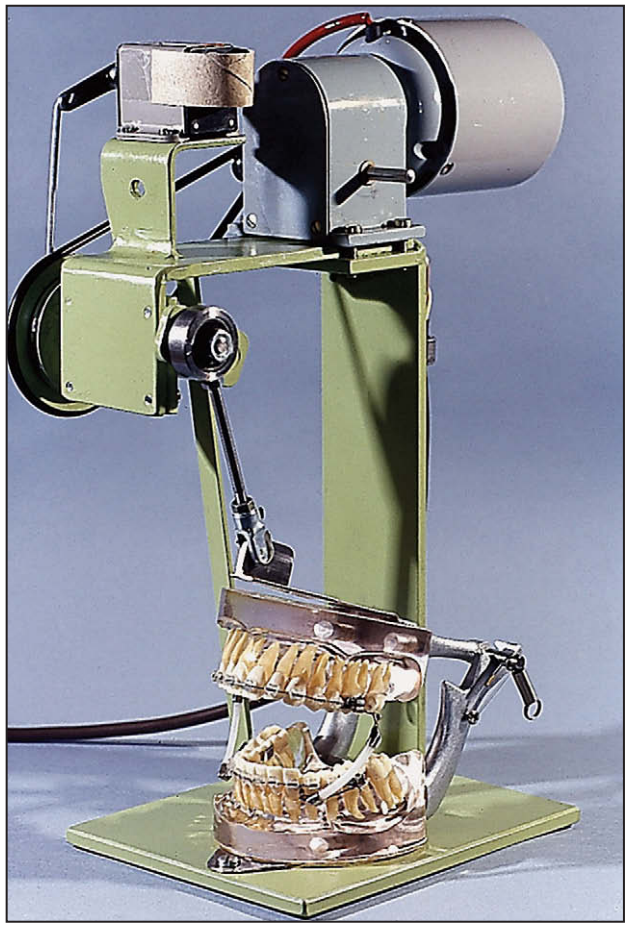


Figure 11.4 In an endurance test of over 2.5 million cycles, the FD showed virtually no loss of power (less than 5%). The test was performed in artificial saliva at 38°C.

smooth rounded finish to the end of the polyamide rod. The desired force can easily be measured with a Correx force gauge.

A *torquing wrench* is also included for fine adjustments of the prebent bypass arch. If the anterior end of the bypass arch and the hooklet module are too close to the gingiva, this wrench allows third-order bends in the posterior region without distorting other parts of this segmented arch.

A *ruler* enables intraoral measurements to determine the length of the elastic minirod and at the same time serves as a gauge to determine the appropriate length of the FD. It also ensures an automatic activation of the FD corresponding to 8 mm. An extra sharp *cutter* helps to shorten the minirod and to crimp the anterior module to the rod.

Durability of the Flex Developer during Occlusal Function

Two FDs underwent an endurance test of 2 million cycles (Fig. 11.4). One had a length of 36 mm and no reduction in diameter (3 mm). The initial force was set at 640 cN. The second FD was 38 mm long and its diameter reduced by 1 mm (diameter 2 mm). The initial force was set at 210 cN. Assuming a patient is opening and closing the mouth 8000 times per day, this would equal 250 days of continuous treatment time.

The bench testing was interrupted after 2 million cycles without failure or breakage (Fig. 11.5). After this test the force reduction of the FD (original diameter 3 mm) was less than 5%. The reduced FD (2 mm) showed no change of elasticity.

Comparison of Different Noncompliance Class II Treatment Appliances

Due to the possibility of adjusting the FD's resilience to any amount between 50 and 1000 cN, a wide range of treatment applications is possible. These findings encourage the use of the FD in numerous types of appliances in removable and permanent orthodontic treatment techniques.

All measured samples were 38 mm in length (Fig. 11.6). In Figure 11.6, the yellow curve displays the rapid increase of power typical for rigid Herbst telescopes. The red lines represent the spectrum of force of three FDs with different diameters (3 mm, 2 mm, 1.5 mm). Note that a 38 mm FD (D 3 mm) develops 300 cN (approximately 300

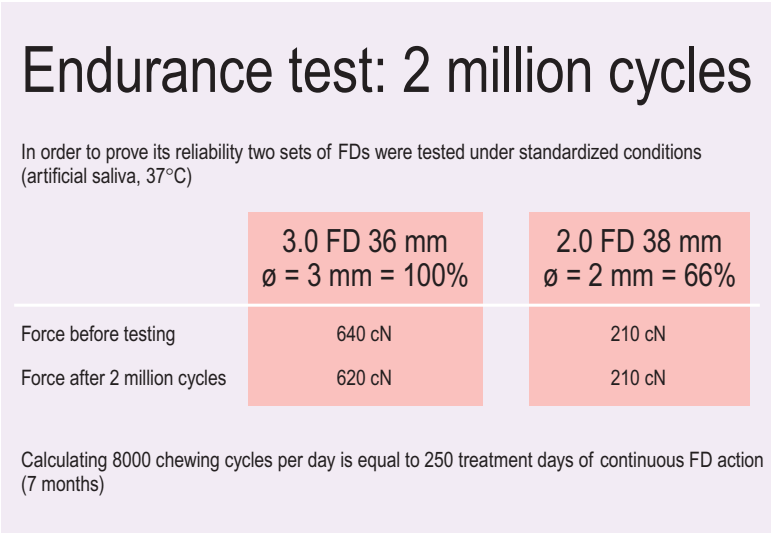


Figure 11.5 The results of bench testing of the FD.

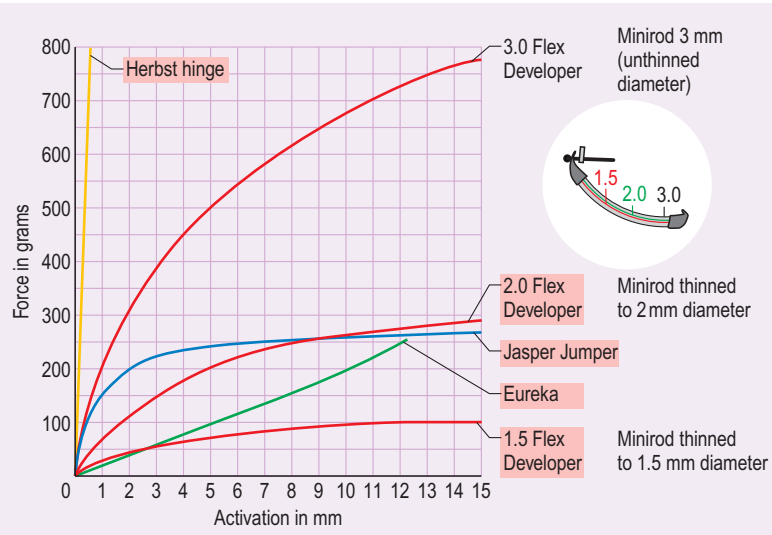


Figure 11.6 Comparison of force values of the Herbst appliance, Jasper Jumper, Eureka Spring and FD (all 38 mm length).

pond) after only 2 mm of activation. The blue line is the Jasper Jumper, quite similar to a FD with a diameter of 2 mm. The smooth and gradual ascent of the green curve is typical of the Eureka Spring.

It is important to know that the use of shorter FDs will cause higher treatment forces and therefore steeper ascents of all red curves (see FD instruction manual, available at: www.flexdeveloper.com).

Because of the greater stiffness of the FD, there is good reason to assume that the skeletal effect is higher than that of the Jasper Jumper or other Class II pushing devices.[6]

Clinical Use

The following is a short review of the FD fitting process. Prior to insertion of the FD, the dental arches should be well aligned and full-sized rectangular stainless steel wires should be fitted. An exception to this rule could be the case of anterior maxillary crowding, where the crowding is to be relieved by distal movement of the maxillary molars using the FD.

Before installation, the little hook of the lower molar attachments should be bent forward, caudal and gingivally. This way, the sticking of the elastic minirod under the molar attachment is avoided.

Bypass Arch

Insert the prebent bypass arch so that its hooklet is situated on the treatment arch between the lower canine bracket and the lower first premolar bracket. The position of the hooklet of the bypass arch is critical. Where the appliance is to induce forward tipping of the mandibular incisors and canines, e.g. in the decompensation of the mandibular arch in Class III cases, the hooklet of the bypass arch may rest against the canine bracket and the distal end of the bypass arch must remain straight (see Fig. 11.62). However, if forward tipping of the lower anterior teeth is to be avoided, the hooklet must not touch the canine bracket and the distal end of the bypass arch should be bent coronally to avoid the arch slipping forward. Using the fine three-prong pliers, a step bend is made and the hooklet is closed with a Weingart plier.

This way the anterior part of the bypass arch is able to move forward, making space closure or anterior movement of posterior teeth possible. The bypass arch also serves as an antitipping and antirotational device for the lower first molars. If spaces are to be closed during treatment (aplasia), the bypass arch will be shortened continuously by pulling it through the auxiliary tube, while moving the step bend more anteriorly.

Determining the Length of the FD

The distance between the anterior surface of the headgear tube and the anterior end of the bypass arch is measured with the FD ruler. The FD is thereafter inserted into the tube of the ruler, so that the posterior module lines up with the number that was just measured. The excess minirod is cut off and the anterior module slid forward into position and crimped with the side cutter. The use of this ruler assures an automatic activation of the FD corresponding to 8.0 mm. Now the FD is at its ideal length and can be inserted into the mouth.

Activation During Treatment

There are four different ways to activate the FD:

- shortening of the bypass arch
- shortening of the pin in the headgear tube

- placing a stop (composite resin) at the anterior part of the bypass arch
- use of a longer FD.

Further details are given in the instruction booklet (available at: www.flexdeveloper.com).

