Early Treatment of Cover-Bite and Class II Division 2 Malocclusion

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5.1 Introduction

Retroclination of upper central incisors is characteristic for two common designations of malocclusion: cover-bite and Angle's class II division 2 (div. 2).

In its original meaning, the term cover-bite refers to an extremely deep frontal overbite leading to the coverage of the lower incisors by the upper incisors (Mayrhofer 1912; Herbst 1922). The fact that such vertical deviation is typically combined with other characteristic symptoms, especially with retroclination of the maxillary central incisors, explains why "cover-bite" has been established as an independent designation with these two features as leading symptoms (Fränkel and Falck 1967; Pancherz and Zieber 1998; Peck et al. 1998). The independent malocclusion category cover-bite seems also justified from a pathogenetic perspective (see corresponding section below). There is a controversy in the literature with respect to the question to which extent these leading symptoms have to be manifested so that the malocclusion may actually considered as a cover-bite. In this context, some authors designate patients with more mild expression of deep frontal overbite and upper incisor retroclination as "cover-bite-like" or an "anomaly with cover-bite character" (Hotz 1974; Schulze 1993).

The malocclusion classification scheme introduced by Edward H. Angle at the end of the nineteenth century (Angle 1899) distinguishes tooth and jaw malpositions primarily on the basis of the sagittal relationships between maxillary and mandibular first molars. The universal and sustainable application of this scheme may be explained by the fact that correction of the relationship between the upper and lower arches plays a key role in the treatment concept for most patients. With regard to Angle's class II div. 2 malocclusion, however, it may be argued that the class II molar relationship is not manifested in approx. 20–40% of patients with retroclined maxillary central incisors (Schulze 1993). This means that a significant proportion of patients forming this clinical entity is not considered in Angle's classification scheme which may be considered as a limitation (Pancherz and Zieber 1998; Peck et al. 1998).

Obviously, this controversy and also historical aspects are the reason why cover-bite is still used in parallel to class II div. 2 as designation for patients with upper incisor retroclination—despite the fact that the characteristic and facultative symptoms largely overlap (Fig. 5.1). It has to be mentioned in this context that the term cover-bite is primarily used in the German-speaking area and less frequently in

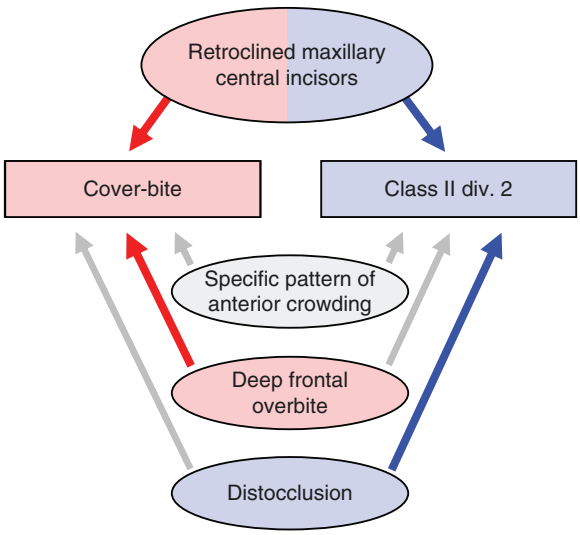

Fig. 5.1 Leading symptoms (red and blue arrows) and frequent facultative symptoms (gray arrows) of cover-bite and class II div. 2 malocclusion, respectively. Although the characteristic and facultative symptoms of these malocclusions overlap to a large extent, both designations are commonly used in orthodontic literature

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the English literature which reflects the global predominance of Angle's classification scheme. Nevertheless, in many respects—e.g., in the description of the clinical picture, pathogenesis, and possible treatment strategies—an overall assessment including both cover-bite and class II div. 2 malocclusion seems reasonable. Accordingly, also in this chapter, both anomalies are considered as one entity.

Regarding the designation of an individual malocclusion with upper incisor retroclination, the following use of the terms cover-bite and class II div. 2 is suggested: malocclusions without a class II component are designated as "cover-bite" (if the lower central incisors are completely covered by the upper centrals) or "cover-bite-like" (if lower centrals are only partially covered). The term "class II div. 2" is used (according to Angle's original definition) for patients with retroclined maxillary central incisors combined with a class II relationship of the buccal segments. If these patients additionally show a complete cover-bite, the malocclusion may be designated as "class II div. 2 with cover-bite."

5.2 Cover-Bite and Class II Div. 2 Malocclusion

5.2.1 Prevalence

Reported percentages for the prevalence of cover-bite vary between 4% and 14% (average 6.8%) (Christiansen-Koch 1981), and those for class II div. 2 between 2% and 5% (Ingervall et al. 1972; Myllärniemi 1970; Ast et al. 1965). Obviously, this difference is related to the fact that investigated class II div. 2 samples excluded patients without distocclusion.

5.2.2 Characteristic Intraoral, Extraoral, and Skeletal Features

Patients with cover-bite or class II div. 2 often show a specific pattern of anterior crowding in the upper frontal segment (Jonas 2000; Schulze 1993; van der Linden 1988; Hotz 1974) in which retroclined upper central incisors are combined with proclined, distorted, and infrapositioned upper lateral incisors (Fig. 5.2a). This pattern, which may occur only on one side (Fig. 5.2b), differs significantly from the hereditary crowding pattern characterized by palatally displaced upper laterals reflecting the persistence of their germ position. The proclined upper lateral incisors in cover-bite patients are usually less elongated when compared to the upper centrals. The fact that also a pattern with inversion of all four maxillary incisors combined with labially displaced or aligned canines may occur (Fig. 5.2c) indicates the importance of collateral influencing factors such as a reduced mesiodistal width of the upper incisors (Kaiser 2002; Peck et al. 1998).

Several morphological studies (Isik et al. 2006; Uysal et al. 2005; Lux et al. 2003; Walkow and Peck 2002) indicated that the increased sagittal dimension of the maxillary jaw base seems to be primarily related to an anterior position of the incisors' roots and not to a general overdevelopment of the maxillary dentoalveolar complex as hypothesized in most orthodontic textbooks.

Particularly in cover-bite cases with an extremely deep overbite, gingival recessions may occur either at the palatal gingival margins of upper incisors or at the labial gingival margins of the lower incisors. These recessions are in causal relationship with traumatic contacts of the lower or upper central incisors, respectively (Fig. 5.2c).

Extraoral features often reported as characteristic for cover-bite and class II div. 2 are a pronounced chin and a relatively large nose leading to a concave lower facial profile (Jonas 2000; Schulze 1993; van der Linden 1988; Hotz 1974), a pronounced supramental fold (Jonas 2000; Schulze 1993; Fletcher 1975; Hotz 1974; Burstone 1967; Korkhaus 1953), and a reduced upper lip height (van der Linden 1988). The patient shown in Figs. 5.3 and 5.4 demonstrates such extraoral features. Corresponding morphological studies, however, revealed that a specific facial morphology seems not to be regularly present in patients with retroclined maxillary incisors, which means that it cannot be considered as characteristic (Themann 1974). A number of studies, however, revealed that individuals with a cover-bite or class II div. 2 show a significantly higher lip line level when compared to controls or other malocclusion groups (Devreese et al. 2006; Karlsen 1994; Luffingham 1982; Fletcher 1975; Mills 1973).

Also cephalometric studies revealed that many dentofacial characteristics often associated with a cover-bite or class II div. 2 are actually inconsistent (Lux et al. 2004; Pancherz and Zieber 1998; Fischer-Brandies et al. 1985; Droschl 1974; Godiawala and Joshi 1974). More specifically, morphological differences between such individuals and controls were found to be limited to variables describing vertical deviations such as a reduced lower facial height and reduced mandibular plane and gonion angles (Barbosa et al. 2017; Lux et al. 2004; Brezniak 2002; Pancherz and Zieber 1998; Karlsen 1994; Maj and Lucchese 1982; Droschl 1974; Mills 1973). With respect to the anteroposterior jaw base relationship, most cephalometric studies reported an orthognathic position of the maxilla but found a retrognathic mandible (Lux et al. 2004; Brezniak et al. 2002; Pancherz et al. 1997; Karlsen 1994; Fischer-Brandies et al. 1985; Hitchcock 1976; Mills 1973). Some studies found a neutral sagittal jaw base relationship (Barbosa et al. 2017; Peck et al. 1998) or even a skeletal class III (Brezniak et al. 2002; Demisch et al. 1992). Such broad range of sagittal jaw base relationships found in

Fig. 5.2 (**a**–**c**) Variants of incisor malpositions in patients with a cover-bite and class II div. 2, respectively. (**a**) Retroclined maxillary central incisors combined with the characteristic anterior crowding pattern in the upper anterior segment, i.e., proclination and distorotation of the lateral incisors. (**b**) Patient with retroinclination of only three of the four maxillary incisors; the right upper lateral is proclined and clearly less elongated than the other incisors. (**c**) Retroclination of all four upper incisors without anterior crowding

these studies may be related to different selection criteria applied. Moreover, it indicates that a class II div. 2 is not necessarily a skeletal class II but has more the character of a dentoalveolar malocclusion (Barbosa et al. 2017).

Regarding dentoalveolar morphology, cephalometric studies revealed that the retroclination frequently not only concerns the upper incisors but also the lower incisors (Pancherz et al. 1997; Hitchcock 1976; Mills 1973), though this trend is usually very mild or even statistically not significant (Brezniak et al. 2002; Peck et al. 1998; Godiawala and Joshi 1974). A comparative study has shown that lower incisor retroclination appears to be more pronounced in cases with neutral buccal occlusion than in cases with distocclusion (Pancherz and Zieber 1998). The great majority of cephalometric studies identified the high lip line as one of the most prevailing morphological features of cover-bite and class II div. 2 malocclusion (Devreese et al. 2006; Karlsen 1994; Luffingham 1982; Fletcher 1975; Mills 1973).

The fact that cephalometric studies could not identify any consistent dentofacial morphological feature beyond the increased overlap of the maxillary incisors by the lower lip has been confirmed by an own cephalometric study of the skeletal, dentoalveolar, and soft tissue morphology (Lapatki et al. 2007). This study included a relatively large patient sample covering the whole spectrum from very mild to severe retroclination of upper central incisors (U1-SN