Case Studies

Patient 1 (Figs 11.7–11.12)

A 15-year-old girl showing dental Class II with increased overjet of 8.0 mm, poor vertical overlap (0.0 mm) and spaces in the upper incisor region. Cephalometrically, a slight protrusion of the maxillary incisors was observed (112°) and a slight increase in mandibular plane angle (Figs 11.7–11.10). The patient was treated using the FD for 6 months, retracting the upper incisors and normalizing canine relationships. Note the overcorrection before removing the FD, which is generally recommended for this type of treatment. The results in Figure 11.11 show good sagittal relationship and space closure. The patient obtained a FD-splint positioner with integrated headgear tubes and bypass arches as an active removable retainer (Fig. 11.12).

Patient 2 (Figs 11.13–11.19)

This patient, a very athletic 38-year-old man, asked for treatment because of increasing discomfort in the TMJ and continuous enamel abrasion on his anterior teeth. The Class II malocclusion was slightly more severe on the right side than on the left (Figs 11.13 and 11.15). The lateral cephalometric radiograph revealed no skeletal discrepancy but obvious retroclination of the maxillary incisors (81°) (Fig. 11.14). Treatment was started using fixed appliances initially with maxillary incisor torque using the torquing rod technique.[9] The functional freeway space thus created permitted dentoalveolar correction of the Class II situation using the FD. The force applied was 350 cN per side (Fig. 11.16).

Immediately after the removal of the FD, a good relationship was observed (Fig. 11.17), which later settled to a perfect Class I. After treatment the patient's dentist started to reconstruct the original cusps of the buccal teeth. The lateral cephalometric radiograph and analysis showed a good inclination of the maxillary incisors (108°) together with a moderate protrusion of the lower incisors (Fig. 11.18).

Note that directly after the FD was placed in the mouth, the patient was encouraged to eat a piece of apple to experience the reliability of the appliance (Fig. 11.19).

Patient 3 (Figs 11.20–11.36)

The patient was a 22-year-old woman with an open bite and contact only in the posterior region. The upper central incisors were root-filled and restored with crowns after previous trauma (Figs 11.20, 11.21, 11.24 and 11.25). The lateral cephalometric analysis (Figs 11.22 and 11.23) demonstrated a slight increase in the vertical jaw relationship and a moderate ANB discrepancy (4°). Due to a relatively large mandible and tongue, it was planned to expand the maxilla to permit correction of the buccal occlusion. During the 6 month period of rapid maxillary expansion, posterior bite plates were used in addition to a vertical chin cap (Figs 11.26 and 11.27). Tongue function was modified by a combination of increased bite opening (bite blocks of the RME device) and logopedic training support.

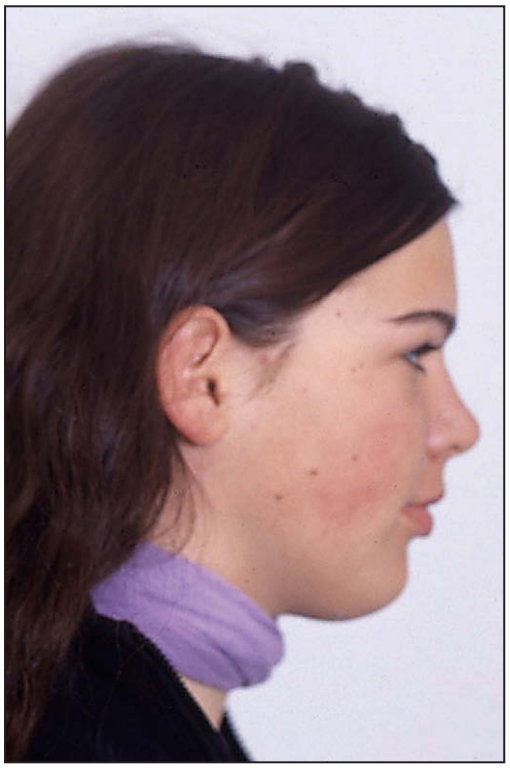
After removal of the rapid maxillary expansion device and dental arch leveling, the left side was in Class I occlusion, although the right side was still in ½ premolar-width Class II relationship. A unilateral FD was used for the correction (Figs 11.28 and 11.29). Figure 11.30 shows the situation before removal of the FD. As already mentioned above, the vertical side effect of the FD is negligible. The minor bite opening in the right buccal region closed 3 weeks after removal of the FD. Figures 11.31–11.34 show the patient at the end of treatment. The lateral cephalometric analysis demonstrated the tremendous changes (Figs 11.35 and 11.36). The comparison of the two analyses shows a slight distalization of the maxillary molars with mild protrusion of the lower incisors.

Patient 4 (Figs 11.37–11.56)

This patient was a 15-year-old girl with a Class II, division 1 malocclusion with protrusion and crowding in the maxillary arch. The lower right second premolar was aplastic and the lower right first molar was mesially tipped. There were large restorations in the first molars (Figs 11.37–11.42). The panoramic X-ray (Fig. 11.43) confirmed the presence of upper third molars, although both lower ones appear to be impacted. The lateral cephalometric analysis revealed a high angle situation and an apparently small maxillary apical base.

The treatment plan included extraction of the upper first premolar on the right side, showing a one premolar-width Class II relationship, and extraction of the upper left first molar, because of the deep filling and ½ premolar-width Class II on the left side. The lower right first molar was to be moved upright and the space anterior to it closed (Figs 11.43 and 11.44). Using segmental arches, spaces were closed with the upper right first molar serving as anchorage. This tooth moved a little too far mesially. On the other side, the upper left first molar moved forward, losing anchorage as well. Somewhat later, as a result of the very deep restoration, a pulpitis developed by the upper right first molar and the treatment plan was modified so that this tooth had to be extracted (Fig. 11.45). At this point it was decided to extract the lower first molars as well, because of the large restorations and the presence of well-shaped third molars (Fig. 11.46).

Later, after eruption of the second molars, intense FD treatment was performed for space closure in the lower arch and to achieve a Class I canine relationship. The force was adjusted to 350 cN, reactivating the FD 1.0 mm every 4 weeks. Note the elongated bypass arch extending underneath the canine bracket (Figs 11.47 and 11.48),



Figures 11.7–11.12 Case 1, Patient LO. Profile view before treatment.

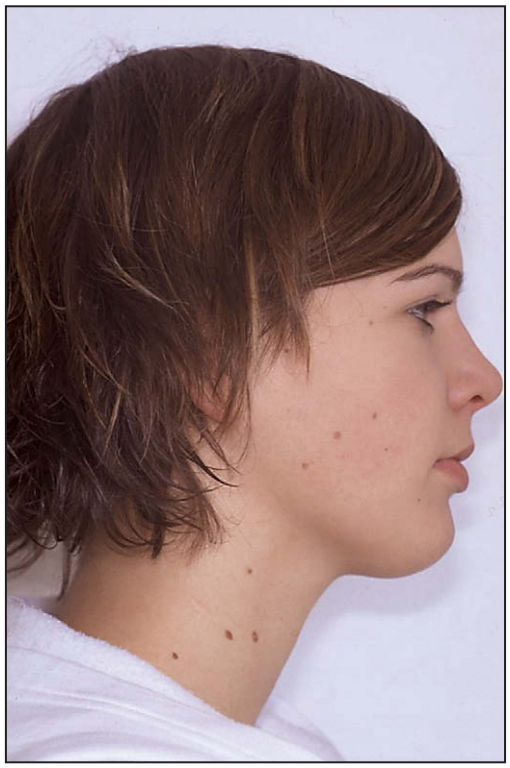


Figure 11.8 Profile view after treatment.