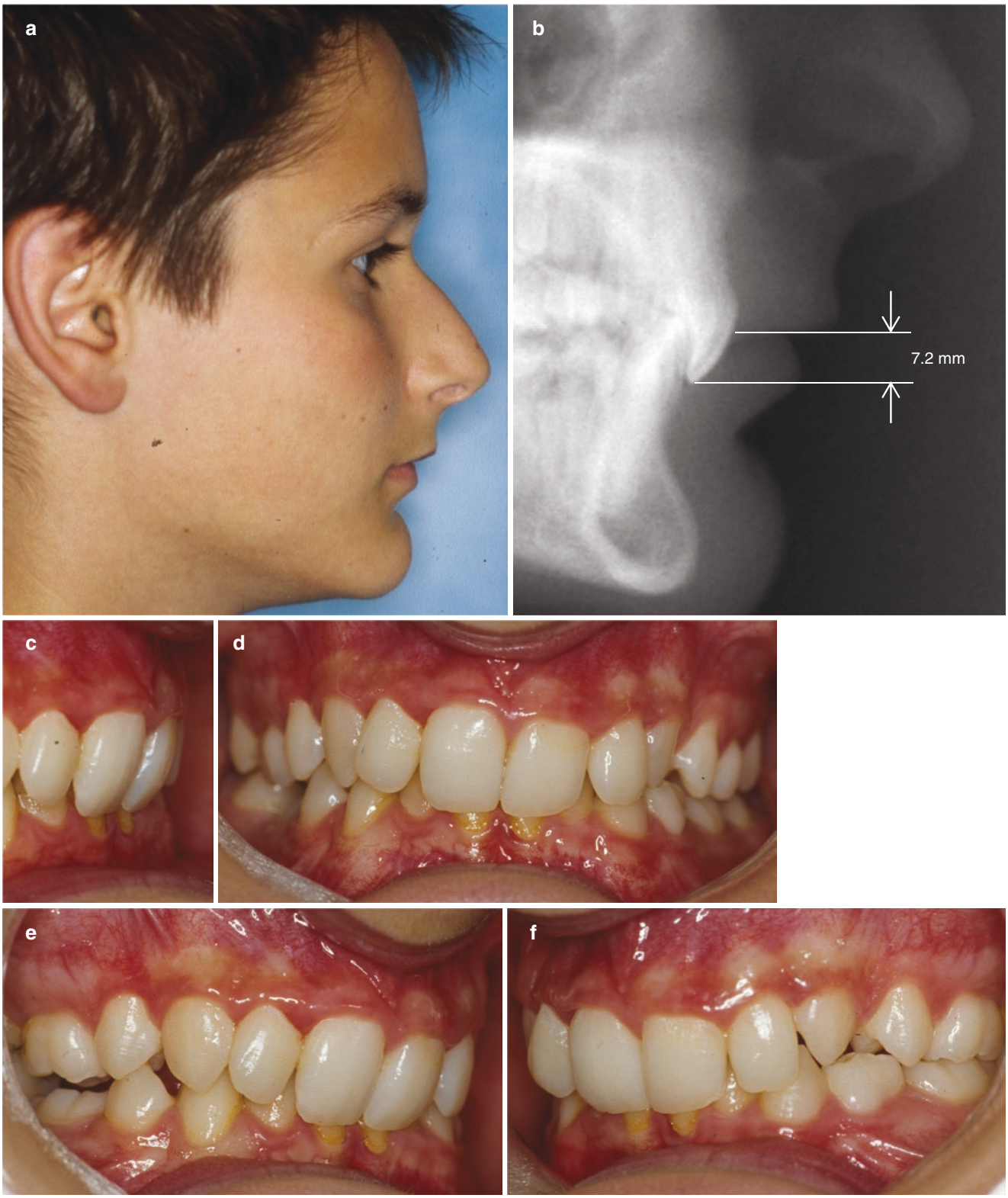

Fig. 5.3 Initial records of a patient with a class II div. 2 with an almost complete cover-bite. (**a**) The facial morphology of this patient is characterized by a concave lower facial profile, a deep supramental fold, and a pronounced chin. Although, these features are often reported as typical for cover-bite and class II div. 2 malocclusion, morphometric studies revealed that they are inconsistent. (**b**) Cephalogram showing the severe retroclination of the upper central incisors with a deviation from reference of −12° and the high lip line level of 7.2 mm. The patient has a horizontal growth pattern and a neutral sagittal relationship of maxillary and mandibular jaw bases with a deviation of the ANB-angle from the individualized reference of 0.6°. (**c**–**f**) Intraoral situation showing the traumatic contact of the upper central incisors with the labial gingiva in the lower jaw leading to gingival recessions

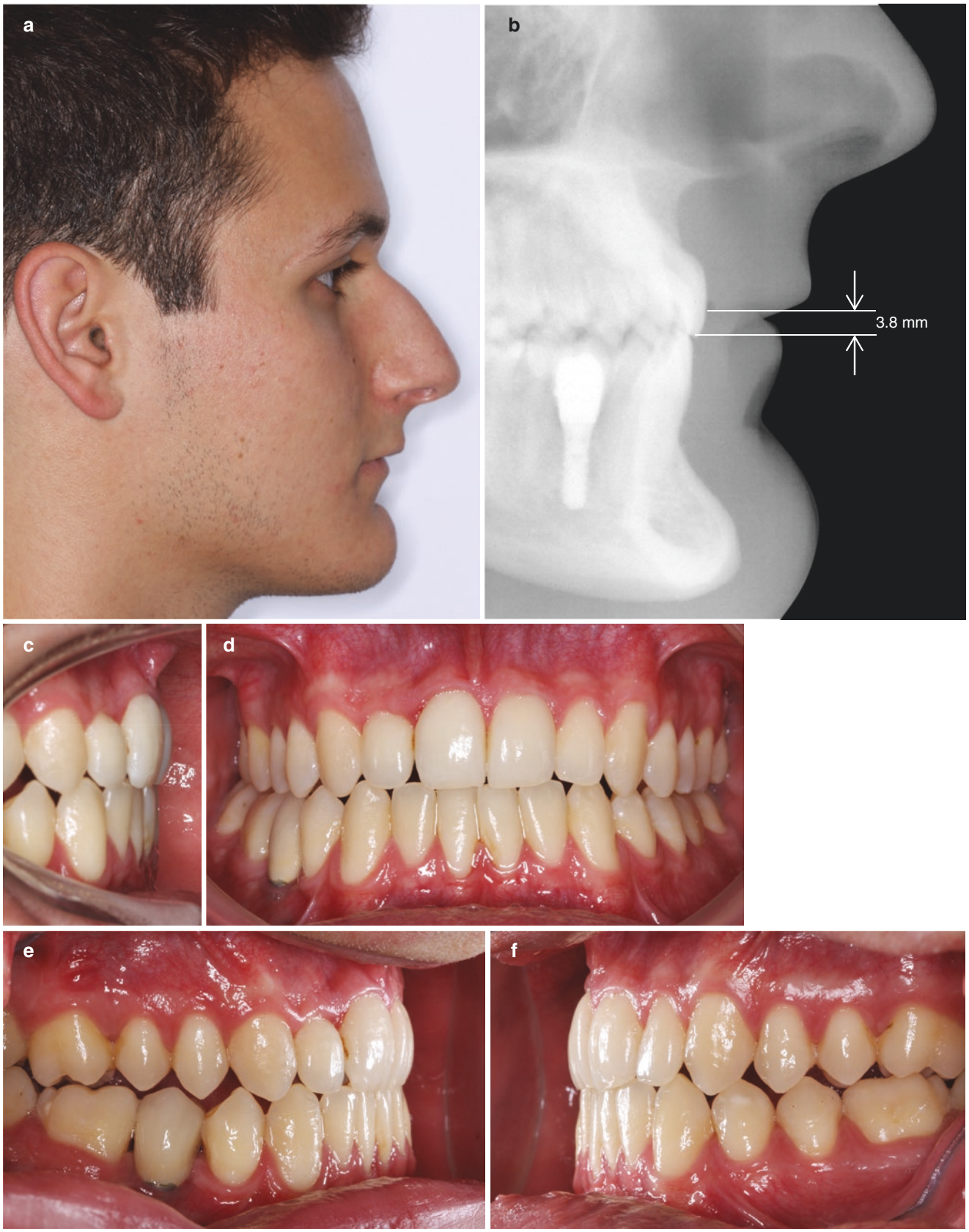

Fig. 5.4 Situation in the patient depicted in Fig. 5.3, 5 years after finalizing the active-mechanical therapy. (**a**) Facial profile. (**b**) Compared to the pretreatment cephalogram, upper central incisors have been proclined by 17.4°. The sagittal jaw base relationship shows a skeletal class III pattern (Wits appraisal: −2.5 mm, deviation of ANB-angle from individualized reference: −2.5°). The high lip line was reduced from 7.2 to 3.8 mm. (**c**–**f**) Intraoral situation demonstrating the high stability of the correction of the frontal overbite and the neutral buccal occlusion. The congenitally missing tooth 45 is replaced by an implant crown

between 104° and 64°). Results revealed that that the lip line level alone accounted for 47% of inclinational variability of the maxillary central incisors indicating the extraordinarily close correlation between these two variables. Multiple regression analysis revealed that the proportion of explained variability of upper central incisor inclination increased to a value of 81% by additional inclusion of the sagittal jaw base relationship and the inclination of the mandibular central incisors. These results demonstrate the predominance of the specific vertical incisor-lip relationship as the characteristic morphological feature for upper incisor retroclination. It may be hypothesized that the other two statistically significant model parameters, i.e., the skeletal class II pattern and retroclination of the mandibular incisors, either provide favorable conditions for upper incisor retroclination due to the increased interincisal sagittal distance or are secondary symptoms.

5.2.3 Etiology

The viewpoint that genetic factors play a major role in the etiology of cover-bite and class II div. 2 is mainly based on studies of twins (Christiansen-Koch 1981; Nakasima et al. 1982), families (Trauner et al. 1961; Kloeppel 1953; Corsten 1953), and probabilities of the anomaly's manifestation (Schulze 1993). Regarding the inheritance mechanism, a polygenic pattern is assumed (Christiansen-Koch 1981). The fact that environmental factors may significantly modify the phenotype or even may be crucial for the manifestation of upper incisor retroclination is impressively documented in the literature by two case reports describing the parallel manifestation of a class II div. 1 and a class II div. 2 in two discordant monozygote twins (Ruf and Pancherz 1999; Leech 1955). It is assumed that this environmental influence is particularly effective during eruption of the permanent upper central incisors (van der Linden 1983).

Possible inherited morphological characteristics of individuals with upper incisors retroclination mentioned in the literature are an inverted inclination of the upper central incisors' germs (Fränkel and Falck 1967), specific morphological dental characteristics such as mesiodistally reduced tooth widths (Peck et al. 1998) or an increased collum angle of the upper centrals (Bryant et al. 1984; Delivanis and Kuftinec 1980), a characteristic perioral soft tissue morphology (van der Linden 1988; Fletcher 1975; Fränkel and Falck 1967), or an unphysiological motor function of the perioral musculature (Fischer-Brandies et al. 1985).

It has to be noted that only a few of these factors are evidence based. Moreover, it is scarcely conceivable that all these features are causative key factors. Instead, significant morphological characteristics of class II div. 2 samples such as decreased mesiodistal width of incisors or the slightly increased collum angle of the upper centrals may rather facilitate or contribute to upper incisor retroclination (Schulze 1993) than trigger or initiate its manifestation. From all the morphogenetic factors considered, only the characteristic lip-to-incisor relationship in cover-bite and class II div. 2 patients expressed by a high lip line may be regarded as a potential causative key factor. Indeed, this seems to be confirmed by experimental studies on the pathogenesis of the malocclusion.

5.2.4 Pathogenesis

Longitudinal studies suggest that the manifestation of a cover-bite or class II div. 2 malocclusion is most likely not related to any preliminary stage but is developing only during the eruption of the deciduous or even the permanent upper incisors (Fletcher 1975; Fränkel and Falck 1967). It is assumed that the inversion of the upper centrals itself plays also an essential pathogenetic role, because it prevents the mutual support of the upper and lower incisors (which physiologically would inhibit the further eruption) and enhances the development of a deep frontal overbite (Kim and Little 1999; Karlsen 1994; Björk and Skieller 1972). Moreover, it is hypothesized that the retroposition of the incisal edges of the upper incisors may contribute or even cause retroinclination of the lower incisors and inhibit mandibular growth in the sagittal direction (Schulze 1993). Based on the mutual reinforcement of the key morphological features of class II div. 2 and cover-bite malocclusion during the eruption of the upper incisors and in the subsequent period of dentoalveolar growth, it may be hypothesized that an early therapeutic intervention may be highly beneficial for the prevention of an exacerbation of the malocclusion.

With respect to the initiation of the inversion process, several causative factors are discussed in the literature. The "functional theory" refers to the "equilibrium of tooth position" (Proffit 1978; Weinstein et al. 1963), i.e., the mechanical balance of forces on the teeth from oral and vestibular directions. It is supposed that the resting pressures exerted from the lips and cheeks are of particular importance due to their more static character when compared to tongue pressures (Thuer et al. 1999a; Proffit et al. 1975; Lear et al. 1974). This means that, for the development of upper incisor retroclination, increased resting lip pressure may be the potential factor disturbing the equilibrium (Jonas 2000; Schulze 1993; van der Linden 1983).

After several experimental studies failed to demonstrate an interrelation between pressure magnitude and upper central incisor inclination (Thuer and Ingervall 1986; Luffingham 1969; Gould and Picton 1968), an own study including 21 individuals with retroclined upper central incisors and 21 controls with physiological incisor inclination and neutral

occlusion could actually prove that the resting lip pressure on the upper central incisors is significantly different in these groups (Lapatki et al. 2002). This difference was found to be related to both the total resting pressure magnitude and its distribution on the crown surface. More specifically, in the controls, pressure data registered with two capacitive miniature pressure sensors on each of the two central incisors (Fig. 5.5a, b) revealed significantly higher resting pressures in the cervical region (+1.34 cN/cm^2) when compared to the incisal region (−1.25 cN/cm^2). In contrast, subjects with retroclined upper centrals showed the reverse pattern, i.e., significantly higher resting pressure in the incisal region (+3.05 cN/cm^2) compared to the cervical region (−1.24 cN/cm^2) (Fig. 5.5c). From correlation analyses, it could be concluded that actually the high lip line level accounts for this difference.