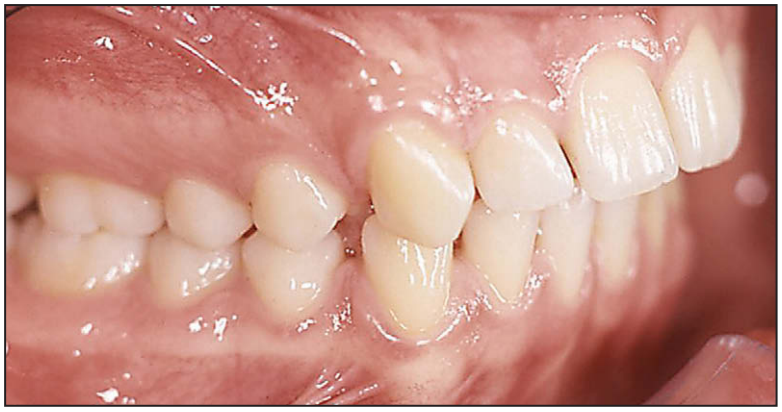


Figure 11.9

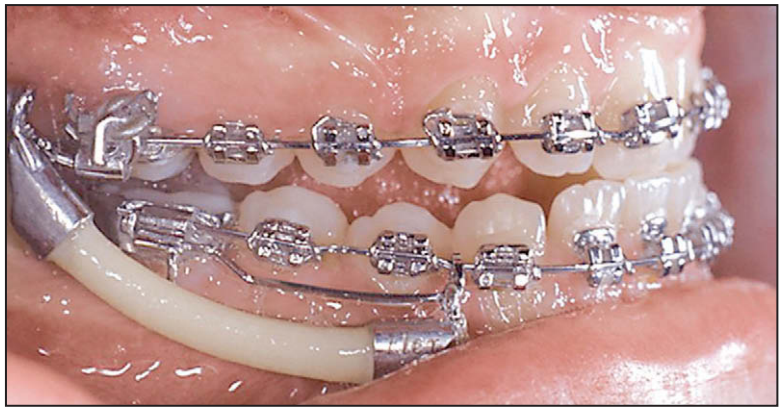


Figure 11.10

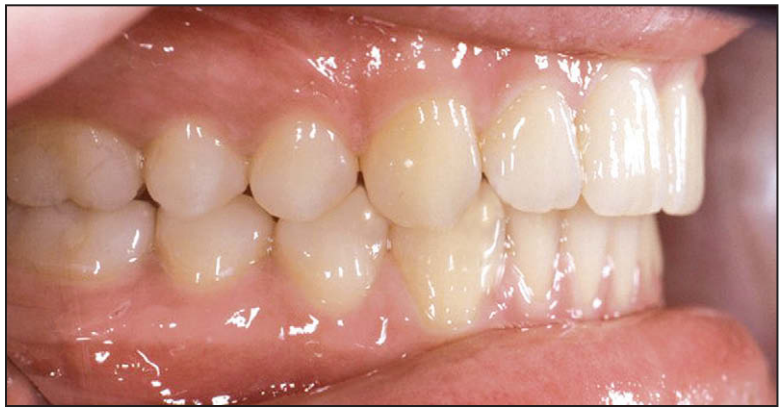


Figure 11.11

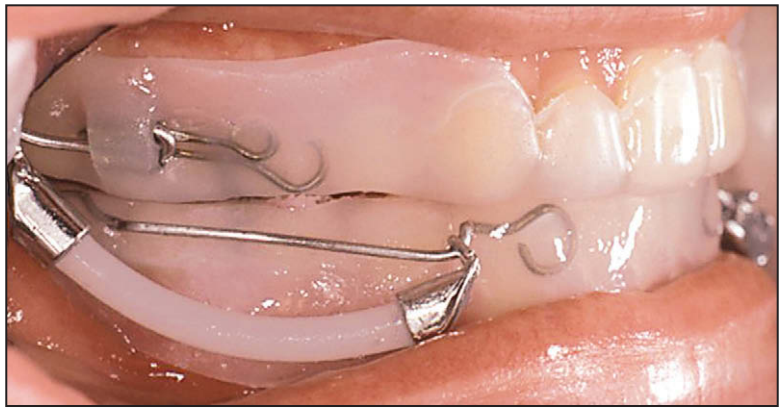
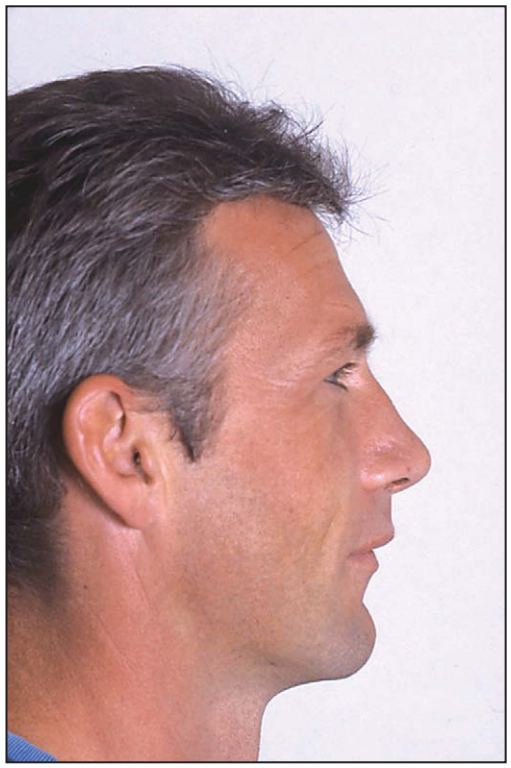


Figure 11.12



Figures 11.13–11.19 Case 2, Patient HR.

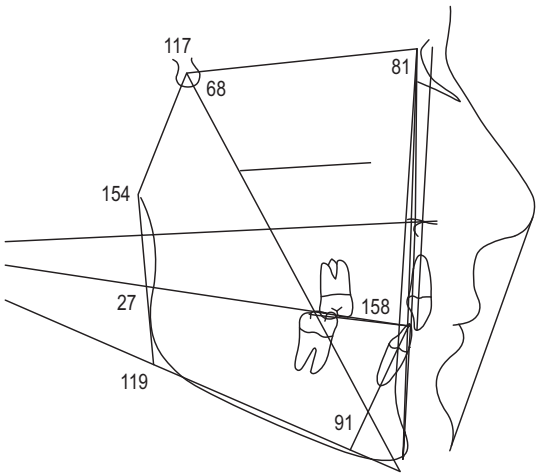


Figure 11.14

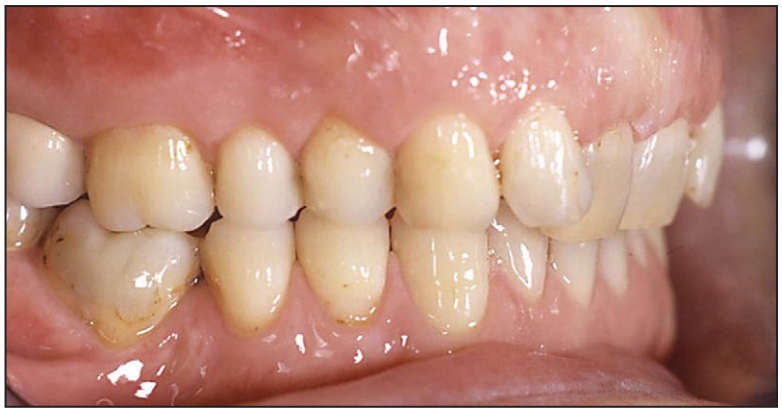


Figure 11.15

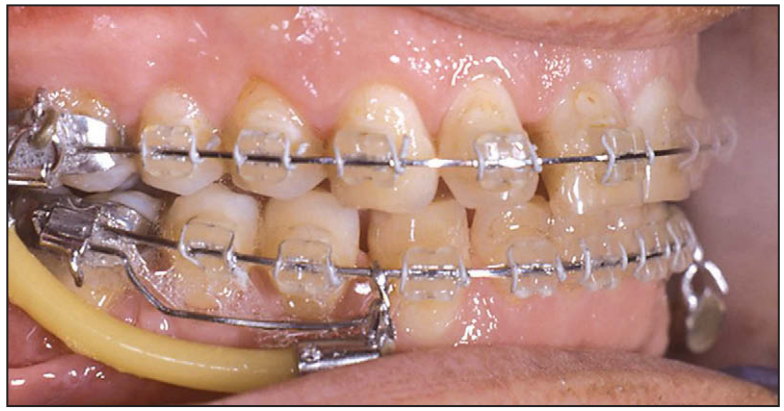


Figure 11.16

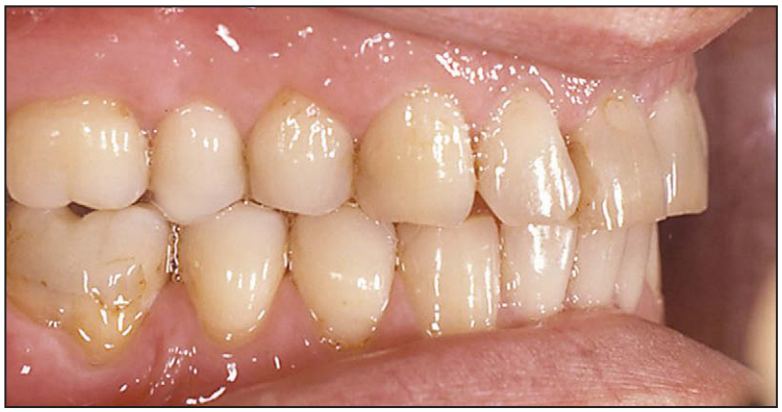


Figure 11.17

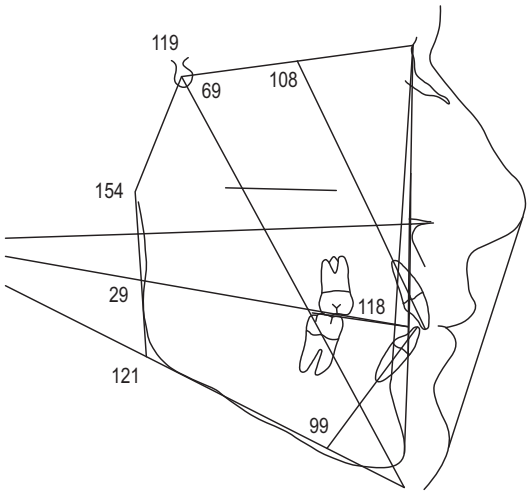


Figure 11.18

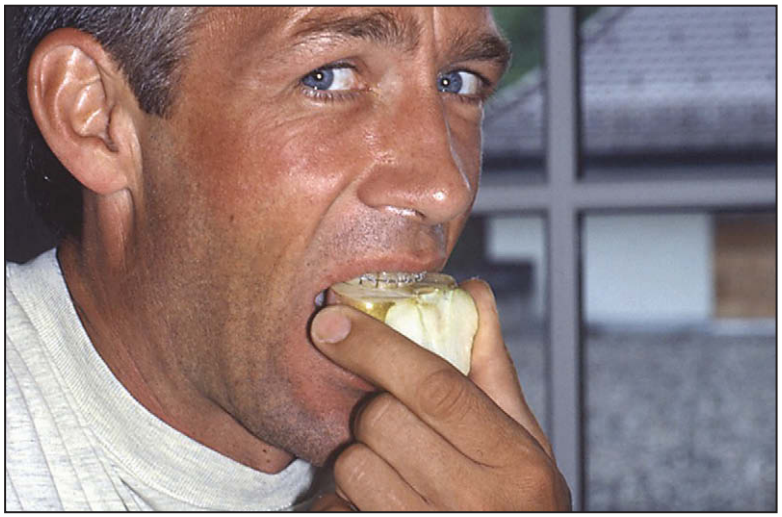


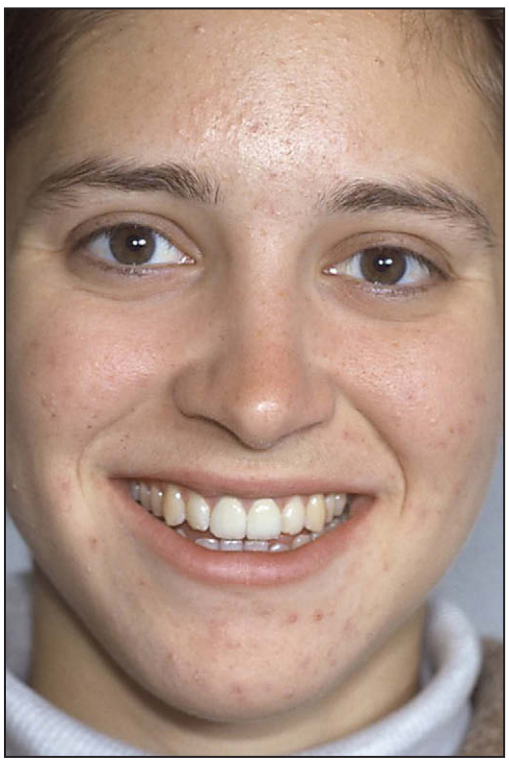
Figure 11.19

giving the FD a longer range of action. A splint positioner with bypass arches and FDs created a reliable active retention device (Fig. 11.49). The results are shown in Figures 11.50–11.56 with harmonious dental arches in Class I relationship.

Patient 5 (Figs 11.57–11.69)

A 44-year-old man presented with severe mandibular prognathism and reversed overjet before presurgical orthodontic treatment (Figs 11.57–11.61). The lateral cephalometric radiograph (Figs 11.58 and 11.59) demonstrated severe retrusion of the mandibular incisors. Therefore a presurgical decompensation was necessary at the same time as the buccal teeth were moved mesially. Two FDs, each delivering a force of 340 cN, were applied over a period of 5 months (Figs 11.62 and 11.63). In Figure 11.62 it can be seen that spaces anterior to the first molar have been developed, since the entire force was pushing on the canine bracket. Space closure was performed by continuously shortening and retracting the bypass arches. Figure 11.64 demonstrates the robustness of the elastic minirods as in such treatments continuous abrasion through adjacent brackets is common. The treatment was completed with only one set of FDs. These pictures demonstrate the presurgical decompensation.

The posttreatment results are presented in Figures 11.65–11.67. The lateral cephalometric radiographs and the comparison of the analyses reveal the change in lower incisor angulation from 66° to 85° (Figs 11.68 and 11.69).



Figures 11.20–11.36 Case 3, Patient CZ.

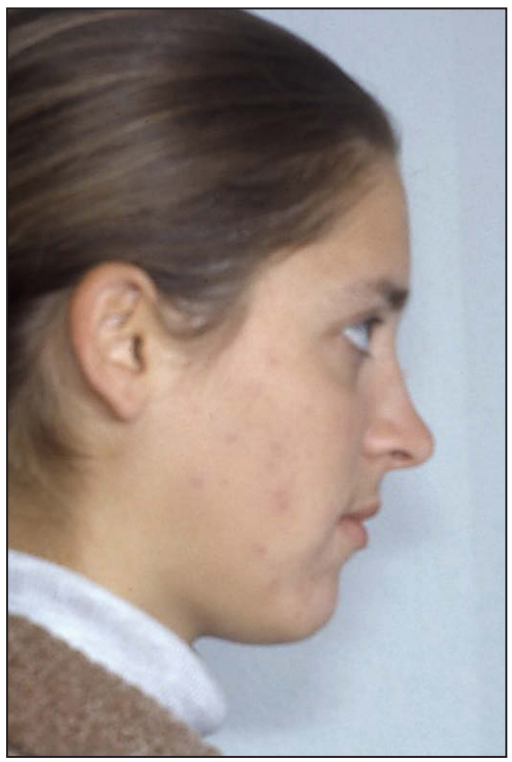
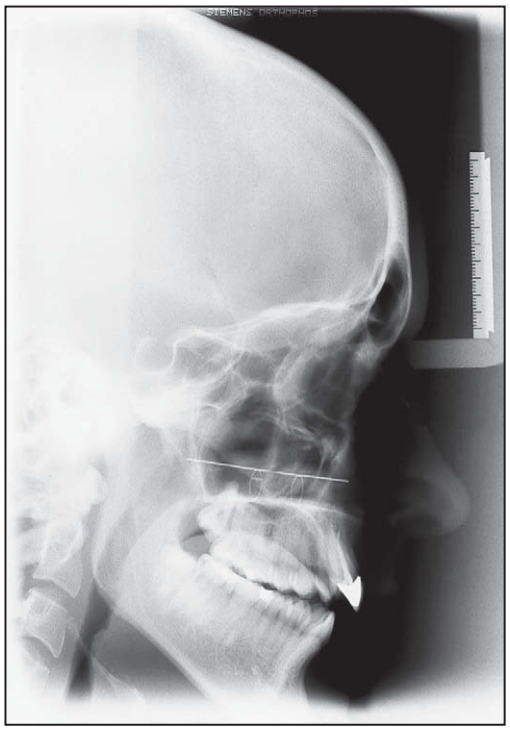


Figure 11.21



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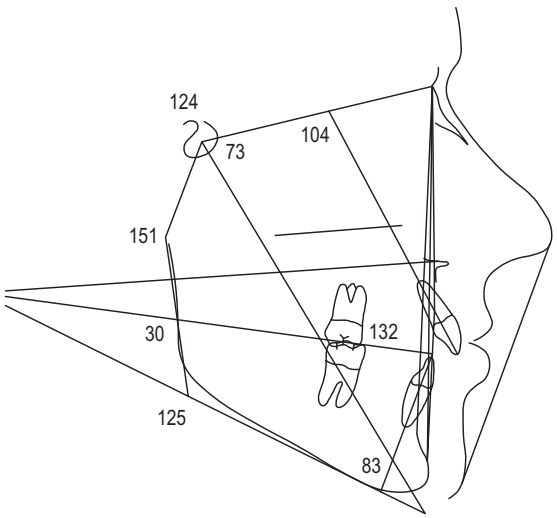

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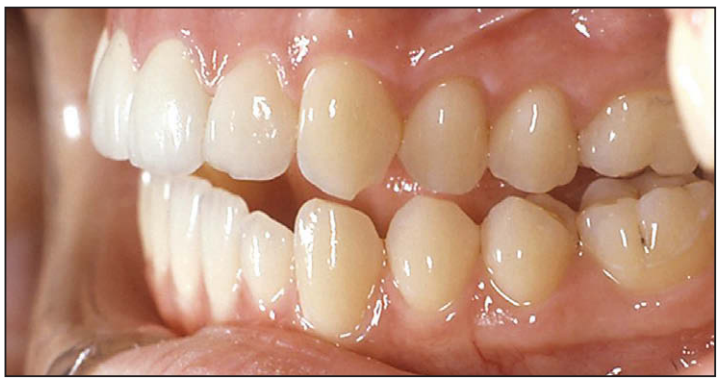

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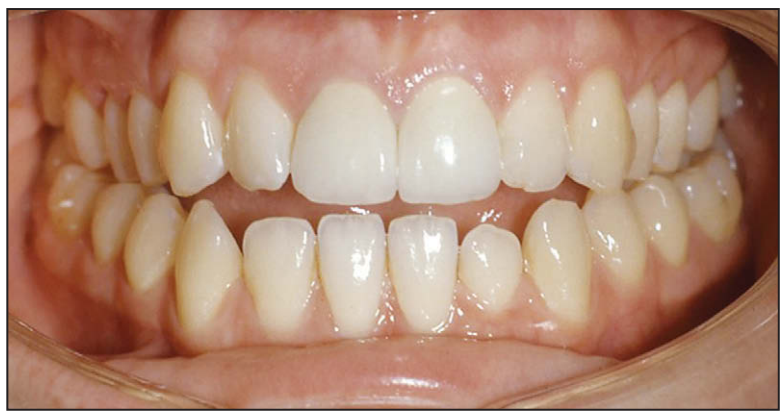

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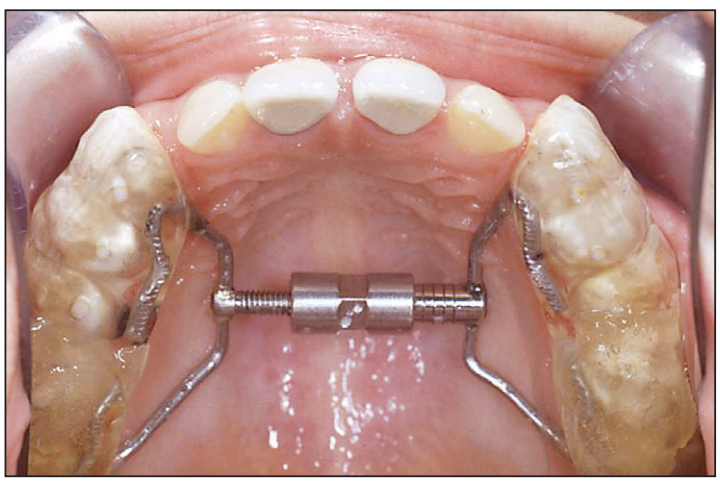

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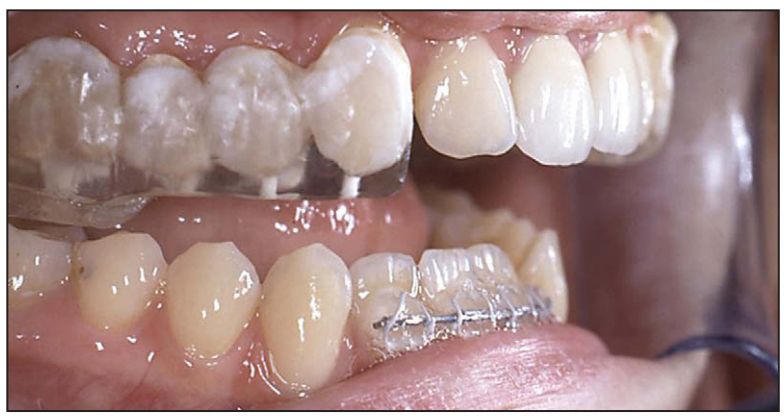