From these data, the following three principles could be derived:

1. In the region close to the lip line level, negligible pressure is applied to the teeth; the experimentally determined negative pressure values in this region might reflect the negative intraoral pressure; this observation agrees with other studies (Shellhart et al. 1996; Thuer et al. 1999b).
2. Resting pressure exerted by the lower lip is approx. 2.5 times higher than those exerted by the upper lip.
3. Total lip pressure magnitude exerted on the upper central's labial crown surfaces significantly depends from the level of the lip line which determines the amount of overlap between the upper centrals and the upper and lower lip, respectively.

Consequently, in case of a physiological lip line level, which means that the contact between the upper and lower lip occurs in the incisal third of the labial crown surface (Fig. 5.5d), upper central incisors are predominantly exposed to the relatively low upper lip resting pressure. Conversely, a high lip line level leads to the application of relatively high resting pressure magnitudes exerted by the lower lip (Fig. 5.5e).

Based on perioral surface EMG measurements, this experimental study has also proven that increased resting lip pressure in cover-bite and class II div. 2 is not related to increased perioral resting muscle activity. Hence, the specific vertical lip-to-incisor relationship may be regarded as the primary determinant of these malocclusions.

The frequent finding of proclined upper lateral incisors in individuals with a cover-bite or class II div. 2 does not contradict the causal interrelationship between incisor inclination and soft tissue resting pressure. The maxillary lateral incisors erupt approx. 1 year after the central incisors, and their eruption occurs from a position palatal to the central incisors in a labio-caudal direction (Schulze 1993; Baume 1955). The fact that the retroclination of the central incisors already occurs prior to the eruption of the laterals, together with the specific eruption path of the laterals, provides a plausible explanation for their position labial to the frontal dental arch. The persistence of this position seems to be related, on the one hand, to the palatal displacement of the upper central crowns leading to reduced mesiodistal space for the laterals between the central incisor and the deciduous canine; this barrier makes lingual movement of the upper lateral incisors impossible (van der Linden 1983; Fletcher 1975). On the other hand, due to their proclined eruption path, contacting of the upper laterals with the lower lip occurs in the cranial lower lip region (and not behind the lower lip). These aspects explain why in many individuals with cover-bite or class II div. 2 malocclusion the upper lateral incisors remain in a more cranial position than the centrals. The fact that proclined upper laterals are more infrapositioned is demonstrated even more clearly in patients showing one retroclined and one proclined upper lateral incisor (Fig. 5.2c).

5.3 Pros and Cons of Early Treatment in the Mixed Dentition

Basically, early orthodontic treatment may be performed as a sole intervention in the mixed dentition. It is much more common, however, that the intervention in the mixed dentition is the first component of an early two-phase treatment approach which comprises fixed appliance therapy in the permanent dentition. The latter may be related to the fact that the majority of patients require the correction of remaining minor single tooth malpositions and a refinement of the occlusion after removable appliance treatment, together with the trend that patients become more and more demanding on the quality of the esthetical outcome.

Obviously, such two- or multiphase approach prolongs total treatment time. Since decades, it is discussed in the orthodontic literature whether the higher costs, longer treatment duration, and demands on the patient's compliance are actually in balance with the benefits (Ren 2004). Specifically in view of an early treatment of class II div. 2 and cover-bite malocclusion, the following issues may be relevant in this discussion: the effect of an early interception on the subsequent development of the malocclusion, the question whether the early intervention may significantly reduce the extent of tooth movement and dentoalveolar compensation required in the fixed appliance phase, the question whether the risk for therapeutic side effects can be reduced, the aspect of treatment efficiency and implications on post-orthodontic stability.

The main justification for an early orthodontic intervention is based on the interception of the pathogenesis before

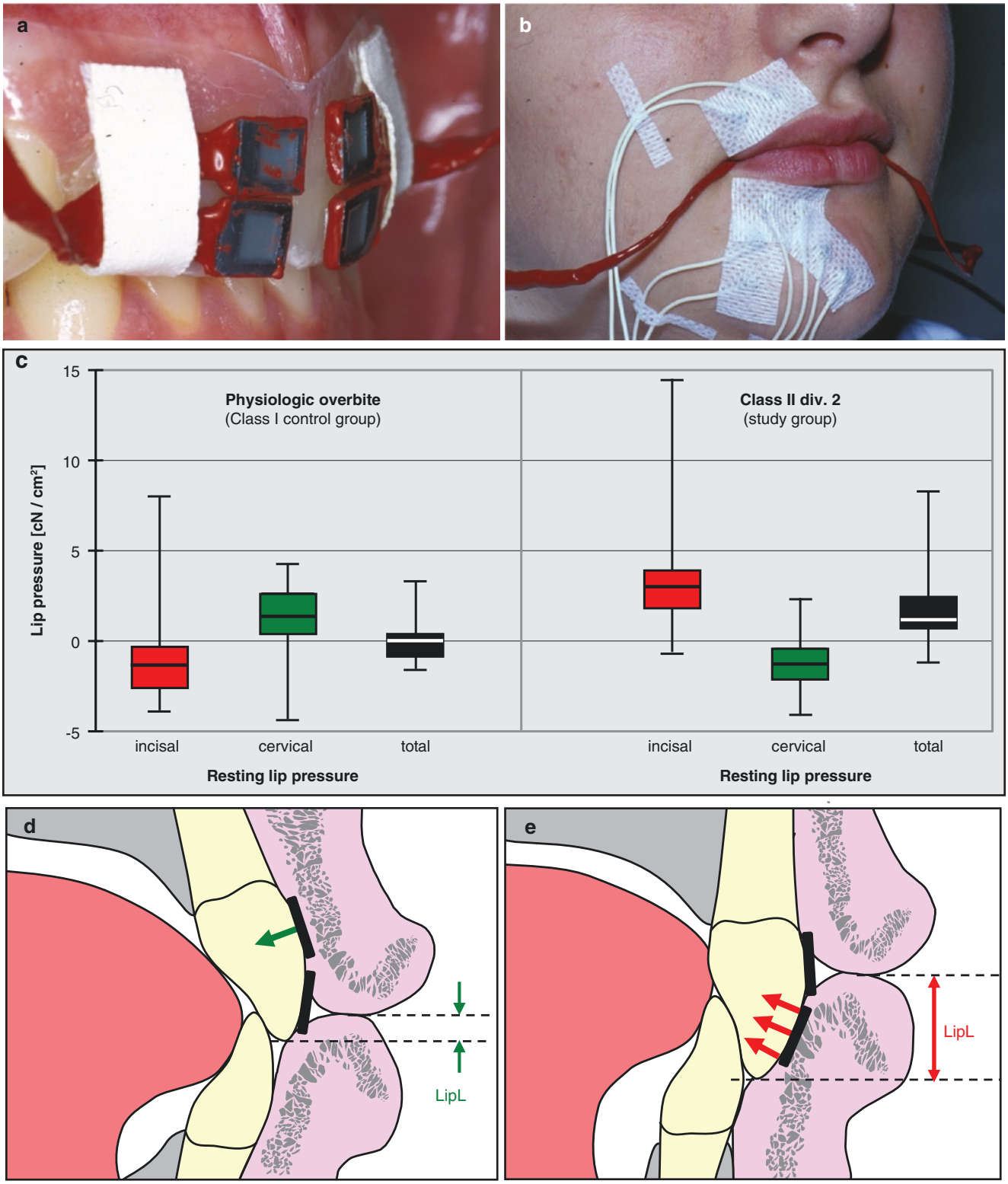

Fig. 5.5 Experimental study on the pathogenesis of upper central incisor retroclination (Lapatki et al. 2002). (**a**) Two thin miniature pressure sensors were positioned in the incisal and cervical region of the upper central incisors' labial crown surfaces. (**b**) Perioral muscle activity and lip pressure were registered while the lips were in their resting position. (**c**) Box plots showing the resting pressure magnitudes registered in the incisal and cervical crown areas. Negative pressure values reflect the negative intraoral pressure. The weighted sum of incisal and cervical pressure (total) is significantly higher in the class II div. 2 sample. (**d**) In the controls showing a physiological lip-to-incisor relationship, relatively low resting pressure is applied by the upper lip (green arrow). (**e**) In the study group, the high lip line level (LipL) leads to exposure of the upper centrals to the resting pressure of the lower lip (red arrows) which is approx. 2.5 times higher than those of the upper lip

the malocclusion is fully manifested, in order to prevent a further exacerbation and to enhance the inherent growth potential. With regard to class II div. 2 and cover-bite malocclusion, such interception may be particularly effective for several reasons. Firstly, as described above, the major pathogenetic factor of the frontal aspect of the malocclusion is to be found in the specific lip-incisor relationship expressed through a high lip line; obviously, this factor is not per se existing, but it is developing during the eruption of the deciduous or permanent upper incisors (Fletcher 1975; Fränkel and Falck 1967). According to a study by Vig and Cohen (1979), the overlap between the upper incisors and the lower lip is increasing until 13 years of age. Consequently, it may be hypothesized that true intrusion of the upper incisors in the mixed dentition phase may terminate the pathogenetic process and prevent the further exacerbation of the frontal malocclusion. Secondly, an early dentoalveolar decompensation in the upper anterior region by proclination of the inverted upper incisors may "unlock" the restrained mandible (Thomson 1986; Litt and Nielsen 1984; Arvystas 1979). Such disinhibitory effect on the inherent mandibular growth potential may significantly contribute to class II correction (Woods 2008; Parker et al. 1995). Thirdly, in cover-bite cases with an extremely deep overbite, early correction of the deep frontal overbite may also eliminate gingival trauma and prevent an exacerbation of gingival recessions. These traumatic effects are related to contacting of the palatal gingiva or mandibular labial gingiva with incisal edges of lower and upper incisors, respectively (see Fig. 5.3).

If early intervention in class II div. 2 malocclusion could actually intercept the pathogenesis and prevent the exacerbation of the malocclusion, it would be logical that the finalization of the treatment in the permanent dentition is confronted with a far less manifested malocclusion. In particular, less active-mechanical palatal root torque for upper incisors and intrusion of the anterior segments should be required during final fixed appliance treatment. It has to be noted that especially these treatment tasks are associated with external apical root resorption (Harris 2000), which is the most common iatrogenic negative consequence of orthodontic treatment. These aspects might explain why the correction of a class II div. 2 leads to significantly more lower incisor root resorptions if the treatment occurs in a late one-phase approach compared to an earlier starting two-phase treatment (Faxén Sepanian and Sonnesen 2018). Another advantage of an early interception in class II div. 2 malocclusion may be related to the partial or even complete correction of the distocclusion during the early treatment phase; this should reduce the need for a dentoalveolar compensation of the class II and may avoid corresponding disadvantages. Admittedly, not all of these theoretical considerations and conclusions are evidence based. However, the well-documented patient examples included in this chapter may at least provide individual clinical evidence.

A review of the literature with regard to the effect of early class II div. 2 therapy revealed that studies evaluating early treatment of class II div. 2 or cover-bite are sparse. Ferrazini (2008) studied the outcome of a sole early interceptive approach. All patients were treated according to the concept described by Hotz (1974) comprising a three-stage protocol aiming at (1) protrusion of the upper incisors by means of a maxillary plate with a protruding screw, (2) protrusion and intrusion of the mandibular incisors by equipping the plate with a guide plane, and (3) a subsequent "activator phase." It was observed that after approx. 3 years of treatment all typical class II div. 2 features could be successfully corrected without any further therapeutic intervention. Furthermore, literature research indicated that studies evaluating a two-phase approach are sparse and focused more on deep overbite correction in general. The corresponding studies of Baccetti et al. (2012) and Franchi et al. (2011) included two patient samples both initially treated with maxillary bite plates in a two-phase approach—either with an earlier or later treatment start. With regard to class II div. 2 or cover-bite malocclusion, included patient numbers were relatively low and results were not separately reported for these patients. Generally, we did not identify any study specifically targeted at comparing the results from larger class II div. 2 samples obtained by a two-phase approach with those of a single-phase protocol in the permanent dentition.

An alternative approach for protrusion of the maxillary central incisors and creating the sagittal space for mandibular advancement—these are chief tasks of early class II div. 2 or cover-bite treatment—may be the use of a partial fixed appliance comprising the maxillary first molars and incisors. The utility arch introduced by Ricketts (1979) is the most common design of such two-by-two or two-by-four systems—as explained more detailed below. The great advantage of the use of a partial fixed appliance in the first stage of early class II div. 2 treatment is related to the possibility of simultaneous protrusion and true intrusion of the maxillary central incisors. Hence, the treatment may not only address the sagittal component of the malocclusion but may also be directly targeted to the reduction of the lip line level—i.e., the key pathogenetic factor of maxillary incisor retroclination.