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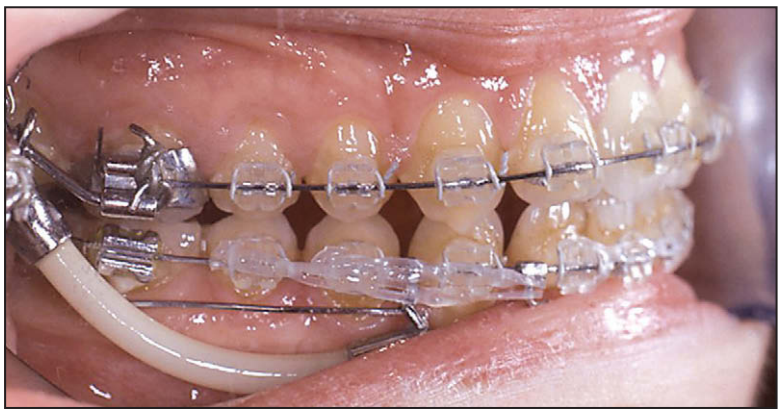

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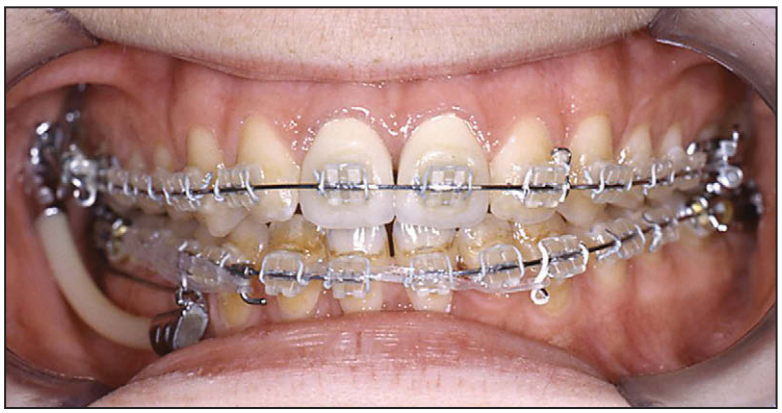

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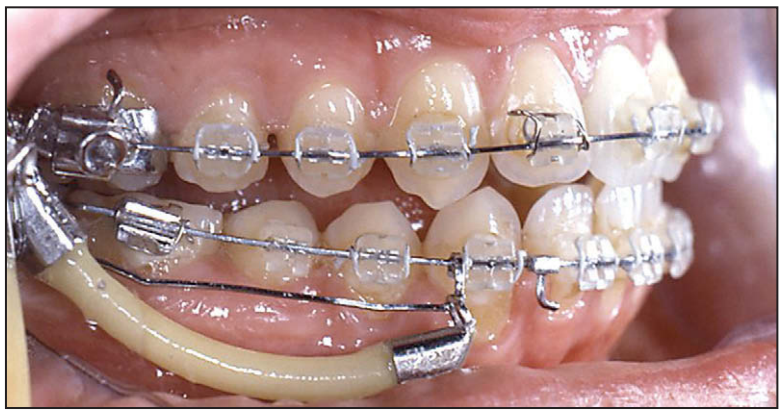

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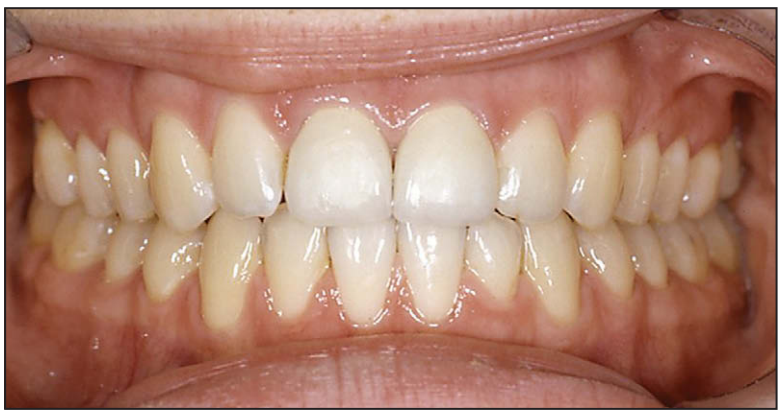

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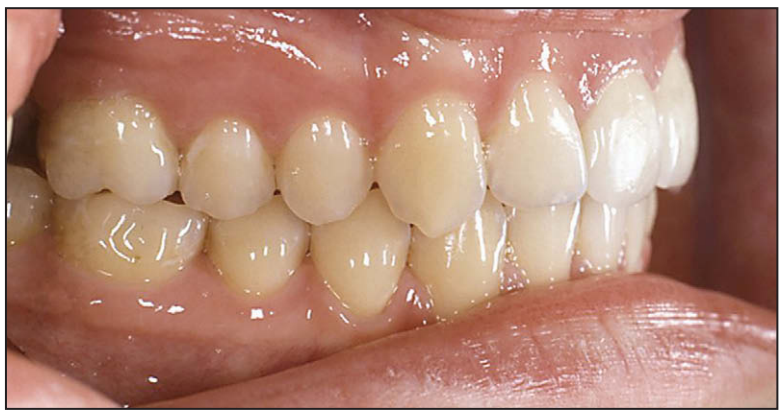

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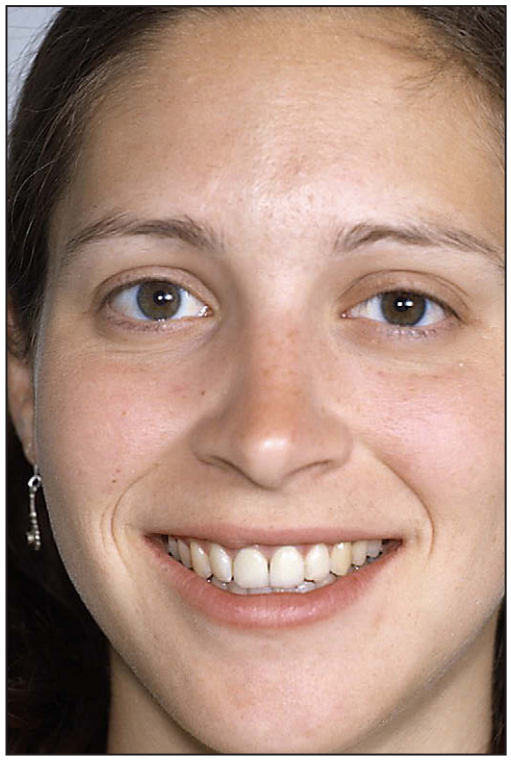

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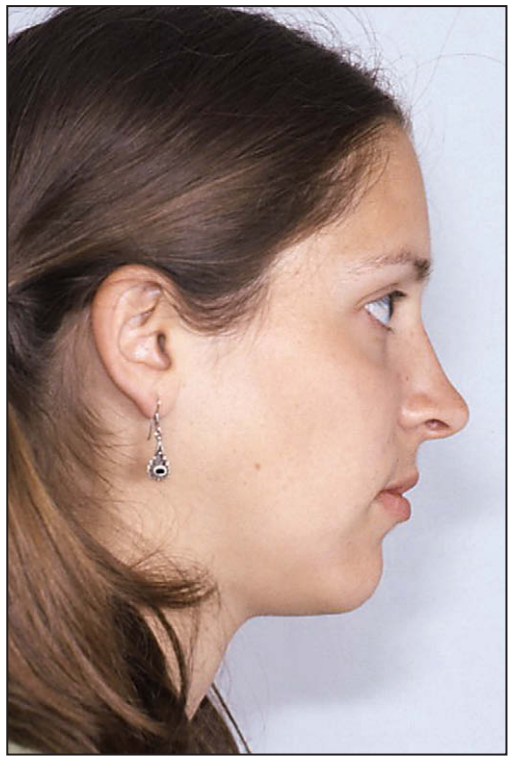

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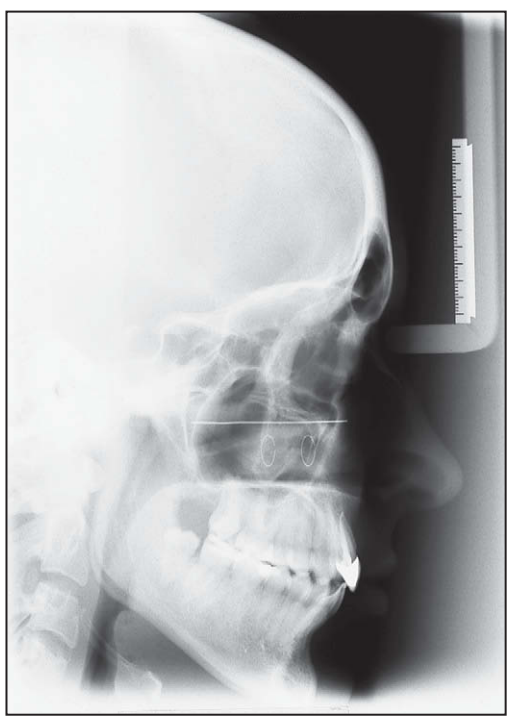

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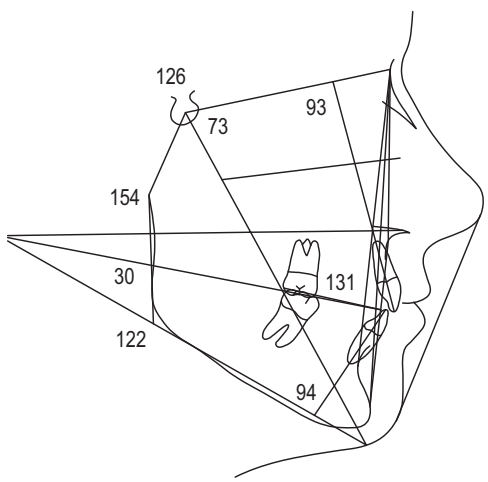

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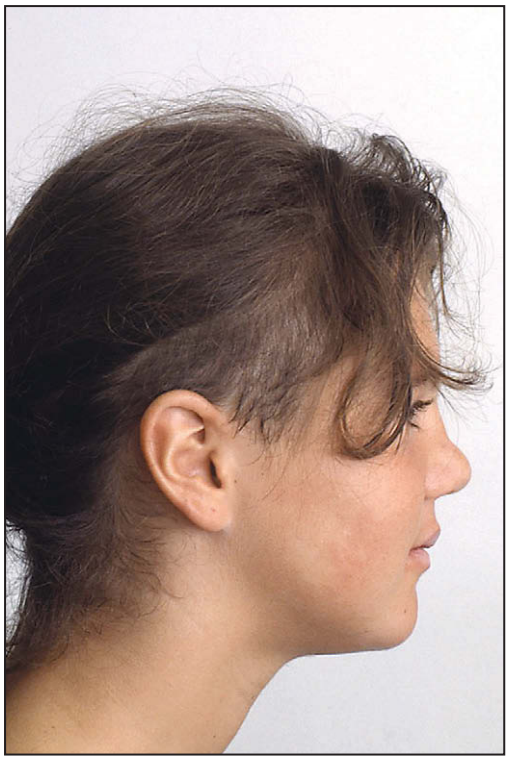
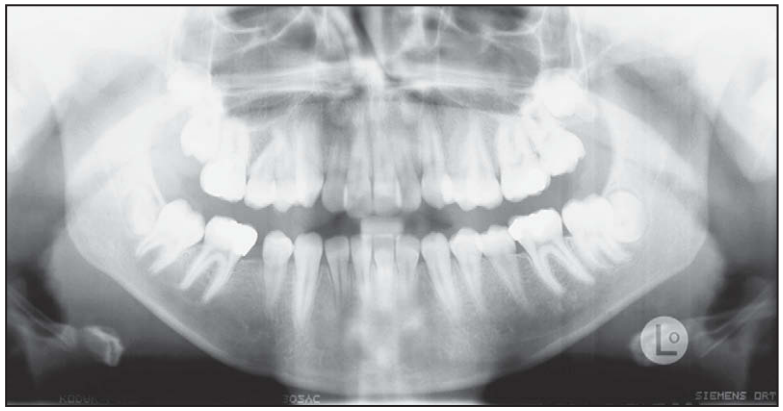


Figures 11.37–11.56 Case 4, Patient MG.



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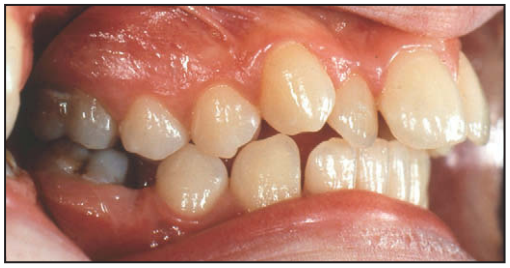

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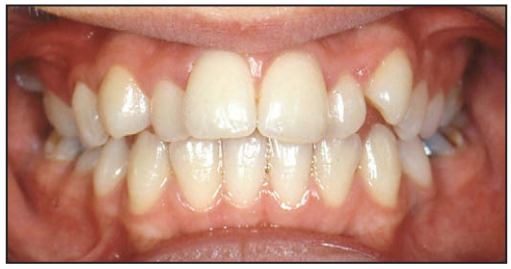

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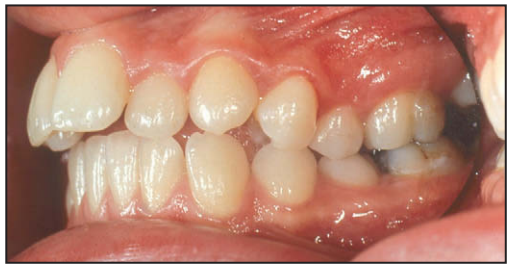

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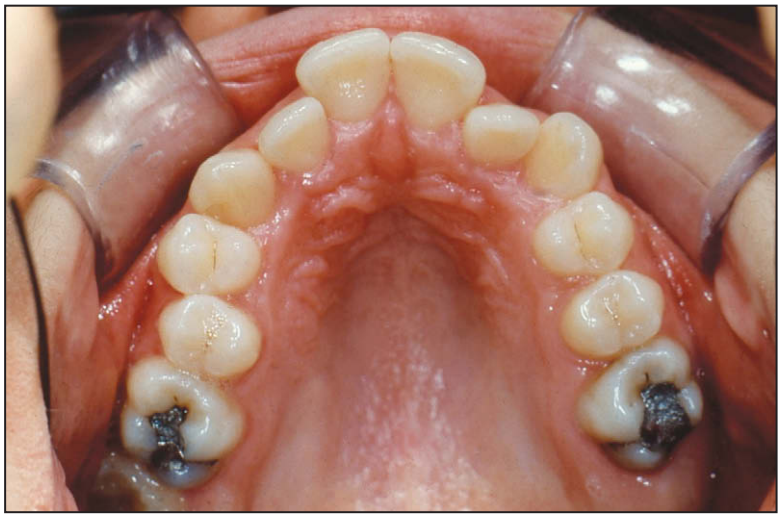

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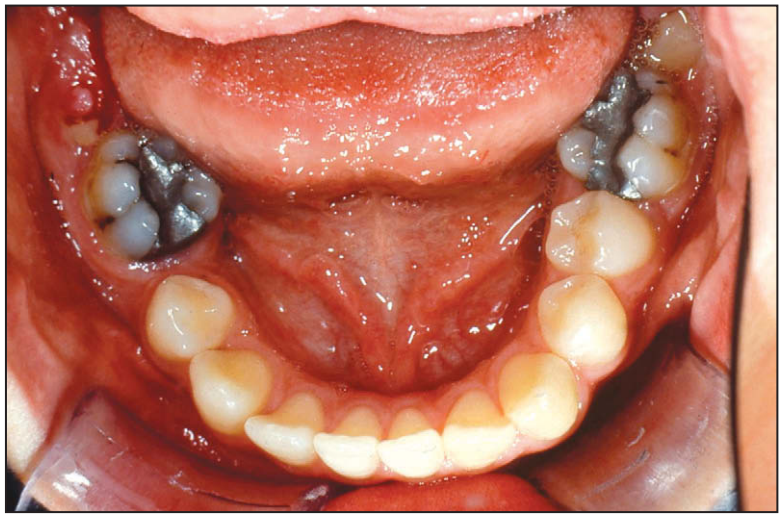

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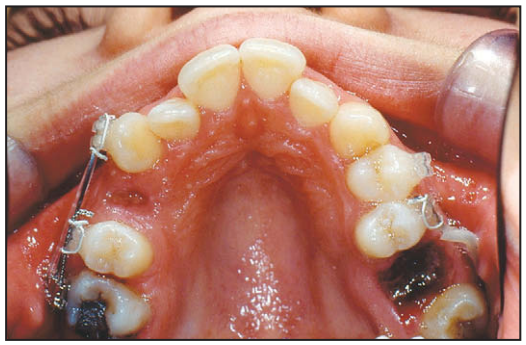

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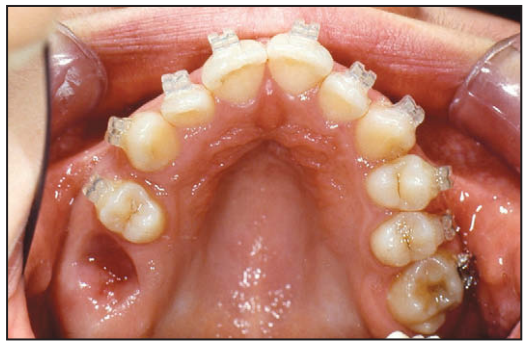

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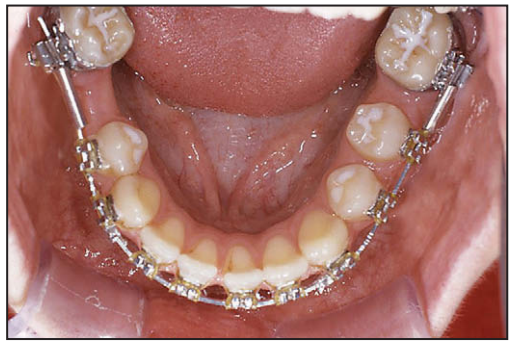

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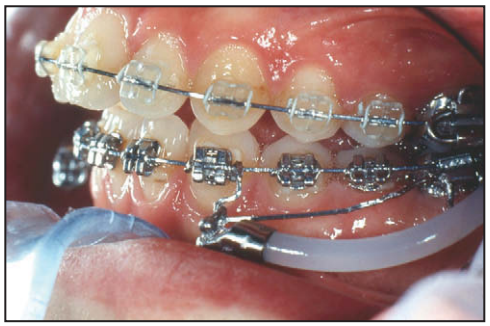

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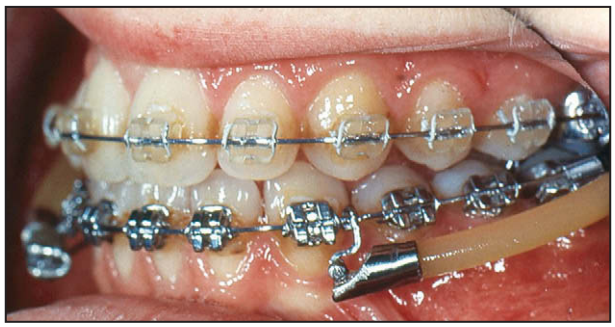

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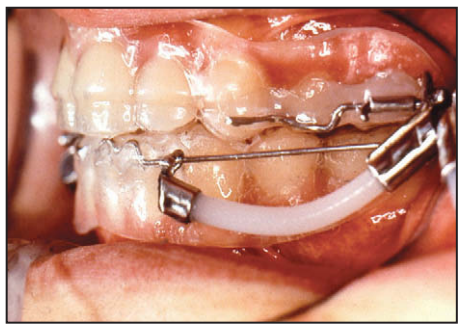