In the discussion whether a two-phase treatment approach comprising an early phase in the mixed dentition may be considered efficient or not, two variables are particularly relevant: (1) the quality of the treatment outcome and (2) the treatment time required for achieving this result (von Bremen and Pancherz 2002). As noted by Ferrazini (2008) also the fundamentally different implications of removable and fixed appliances on treatment costs, requirement of

treatment monitoring, and intervention by the clinician are to be considered. For instance, during activator therapy, monitoring of the treatment by the clinician may be limited to 4–6 visits per year, and the patient usually has to use the appliance only at home and mainly at night. Additionally, removable appliances have other obvious advantages such as facilitated oral hygiene and less affected social life compared to the use of fixed appliances in combination with additional mechanics for class II correction (such as a Herbst appliance or skeletally anchored appliances for upper molar distalization). These aspects are also important in the discussion on whether treatment of class II div. 2 and cover-bite patients should already be started in the mixed dentition.

In conclusion, according to the opinion of the author of this chapter, the decision whether an early or later treatment start is preferred in class II div. 2 and cover-bite malocclusion is to be tailored to the individual patient and the available therapeutic tools. The basic prerequisite for an early begin of orthodontic treatment is the patient's and parent's willingness for a longer treatment when compared to a single-phase approach in the permanent dentition. Furthermore, interceptive treatment of a class II div. 2 or cover-bite malocclusion should be targeted to the pathogenetic key factors—i.e., the high lip line and the class II tendency (if applicable). Patients and parents must be involved in the decision-making process and have to be informed that an early intervention may prevent the further exacerbation of the malocclusion and, consequently, may reduce the need for tooth movements associated with a high risk for root resorption and dentoalveolar compensation of the class II. Such informed consent, however, must also include that not all of these arguments are based on very solid scientific evidence and that a controversy discussion regarding the justification of an early treatment of class II div. 2 and cover-bite is still ongoing.

5.4 Stability After Orthodontic Treatment

Many clinicians and authors consider cover-bite and class II div. 2 as relapse-prone malocclusions. For instance, Selwyn-Barnett (1991) concluded that class II div. 2 therapy is associated with a doubtful prognosis and high relapse probability. Mills (1973) reported that therapeutic proclination of maxillary incisors by 13° relapsed after >1 year of retention by approx. 50%. Other authors, however, stated that upper incisor proclination was relatively stable. Devreese et al. (2007) reported that therapeutical upper incisor proclination by 15.2° relapsed only by 2.2° in the 3.5 years posttreatment interval. Several authors concluded that instability of upper incisor proclination does not apply to the majority of patients but in particular to individual cases with an extreme relapse tendency (Kinzel et al. 2002; Kim and Little 1999; Binda et al. 1994; Berg 1983).

The studies mentioned above investigated malocclusion samples which had undergone fixed appliance therapy in a two-phase or one-phase approach. There is only one study of Ferrazini (2008) investigating long-term stability of class II div. 2 correction comprising a sole early interceptive approach corresponding to the concept described by Hotz (1974). The author noted remarkable stability of most corrected dental and skeletal variables 20 years after treatment. An important finding, however, was that the therapeutical upper central incisor proclination by approx. 5–6° relapsed nearly completely. From a pathogenetic viewpoint, this may be explained by the fact that active-mechanical intrusion of upper incisors has not been an integral component in the applied treatment concept. Thus, the high lip line level may have persisted and, consequently, the pathogenetic mechanism of upper incisor reclination may have continued to exert its effect.

Actually, the latter hypothesis could be verified by two retrospective investigations on the basis of cephalometric analyses, evaluation of plaster casts and clinical measurements of the lip line level after mean post-therapeutic intervals of 2 years (Lapatki et al. 2004) and 9 years (Lapatki et al. 2006). Multiple regression models were calculated in these studies to statistically identify significant relapse determinants. A common finding of both studies was that the relapse of the therapeutic proclination of the maxillary central incisors mainly depends on the amount of therapeutic inclinational change as well as the post-therapeutic lip line level. Based on these results it may be concluded that one of the most important objectives when treating patients with cover-bite or class II div. 2 must be the reduction of increased overlap between the upper incisors and the lower lip—as demonstrated by the pre- and posttreatment records of the patient example shown in Figs. 5.3 and 5.4. This can be achieved either in an early treatment phase by active-mechanical intrusion and/or impeding the vertical development of the upper anterior segment (see patient examples below) or in the permanent dentition by active-mechanical intrusion of the upper incisors using segmented mechanics. Obviously, an increased relapse risk has to be taken into account if this aspect is not considered in treatment planning.

5.5 Early Treatment Phases and Therapeutical Approaches

5.5.1 Overview

The treatment of cover-bite and class II div. 2 malocclusion respectively can be subdivided into an early phase in the mixed dentition and a late phase beginning after complete eruption of the permanent canines and premolars.

The early treatment phase may be further divided into two successive main stages. The main focus of the first stage is to correct the key feature of the malocclusion—i.e., the retroclination and supraposition of the upper central incisors. The decision whether the deep frontal overbite is corrected primarily through intrusion of the upper incisors or intrusion of the lower incisors has to consider the lip-incisor relationship. This analysis should be undertaken with the lips in their resting posture (e.g., on the lateral cephalogram) and also during smiling (Zachrisson 2007)—as exemplified by the included patient examples. In patients with a more severe class II (i.e., more than half-step distocclusion of first molars), it is advisable to first distalize the upper first molars in a preliminary phase before the upper incisor segment is corrected.

The use of a removable functional appliance in the second stage of early treatment enables the retention of the achieved sagittal and vertical improvements in the upper frontal segment and further correction of the deep overbite by inhibiting the vertical development of the upper and lower anterior segments (i.e., relative intrusion) and enhancing the eruption of the first molars. Functional appliances may also stimulate mandibular growth (Pacha et al. 2016; Perinetti et al. 2015) which is favorable in the majority of cover-bite or class II div. 2 patients. In addition, they may guide canine and premolar eruption and may contribute to the correction of collateral problems such as anterior crowding or tooth agenesis.

If the treatment of a severe cover-bite or class II div. 2 malocclusion is started only in the late mixed dentition or in the early permanent dentition, it is recommended to replace the functional appliance by a Herbst (or Herbst-like) appliance (Schweitzer and Pancherz 2001; Obijou and Pancherz 1997) or by a skeletally anchored distalization appliance (Wilmes and Drescher 2010) for class II correction. Malpositions in the frontal segments are then to be treated subsequently in the permanent dentition, e.g., by using Burstone's segmented multibracket appliance mechanics (Burstone 2001) or adaptations of this approach.

This basic concept for early treatment of cover-bite and class II div. 2 malocclusion is described in more detail in the following sections. Reference is made to seven patient examples which are included and described at the end of this chapter; these patients were personally treated by the author of this chapter. The early treatment phase of patient examples #1 to #4 followed the classical two-stage protocol comprising the intrusion and/or proclination of the upper central incisors and subsequent functional appliance therapy. Early treatment of patient example #5 skipped the first main stage for active-mechanical correction of the upper central incisors, and in the treatment of patient example #6 the second main stage (i.e., functional appliance therapy) was omitted due to the long duration of the initial utility arch and headgear treatment. In patient example #7, early treatment of the more severe distocclusion was not sufficient, which is why an intermediate phase for skeletally anchored distalization of upper molars was required between the functional appliance therapy and the final full multibracket treatment.

5.5.2 Pretreatment in Patients with Severe Distocclusion

As mentioned, the retroclination and supraposition of the upper central incisors is usually the therapeutic key measure of the first stage of early class II div. 2 and cover-bite treatment. In those patients, however, with a severe class II first molar relationship (i.e., with distocclusion clearly greater than half-step), it may be reasonable to start the treatment with distalization of the upper first molars using a cervical-pull headgear, which means that the upper incisors are corrected afterward. Such deviation from the standard procedure may be justified, because intrusion of upper incisors is difficult to be combined with cervical-pull headgear therapy; this is related to the extrusive effect on the upper first molars of both of these measures (see also Fig. 5.6); consequently, the extrusive effect may be too strong in total. As a cervical-pull headgear is more effective in distalizing upper molars than the high-pull headgear, the combination of parallel high-pull headgear and utility arch treatment (without a previous cervical-pull headgear phase) may be insufficient for correction of a severe distocclusion. Another reason for starting the treatment with upper molar distalization may be that headgear therapy must be initiated before the second molars begin to erupt—simultaneous distalization of first and second molars using a headgear has proven to be unrealistic.

It has to be noted that in an initial cervical-pull headgear phase only partial correction of the distocclusion is required. The correction of a remaining mild (e.g., quarter-step) distocclusion may be postponed to the second main stage of early treatment (see corresponding section below).

Generally, the collateral extrusion of upper first molars during cervical-pull headgear therapy is very desirable in class II div. 2 patients with a deep overbite or cover-bite. In this respect, the anterior bite opening during the initial headgear phase may represent the first measure addressing the vertical

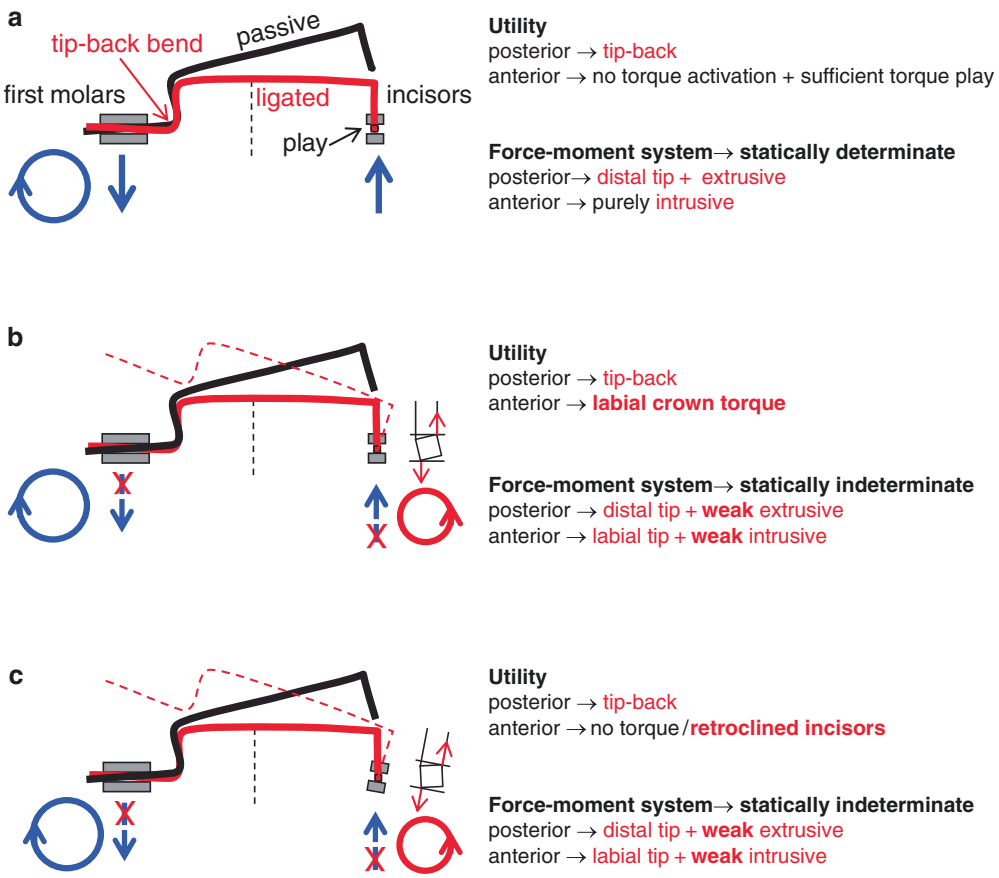

Fig. 5.6 Force-moment systems generated by the utility arch (Ricketts 1979) under different conditions. According to Newton's third axiom, the forces and the moments generated by an orthodontic appliance must be balanced in any plane. (**a**) In an idealized utility arch configuration, no moment would be applied to the maxillary anterior segment, due to sufficient play of the anterior wire segment in the anterior bracket slots. In this case, the utility arch would reflect a "one-couple configuration" generating a "statically determinate system"—which is desirable for quantitative control of the intrusive force. Practically, this may occur only under the following conditions: (1) wire dimensions are significantly smaller in relation to bracket slot height (e.g., 0.016 × 0.016-in. wire combined with 0.018-in. bracket slot height) and (2) there is no or only a very weak curvature of the anterior wire segment—this should be the case if only the two central incisors are included (so-called two-by-two configuration, see Fig. 5.7a). (**b**) Activation of the utility arch's anterior segment for labial crown torque. Although labial crown torque may be favorable in class II div. 2 patients, such anterior torque activation is not recommended, because the intrusive effect on the incisors may significantly decrease. To avoid such partial or even complete elimination of the desired intrusive effect, the utility arch should only be tied to an anterior underlay wire segment or ligated on top of this segment only at the central incisor brackets (see examples in Fig. 5.7b, d). (**c**) Force-moment system equal to that of (**b**) resulting from extreme upper incisor retroclination

component of the malocclusion. It has to be noted that a preliminary headgear phase may already be combined with the treatment of collateral problems in the lower arch. In particular, a mandibular plate equipped with plane lateral bite plates may facilitate the distalization of the upper first molars. This effect is related to the elimination of mesially directed force components on the upper first molars during occlusion resulting from occlusal contacts with the lower first molars.