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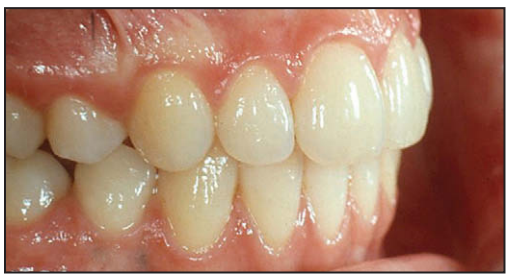

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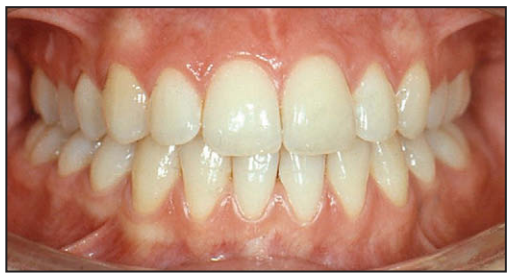

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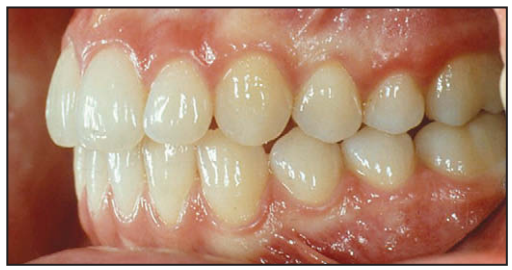

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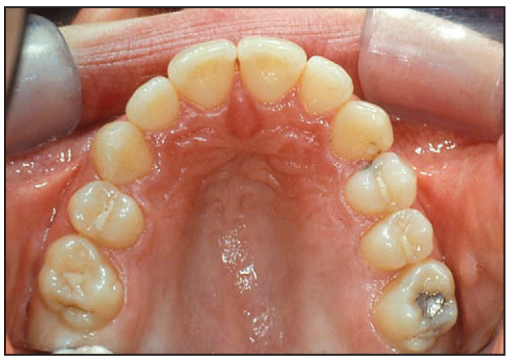

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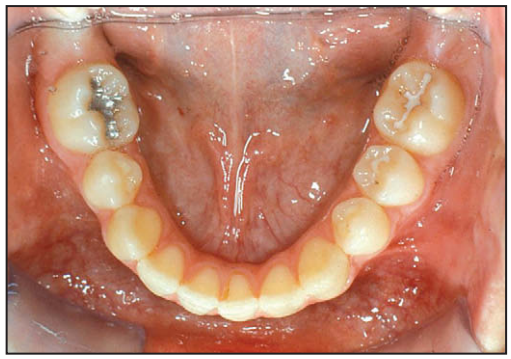

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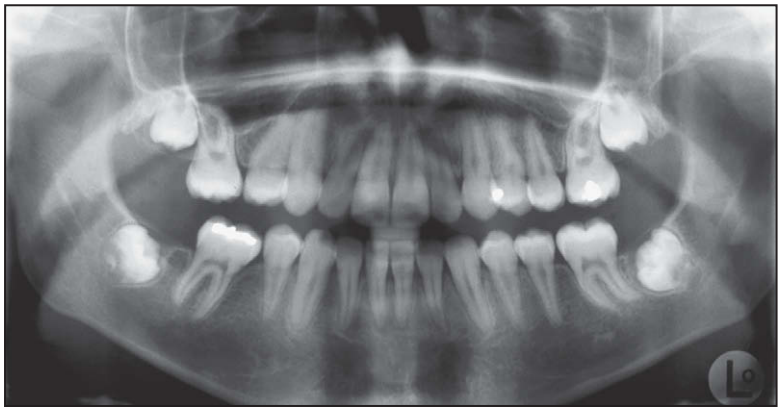

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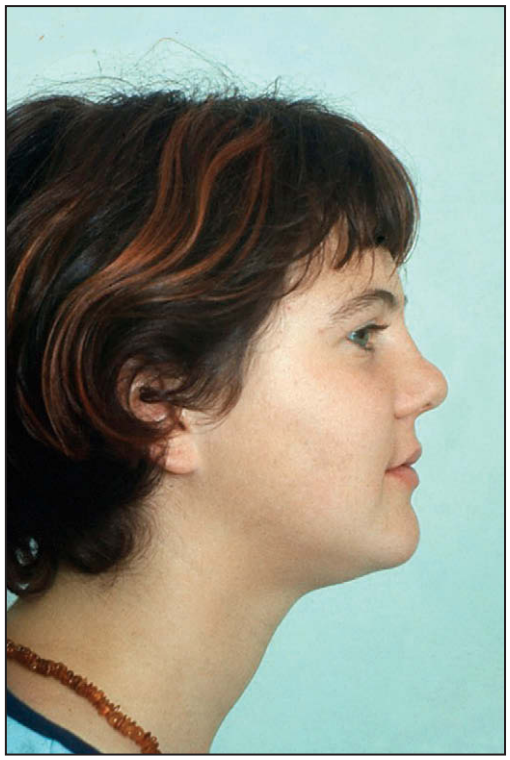

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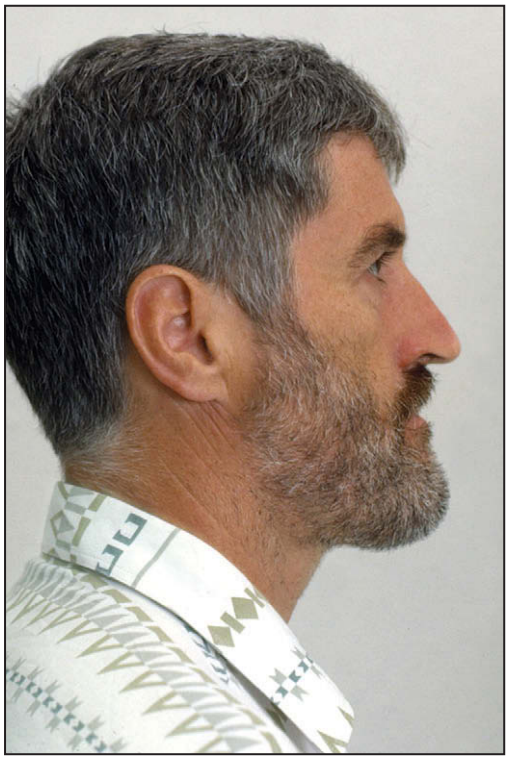
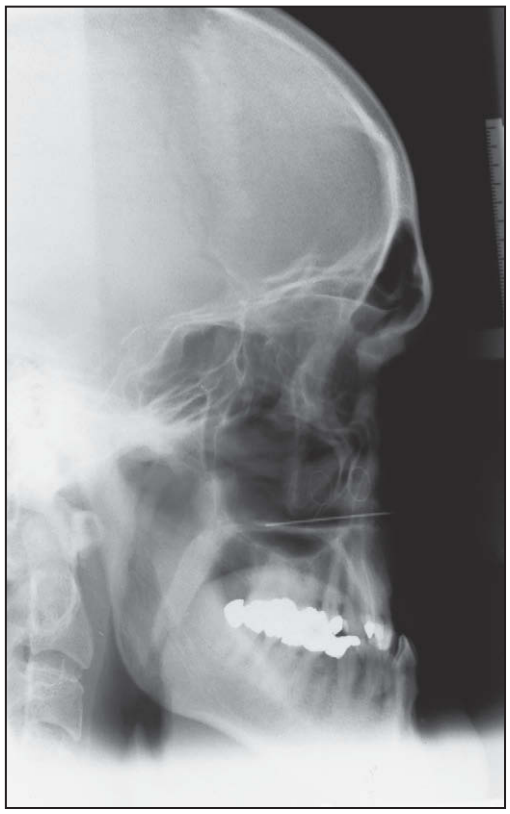


Figures 11.57–11.69 Case 5, Patient HZ.



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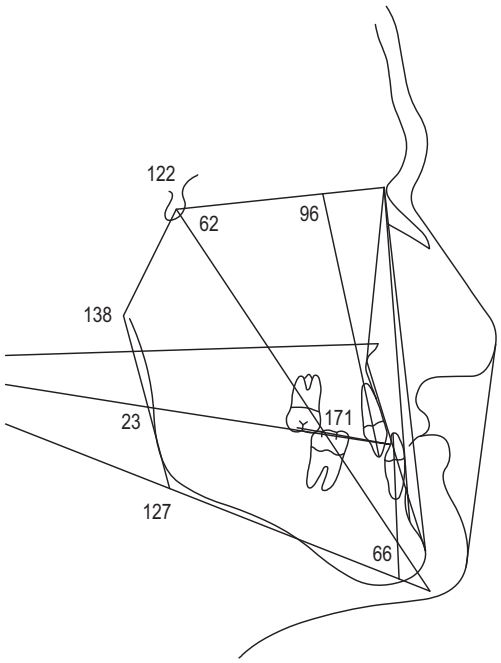

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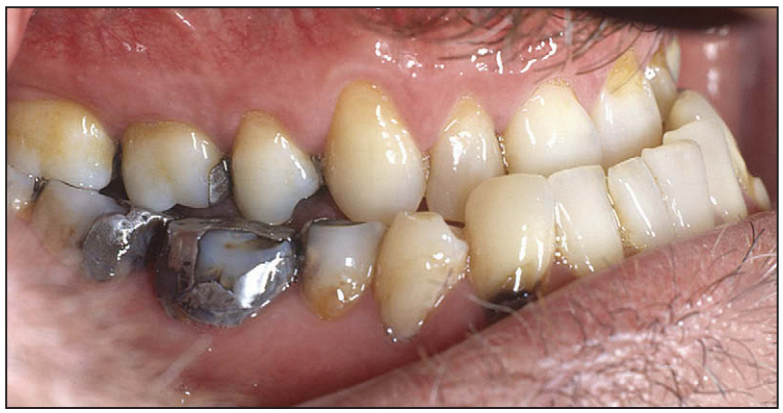