5.5.3 First Main Stage of Early Treatment

In most patients, the first main stage of early treatment of cover-bite and class II div. 2 is focused on the correction of the malocclusion's key feature, i.e., the retroclination and supraposition of the upper central incisors. This task usually requires proclination and intrusion of the upper central (and often also the lateral) incisors, which may be simultaneously accomplished by means of a partial multibracket appliance comprising the fully erupted permanent incisors and the first molars as posterior support (see patient examples # 1, 2, 3, 6, 7). In this respect, the so-called utility arch design originally described by Ricketts (1979) is particularly suitable mainly for three reasons:

1. Provided that there is enough play between the wire and the anterior bracket slots, the utility arch induces a "statically determinate force-moment system" (Proffit et al.

2007b) which can be easily understood and clinically monitored (Fig. 5.6a).
2. It allows simple (re-)activation by means of bilateral tip-back bends mesial to the first molars.
3. The bypass of the deciduous canine and molar crowns at their cervical level makes the relatively long free wire segments less susceptible to plastic deformation during mastication.

To increase the patient's comfort, a silicone tube or dental flow composite may be used to cover the two upper bends of the utility arch; in this manner, irritation of the vestibular mucosa is minimized (see also Fig. 5.7a–c).

Root resorption is a very frequent consequence of tooth movement, especially intrusion and torquing of incisors (Linkous et al. 2020). The study of Goel et al. (2014) compared the rate of true intrusion, proclination, and root resorption of maxillary incisors for three different intrusion mechanics. The authors observed that Rickett's utility arch was most effective in all three tasks. The higher rate of root resorption observed for the utility arch may be related to the higher intrusion rate.

From a biomechanical point of view, the classical two-by-four utility arch basically reflects a two-couple configuration (Davidovitch and Rebellato 1995), because of the curvature of the incisor segment and the ligation of the rectangular 0.016 × 0.016-in. wire into the anterior brackets. The fact that in such "statically indeterminate system" moments with unknown magnitudes may be generated at the first molars and the incisor segment limits the control on therapeutically applied forces and moments (Fig. 5.6).

Although initial upper incisor retroclination may tempt to incorporate labial crown torque into the utility arch's anterior segment, such combined activation is absolutely not recommended. This is related to the generation of a reactive force couple consisting of extrusive anterior and intrusive posterior components. These reactive loads may significantly decrease or even completely neutralize the desired intrusive effect on the upper incisors (Fig. 5.6b). A preferable alternative for enhancement of the protrusive effect of a utility arch without losing control on its intrusive effect is to slightly activate the step bends in anteroposterior direction before ligation of the anterior segment. Such sagittal activation may also be performed asymmetrically, if the dental midline has to be corrected (see patient example #2).

Since the sagittal distance between the incisor and molar brackets is several centimeters, the resulting reactive moments exerted to the two first molars have a strong distally tipping effect. This (often undesired) collateral effect may be efficiently addressed by applying a high-pull headgear during nighttime with cranial angulation of its extraoral arms (see patient example #3). In this manner, the extraoral force vector runs above the first molars' center-of-resistance (C_r) causing the required neutralizing moment with a counterclockwise direction. The remaining distally directed force vector running above the C_r leads to bodily distalization of the first molars which is desirable in most patients with maxillary incisor retroclination due to their class II tendency.

As mentioned, simultaneous application of a maxillary utility arch with a cervical-pull headgear is absolutely not recommended. The relatively strong extrusive effect of both appliances together with occlusal precontacts exerting forces in opposite direction may lead to "jiggling" of the first molars which may overload the periodontal ligaments.

Ricketts originally recommended the use of 0.016 × 0.016-in. Elgiloy® blue as wire material. Mechanical in vitro testing in our lab at Ulm University, however, revealed that the force deflection behavior of 0.016 × 0.016-in. stainless steel is quite similar. Therefore, this cheaper alternative may also be recommended.

Depending on the question whether intrusion of only the upper centrals or all four maxillary incisors is required, the utility arch may be designed as two-by-two or two-by-four appliance (Fig. 5.7). Adequate force magnitudes for different scenarios can be determined on the following basis: recommended intrusive force magnitudes are 15 cN per maxillary central incisor and 10 cN per maxillary lateral incisor (Proffit et al. 2007b; Burstone 2001). Thus, adequate intrusive activations of the two-by-two and two-by-four utility arch configurations are 30 cN and 50 cN, respectively. Own in vitro testing revealed that a 0.016 × 0.016-in. stainless steel utility arch with tip-back bends of only 15° and 25°, respectively, produce such force magnitudes. Unilateral or asymmetrical activation of the utility arch enables the correction of a canted anterior occlusal plane.

It has to be noted that small deformation of the free segments (e.g., occurring during mastication) may easily be overlooked by the clinician. Such unintended bending may significantly alter the applied force systems leading to uncontrolled incisor and molar movements. Hence, to avoid application of an inadequate intrusive force magnitudes at least for longer time, it is recommended to detach the anterior utility arch segment during each patient appointment (see patient examples #1, #6, and #7).

Many patients initially require intrusion of the upper central incisors before the laterals are to be intruded, as well. This aspect might be clinically addressed using first a two-by-two appliance for upper central incisor intrusion until the level of the lateral incisors is reached. Subsequently, a supplemental underlay wire segment spanning all four incisors may be used. Usually, a superelastic underlay wire (e.g., 0.016 × 0.016-in. NiTi) is to be applied (Fig. 5.7b, d), because lateral incisors often need angulation or rotational corrections.

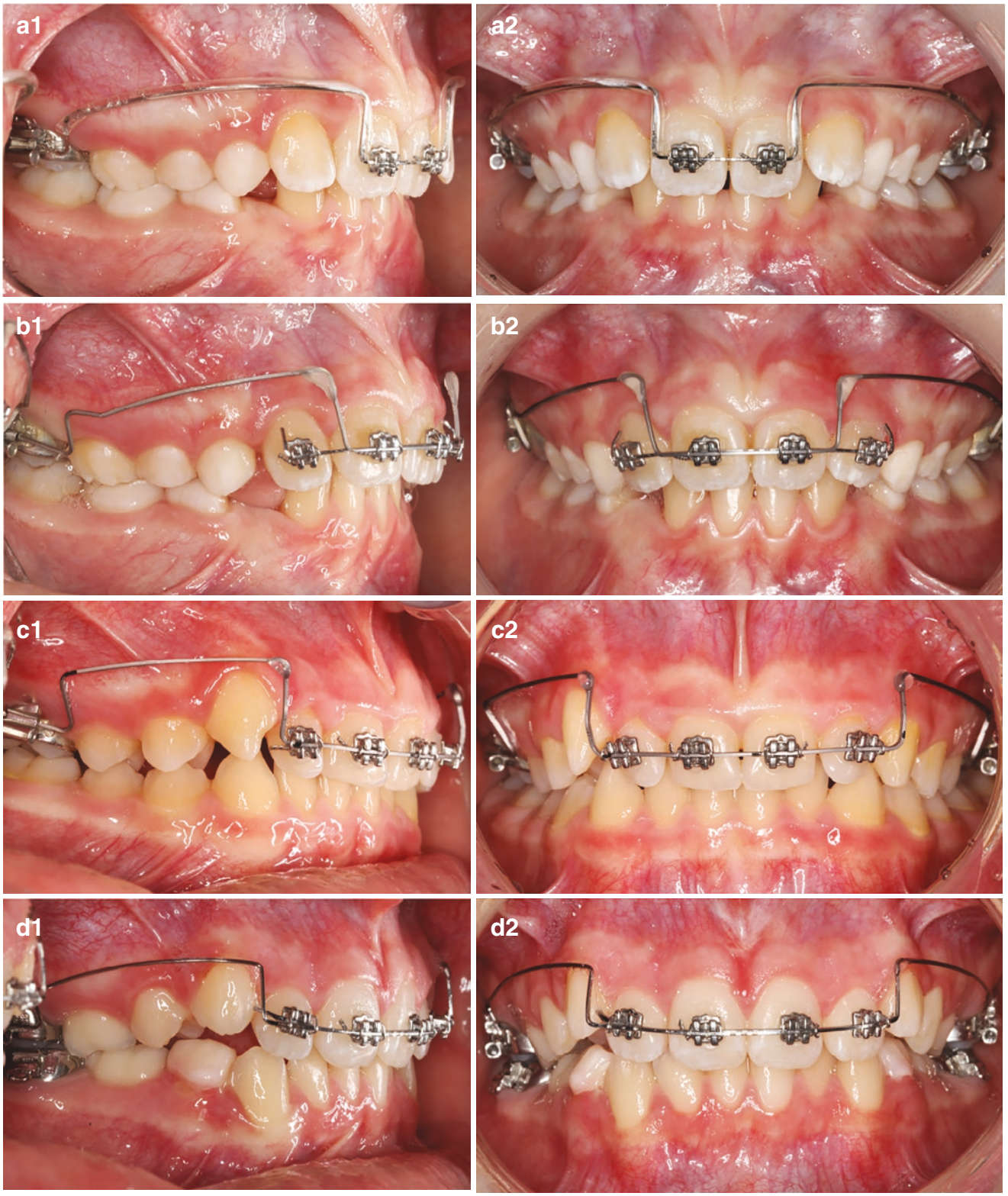

Fig. 5.7 Variants of the utility arch. (**a**) Two-by-two utility arch configuration activated by posterior tip-back bends for generating an intrusive force at the central incisor brackets. This configuration largely avoids anterior torque application which is, as already mentioned, favorable for vertical force control. (**b**) Example for inclusion of the lateral incisors at a later stage using a superelastic underlay wire. (**c**) Example of a classical two-by-four utility arch configuration without underlay wire. (**d**) In this patient, full insertion of a utility arch in all four brackets of the reclined incisor segment would cause a proclining moment; consequently, the intrusive effect on the incisors would be decreased or even eliminated (see also Fig. 5.6c). This problem is minimized by using an underlay segmental wire and only tying the utility arch to the central incisor brackets

The decision whether combined intrusion and proclination of the upper incisors or only their protrusion is required has to consider both pathophysiological and esthetical issues. As mentioned, a high lip line is the most important causative factor for the retroclination of the upper central incisors (Lapatki et al. 2002). From a pure pathophysiological point of view, elimination of this factor is of utmost importance for achieving a high post-therapeutic stability (Lapatki et al. 2004, 2006). Orthodontic treatment, however, must also meet esthetical treatment goals. It has to be noted that in the majority of cover-bite and class II div. 2 patients, the upper central incisors are suprapositioned not only in relation to the occlusal plane but also relative to the lip line. The latter is usually reflected by the significant appearance of maxillary gingiva during smiling (see initial records of patient examples #1, #2, and #6). Thus, greater compromises between high treatment stability and favorable smile esthetics are often avoidable.

A certain part of the patients with retroclined upper incisors, however, displays no maxillary gingiva during smiling or shows even some coverage of the crowns' cervical regions by the upper lip (see initial records of patient examples #5 and #7). Provided that also the lip line level is only moderately high in these patients, the preferred strategy might be to omit the utility arch treatment for active-mechanical intrusion of the upper incisors and only to protrude the upper incisors. As a consequence, significantly more intrusion is later required in the lower incisor segment during the final multibracket treatment phase in the permanent dentition. If these esthetical considerations are ignored, it cannot be denied that the smile esthetics is unfavorable at least in the long term (Zachrisson 2007).

The simplest approach for protrusion without intrusion of upper incisors is the use of a maxillary plate with protrusion springs. This universally applicable orthodontic tool may effectively address other measures in parallel, such as the correction of a dental midline shift or transversal arch expansion in parallel (see patient example #4).

It is important to note that the correction of the malposition of the upper central incisors using a utility arch or maxillary plate may easily be combined with the treatment of collateral problems in the lower arch. For instance, a dental midline shift in the mandible can be corrected in parallel using a mandibular plate with finger springs (see patient example #4). The therapeutic tasks addressed with a mandibular plate may also include uprighting of proclined lower incisors (see patient examples #2 and #3) or transversal expansion of the lower dental arch (see patient example #4).

5.5.4 Second Main Stage of Early Treatment

The results achieved in the preceding early treatment phases (i.e., the intrusion and proclination of the upper incisors and, if required, the distalization of upper first molars) require retention in both the vertical and sagittal dimensions. From a mechanical point of view, an appliance is needed that supports the incisal edges and palatal surfaces of the upper incisors. The vertical force components may also inhibit alveolar growth in the anterior segments leading to further correction of the deep frontal overbite. The prevention of mesial migration of the first molars in the late mixed dentition may be regarded as a further important function of the appliance, if a space discrepancy is present.

A bimaxillary removable appliance seems particularly suitable for these therapeutic tasks since the jaw closing muscles (i.e., the masseter and temporalis) are very effective in generating the required force components. If the malposition of the upper incisors is accompanied by distocclusion and/or a skeletal class II jaw base relationship—which applies for the majority of cover-bite patients—the bite registration required for fabrication of the bimaxillary removable appliance has to be taken in a approx. 4–5 mm protruded mandibular position. Systematic reviews showed that such functional appliances may significantly stimulate mandibular growth (Pacha et al. 2016; Perinetti et al. 2015).

The bite registration for an activator may also address the correction of a skeletally based mandibular midline deviation. It has to be noted, however, that this approach is only promising if the transversal occlusion of the buccal segments is adapted in parallel, e.g., by using differential crisscross elastics worn full-time together with the activator (see patient example #3). Otherwise, the neuromuscular training initiated by functional appliance therapy would be counteracted by occlusal guidance back into the laterognathic position (when the activator is not in situ).

From the available variations of functional appliances, Andresen's "activator" (Graber et al. 1997) or successor versions of this appliance seem most suitable for the second main stage of early cover-bite and class div. 2 treatment. This preference is mainly related to the following aspects:

- An activator enables the implementation of anterior bite planes in its acrylic basis to inhibit further vertical growth.
- This appliance may also enhance the vertical alveolar growth in the molar region by grinding of the interocclusal acrylic to eliminate the vertical support of the molars.
- The wire elements of the activator, together with the relatively large extensions of the acrylic basis to the palatal and lingual attached gingiva, provide a sufficiently good fit even in case of a compromised dental support, i.e., during eruption of the permanent canines and premolars in the late mixed dentition.
- A standard activator also comprises stop loops mesial to the first molars which prevent the mesial migration of the first molars; in this manner, the leeway space may be preserved for the anterior teeth.

The preservation of the leeway space is to be regarded as a highly efficient approach for reducing a space discrepancy in the dental arch (see patient examples #2). This is due to the possibility of gaining approx. 2.5 mm additional space on each side of the lower arch and approx. 1.5 mm per side in the upper arch (Proffit et al. 2007a). This measure is to be applied to the lower arch more frequently because many class II patients initially show proclined incisors which means that additional space is required for incisor uprighting by means of an activated labial bow. The proclination of the lower incisors observed during class II functional appliance therapy may cause or increase a space discrepancy in the lower arch. This effect is related to fatigue of the mandibular protractor muscles after the appliance is in situ for longer periods. Consequently, the mandible is not any more actively hold in its therapeutic anterior position and tends to return back into its original (more posteriorly located) resting position. As a result, the appliance exerts posteriorly directed contact forces on the maxillary first molars and incisors (via the stop loops and upper labial bow, respectively) and labially directed contact forces onto the mandibular teeth (mainly via the lower frontal acrylic part onto the lower incisors' lingual surfaces). The latter explains the collateral protrusion of the lower incisor during class II functional appliance therapy.

The preservation of the leeway space requires the intervention of the clinician (see patient example #2, Fig. 5.26). More concretely, if the incisors are to be uprighted, the first intervention is to grind the deciduous canines mesially. If the first deciduous molars are not exfoliating before or during the eruption of the permanent canines, another required intervention is to grind these teeth mesially or to extract them. The same applies for the second deciduous molars during eruption of the first premolars. To ensure that enough enamel is reduced by grinding of deciduous molars and to avoid contacting and damaging of erupting or erupted adjacent permanent teeth, it is recommended to use a very thin, long diamond bur and to leave a thin, vertical slice of enamel between the bur and the neighboring tooth (Fig. 5.26b). In this manner, approx. 1 mm of space may be provided.

In patients with congenitally missing mandibular second premolar(s), another task performed with an activator during the mixed dentition phase may be the guidance and enhancement of the mesial migration of the permanent molars into the second premolar space(s). The remaining spaces are then to be closed by fixed appliance therapy, often in combination with skeletal anchorage.

According to own clinical experience, clinical monitoring of functional appliances in intervals of 2–3 months seems sufficient—particularly, in the "resting phase" of the mixed dentition, i.e., before the permanent canines and premolars begin to erupt. The subsequent eruption guidance in the late mixed dentition requires more careful examination of the appliance fit and grinding of the activator's interocclusal acrylic part (see Fig. 5.12a).

5.5.5 Consequences of Later Treatment Begin in the Final Mixed Dentition Stage

Particularly if the therapeutic correction of a class II div. 2 or cover-bite is started relatively late, i.e., in the final stage of the late mixed dentition, the second stage of early treatment (i.e., the functional appliance phase) may or must be omitted. This means that the treatment may directly or progressively transit from the utility arch to a full multibracket appliance. An advantage of omitting functional appliance therapy in these patients is that total treatment time is not unnecessarily prolonged which is particularly important in severe cover-bite cases requiring excessive and time-consuming further anterior bite opening and upper incisor torque correction.

If in such situation, however, significant distocclusion is present, an intermediate or parallel phase is required for correction of the class II pattern. The same applies to patients which are noncompliant with removable appliances for class II correction such as the headgear and activator. Depending on the localization of the problem (i.e., mandibular retrognathism, maxillary prognathism, or a combination of both) and on the inclination of the lower incisors, either a Herbst or Herbst-like appliance (Schweitzer and Pancherz 2001; Obijou and Pancherz 1997) or a skeletally anchorage distalization appliance (Wilmes and Drescher 2010) (see patient example #7) may be considered for class II correction. The frontal class II div. 2 features, i.e., the deep frontal overbite and the upper incisor retroclination, are then to be completely corrected during the subsequent treatment phase, e.g., by using Burstone's segmented multibracket appliance mechanics (Burstone 2001) or adaptations of this approach.

5.6 Patient-Specific Treatment Concepts for Successful Class II Div. 2 and Cover-Bite Correction: Seven Patient Examples

If orthodontic therapy of a cover-bite and class II div. 2 malocclusion is initiated in the early mixed dentition, a two-phase approach comprising the classical two stages of the first phase (as described above) and a directly following second multibracket phase may be applicable in most of these patients. Five of seven patient examples included in this chapter fall into this category. In the remaining two patients, treatment was either started with molar distalization with the omission of the first classical early treatment main stage (patient #5) or significant molar distalization was to be carried out prior to final multibracket therapy due to compromised compliance with the functional appliance (patient #7). All patients included were treated personally by the author of this chapter.

5.6.1 Patient Example #1

The clinical findings and the treatment approach applied in this female patient may be considered as typical for a severe class II div. 2 (Table 5.1). Her initial records show a complete cover-bite combined with ¾-step distocclusion and a skeletal class II (Figs. 5.8 and 5.9). Her initial lip-to-incisor relationship has been characterized by a high lip line level in the lips' resting posture and clear maxillary gingiva display during smiling. Hence, it could be assumed that intrusion of the maxillary incisors using a utility arch would not compromise the smile esthetics.

The course and result of early treatment is documented in Figs. 5.10, 5.11, 5.12, 5.13, and 5.14. Since the correction of the distocclusion during the two main early treatment stages has not been fully achieved, distalization of the upper molars by means of a cervical-pull headgear has been required before insertion of the full multibracket appliance. Figure 5.15 proves that this measure was successful. The records taken during the final multibracket phase, directly after debracketing and after 12 months retention (Figs. 5.16, 5.17, 5.18, 5.19, and 5.20) show that all treatment goals could be achieved. The observed proclination of the lower incisors in relation to the lower mandibular border should be considered unproblematic, due to the patient's horizontal growth pattern. As demonstrated by the frontal image during smiling taken in the retention period (Fig. 5.20), the smile esthetics was actually not compromised by the active-mechanical intrusion of the upper incisors. Figure 5.21 shows the buccal and frontal occlusal relationships prior to and after therapy.

Table 5.1 Problem list and conceptual treatment planning in patient #1. The items (a), (b) etc. are to be interpreted as successive treatment stages.

	Problem list and relevant collateral findings	**Conceptual treatment planning**
1.	Class II div. 2 malocclusion with a cover-bite • Retroclination of upper centrals by −13° • Deep frontal overbite of 5.5 mm with – Supraposition of upper centrals – Supraposition of all 4 lower incisors • High lip line level of 6 mm • Smile with 2 mm maxillary gingiva display	Treatment in mixed + permanent dentition (a) Early active-mechanical correction of upper centrals (utility arch) (b) Passive incisor intrusion (activator) (c) Active-mechanical finalization of incisor intrusion, palatal root torque for U1
2.	Severe distocclusion (¾-step) + skeletal class II pattern (Wits appraisal + 2.7 mm)	(a) Functional appliance therapy (activator) (b) (If required) active-mechanical distalization of upper molars prior to multibracket therapy
3.	Maxillary dental midline deviation (1 mm to right side)	Slightly asymmetric protrusive activation of the utility arch
4.	Multiple ankylosed deciduous molars	Extractions at the necessary times
5.	Peg-shaped tooth 22	Composite restauration after finalization of multibracket therapy
	Sequence of therapeutic measures (begin at the age of 9:0 years)	**Duration**
1.	Extraction of severely ankylosed tooth 55	
2.	Utility arch treatment (two-by-two) + high-pull headgear during bedtime	8 months
3.	Activator with mandibular advancement + anterior bite plates	1:04 years
	Reevaluation → further distalization of upper first molars was required	
4.	Cervical-pull headgear	11 months
5.	Multibracket appliance	1:03 years
6.	Retention with maxillary and mandibular plates	