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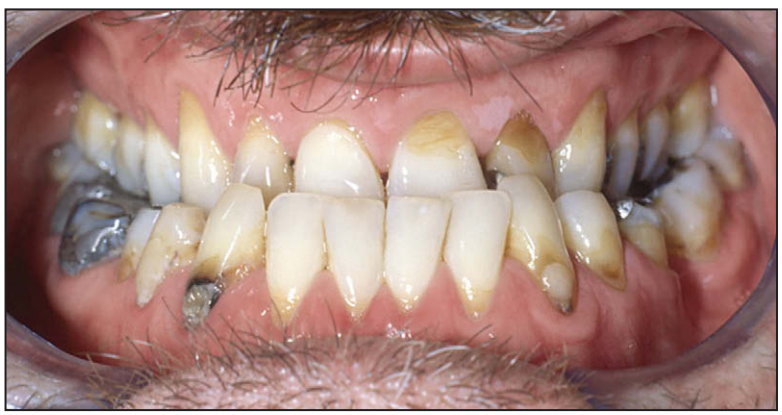

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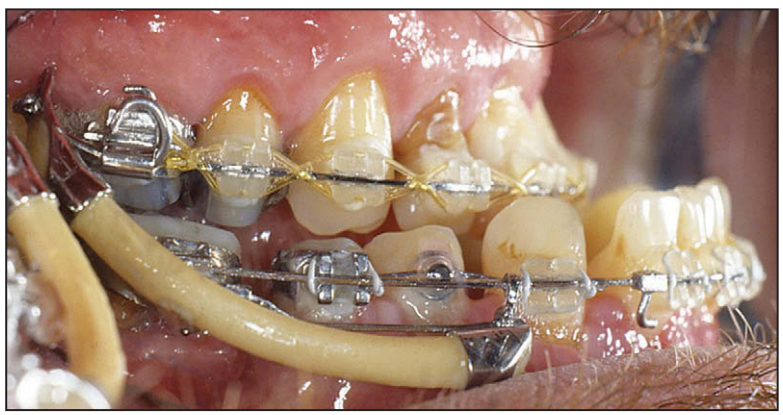

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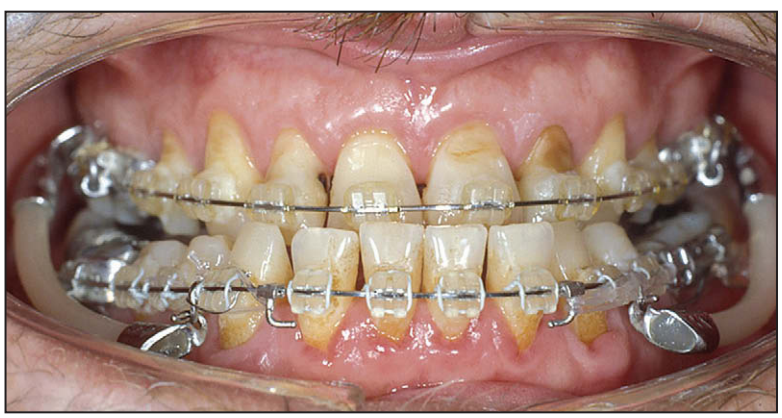

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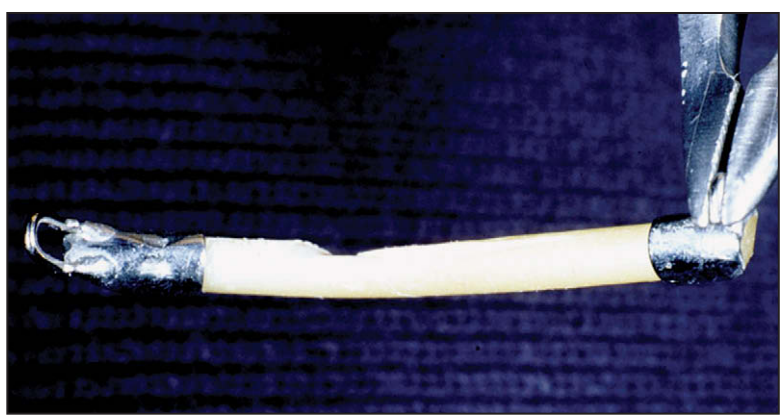

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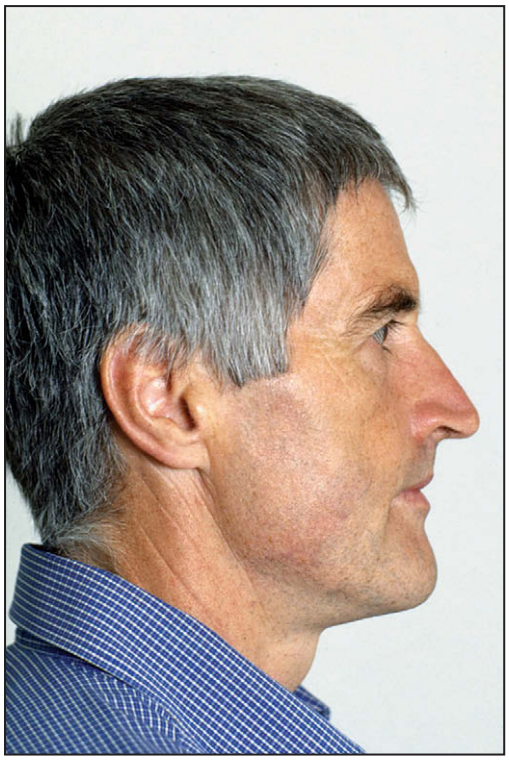

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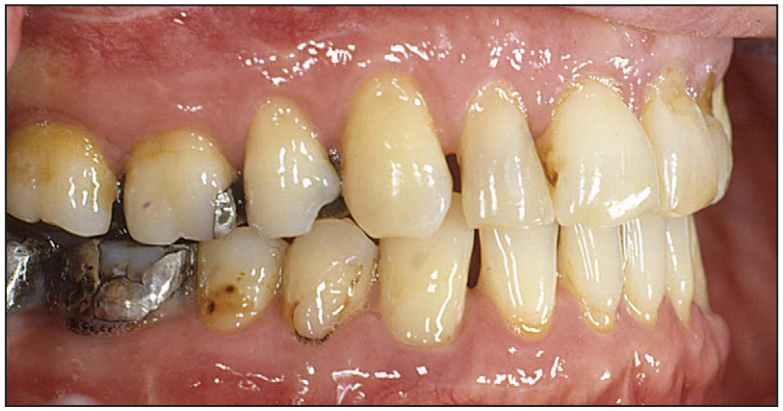

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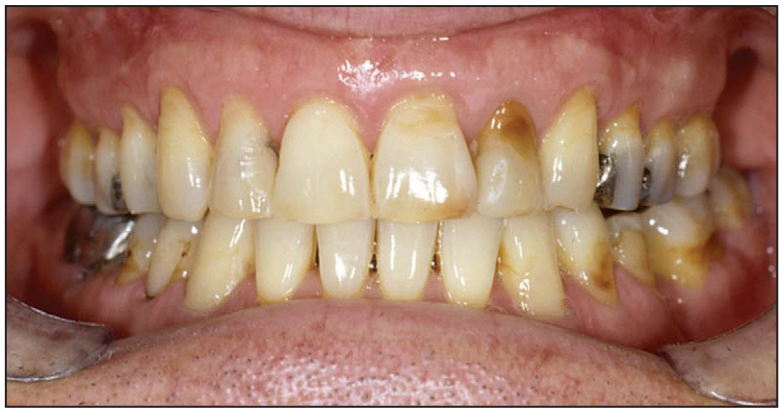

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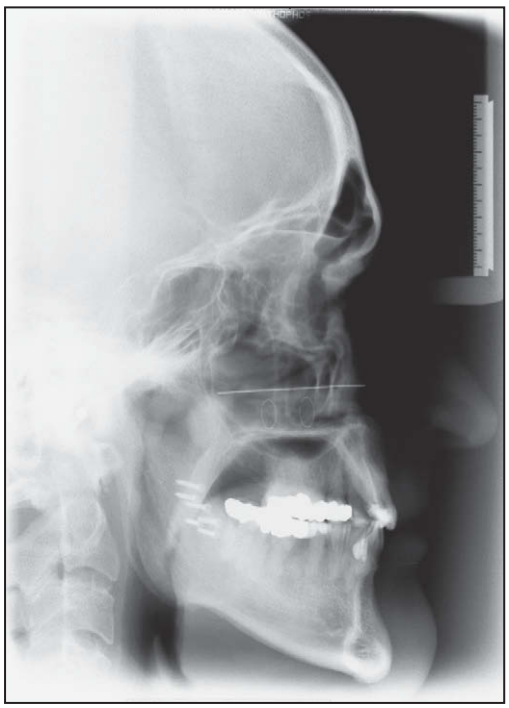

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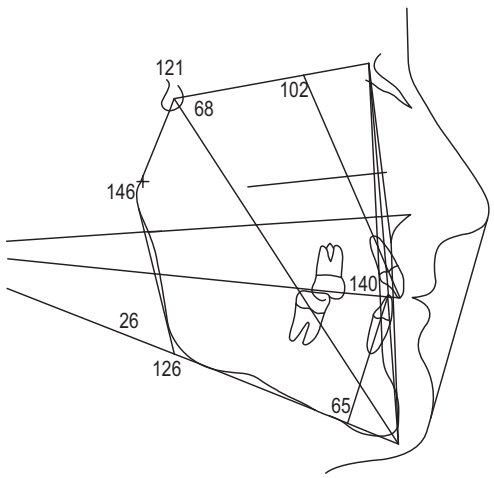

Figure 11.69

Acknowledgments

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