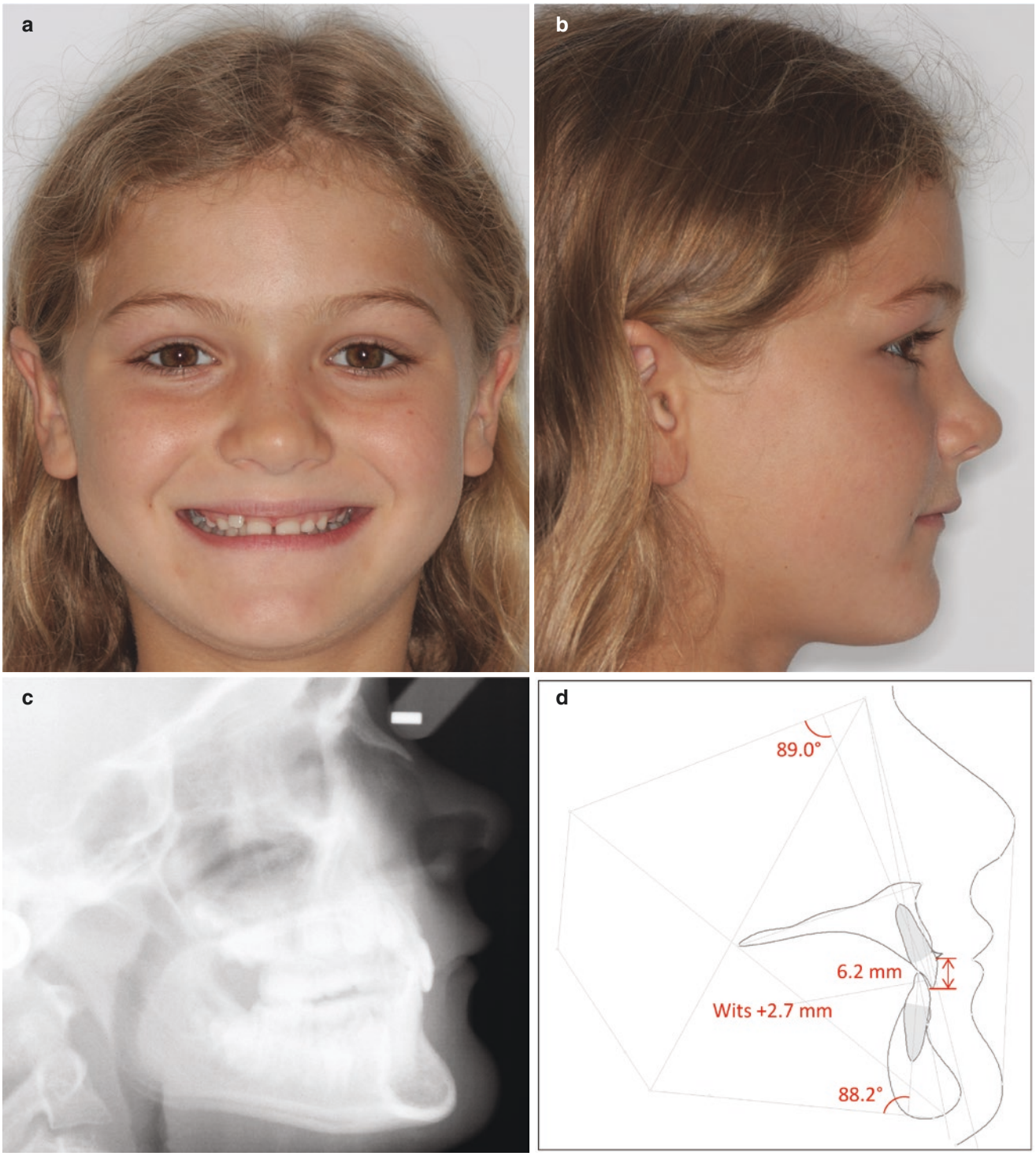

Fig. 5.8 (**a**–**d**)/patient #1. Facial images and cephalogram of patient #1 taken at age 8:11 years prior to treatment. (**a**) The frontal image shows the significant maxillary gingiva display during smiling. (**b**) The facial profile is concave due to a prominent chin. (**c**, **d**) The cephalogram reveals the characteristic features of a cover-bite, i.e., a high lip line level, deep frontal overbite, and retroclination of the upper centrals reflected by an SN/U1 angle of 89.0° (reference: 102°). The Wits appraisal (+2.7 mm) indicates a skeletal class II pattern

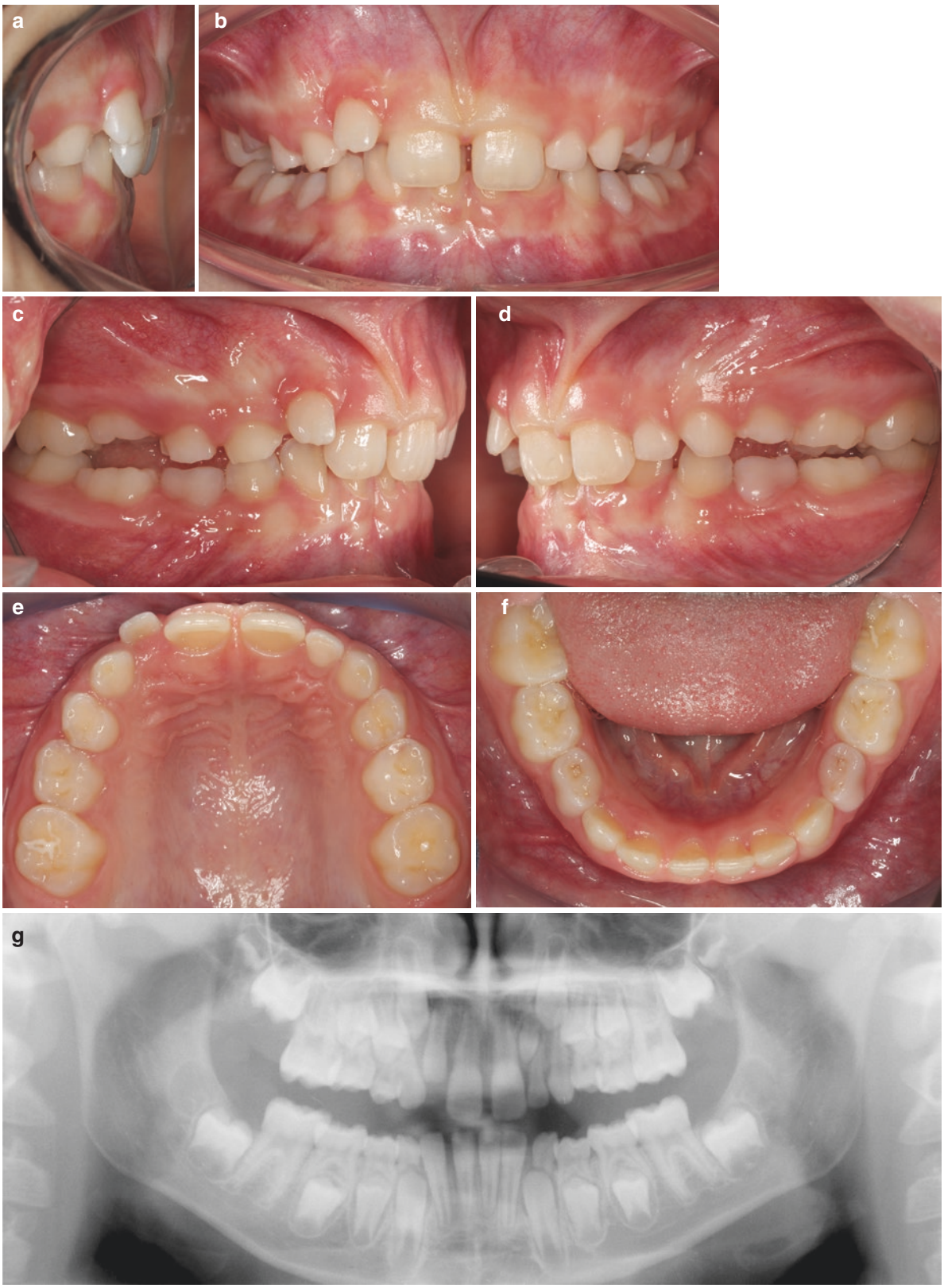

Fig. 5.9 (**a**–**g**)/patient #1. Dental images and panoramic X-ray of patient #1 associated with the records depicted in Fig. 5.8. (**a**, **b**) The frontal and lateral views of the dentition reveal the class II div. 2 malocclusion with a cover-bite in the early mixed dentition. The lower central incisors are nearly completely covered by the retroclined upper centrals. (**c**, **d**) First molars showed nearly full-step distocclusion. All deciduous molars are ankylosed except for tooth 54. (**e**, **f**) Occlusal views on both arches. Tooth 12 is tipped labially. The infraposition of this tooth is related to the position of its incisal edge on top of the lower lip at rest. In the second quadrant, the deciduous lateral incisor is persisting. (**g**) The panoramic X-ray reveals the peg-shaped tooth 22 showing also a delayed development

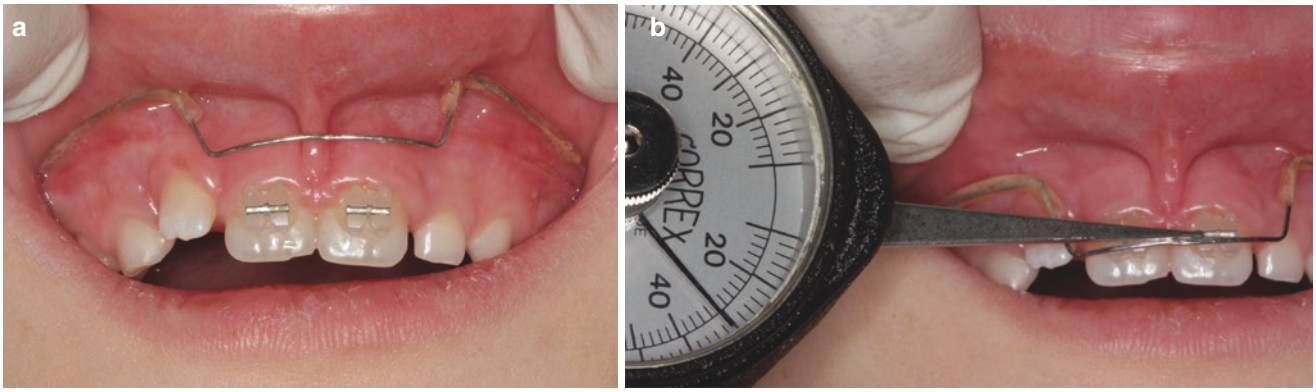

Fig. 5.10 (**a**, **b**)/patient #1. The first stage of early treatment comprised a utility arch (two-by-two configuration) in the upper jaw. (**a**) For the second reactivation 2 months after treatment start, the wire is detached from the brackets. For symmetric intrusion, the anterior wire segment has to run horizontally to achieve uniform loading of both incisors. (**b**) The intrusive force is measured by leveling the anterior wire segment with the bracket slots using the tip of a spring balance. Attention must be paid that during the measurement that the utility arch contacts only the probe's tip. If necessary, the tip-back bends of the utility arch are adjusted to obtain an adequate total intrusive force of 30 cN (15 cN per tooth)

Fig. 5.11 (**a**–**h**)/patient #1. Situation after 9 months utility arch treatment. (**a**, **b**) The frontal view on the face during smiling shows the appearance of the upper centrals' incisal edges and the absence of maxillary gingiva display during smiling. (**c**, **d**) Intrusion and proclination of the upper central incisors resulted in a decrease of the frontal overbite to 3 mm. (**e**, **f**) The proclination of the upper central incisors led to a sagittal interincisal distance of 1.5 mm which is to be regarded as a precondition for the subsequently planned mandibular advancement in the second stage of early treatment. (**g**, **h**) Occlusal views indicating that sufficient space is provided in both arches for the permanent teeth

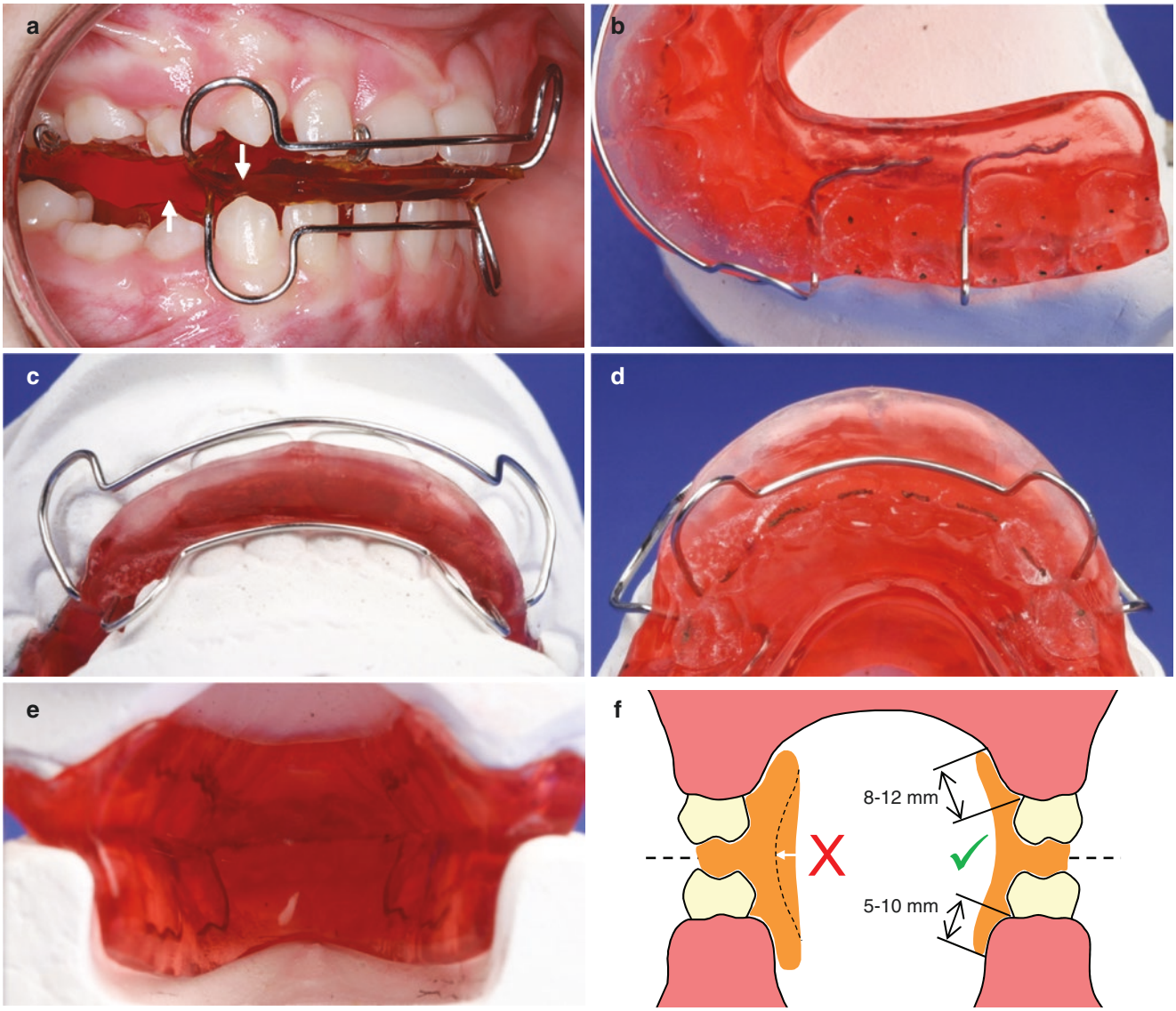

Fig. 5.12 (**a**–**f**)/patient #1. Construction of the class II activator. (**a**) A class II activator with anterior bite blocks is applied to patient #1 in the second early treatment stage. The construction bite has been registered during approx. 4 mm mandibular protrusion and approx. 3–4 mm bite opening in the first molar region. (**b**) During fabrication, the posterior acrylic part has to be extended so that it supports oral and buccal cusps of upper and lower buccal teeth. In situ, the interocclusal acrylic part may locally be ground to enable eruption of the permanent canines and premolars in the late mixed dentition (see panel (**a**), white arrows) or to enhance alveolar growth in the corresponding region. (**c**) In class II div. 2 patients with a deep frontal overbite, the anterior acrylic part has to support the maxillary incisors at their incisal and palatal surfaces for retention of the previously achieved intrusion and proclination of the upper incisors. (**d**) The activator's lower frontal surface contains grooves for the mandibular incisors' incisal edges to inhibit vertical alveolar growth in this region. (**e**) The activator's oral extension has to be concave so that the restriction of tongue functions is minimized. This is an important factor regarding the patient's compliance. (**f**) The vertical extension of the acrylic (usually 8–12 mm in the maxilla and 5–10 mm in the mandible) has to adapt to individual alveolar bone height

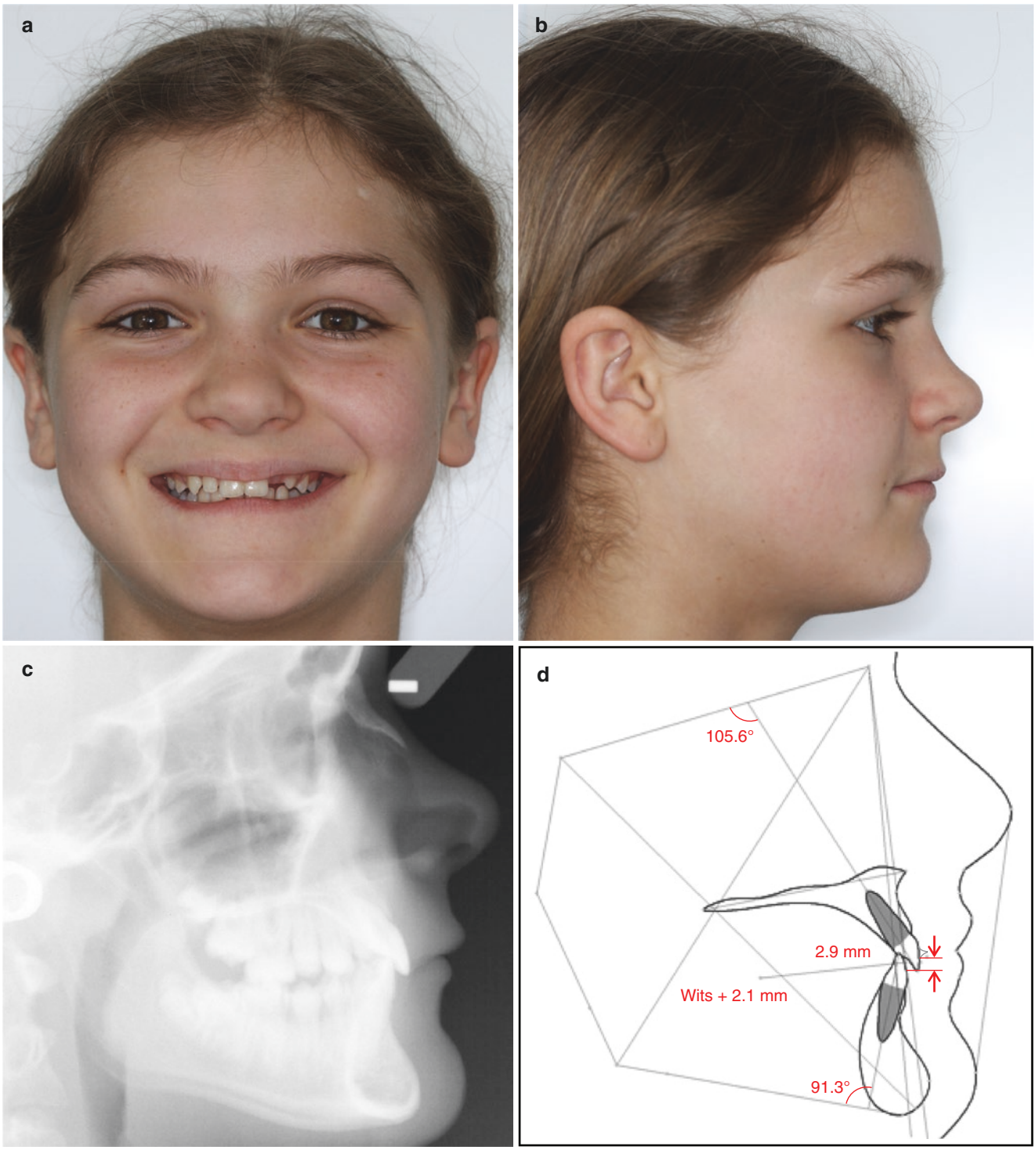

Fig. 5.13 (**a**–**d**)/patient #1. Facial images and lateral cephalogram taken after 9 months utility arch treatment and 7 months activator therapy. The lateral cephalogram demonstrates the achievements in the first early treatment stage, i.e., proclination of the upper central incisors by 16.6° and reduction of the lip line level to approx. 3 mm

Fig. 5.14 (**a**–**i**)/patient #1. Dental images corresponding to the facial images and cephalogram depicted in Fig. 5.13. (**a**, **b**) Activator in situ. A rectangular spring welded to the labial bow is used for palatal movement of tooth 24. (**c**, **d**) The original cover-bite characteristics have already disappeared. (**e**) The late developed peg-shaped left upper lateral incisor is shortly before eruption. (**f**, **g**) Buccal segments still show distocclusion >½-step. Thus, an additional phase comprising the distalization of the upper first molars using a cervical-pull headgear was added to the original treatment plan. (**h**, **i**) Occlusal views on the dental arches

Fig. 5.15 (**a**–**f**)/patient #1. Dental images taken 12 months after begin of cervical-pull headgear therapy. Neutral occlusion of the first molars has been achieved. Maxillary premolars show passive distal drift. The extrusive force component of the cervical-pull headgear resulted in a further reduction of the deep overbite. The peg-shaped tooth 22 is erupting

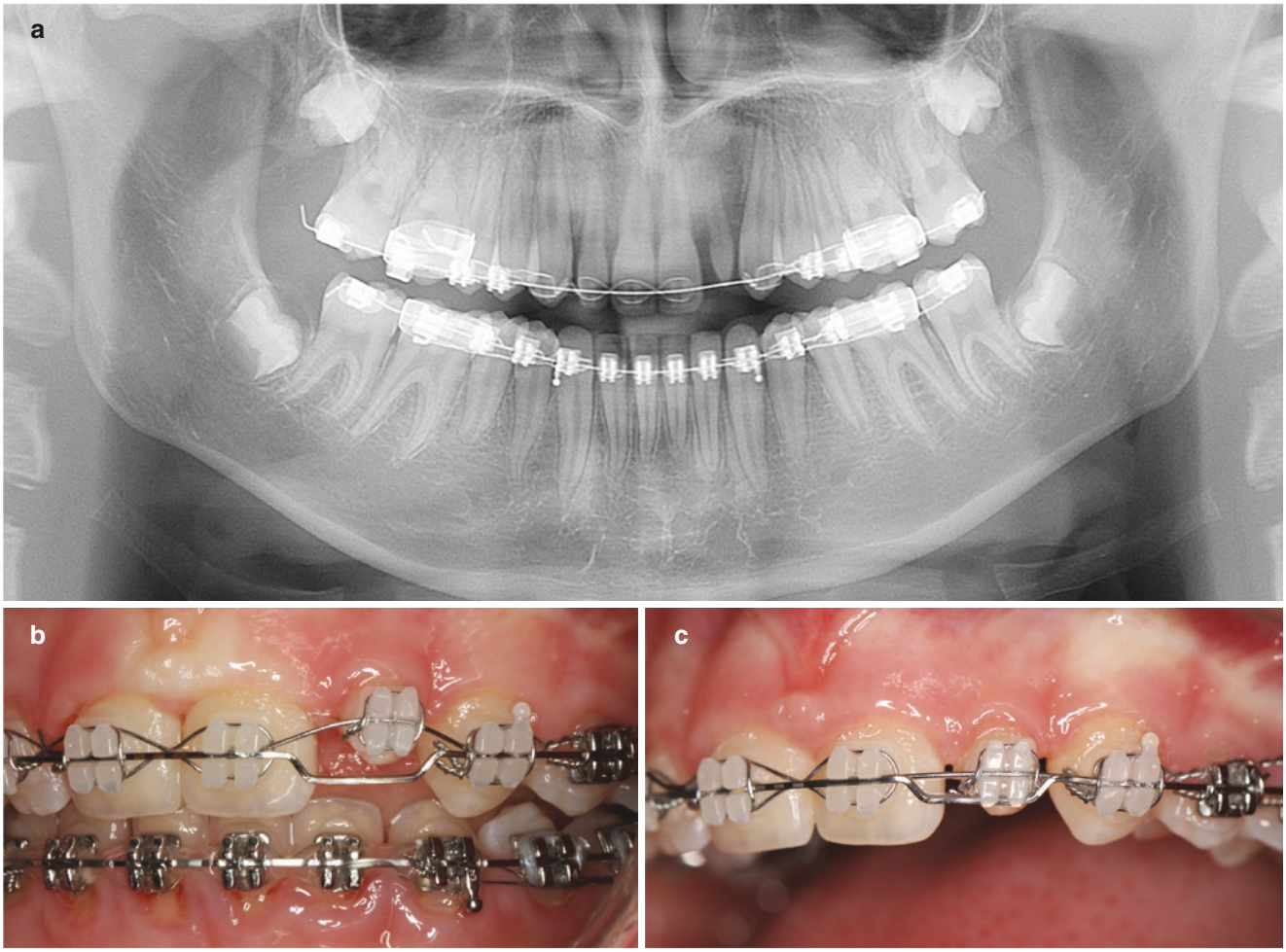

Fig. 5.16 (**a**–**c**)/patient #1. (**a**) Panoramic X-ray taken 6 months after bracketing for clarification whether the patient has a genetic predisposition to severe apical root resorptions (which is not the case). (**b**) Leveling and alignment are completed so that a 0.016 × 0.016-in. stainless steel wire with a 2.5-mm offset bend is inserted. Tooth 22 is now equipped with a bracket and integrated in the appliance using a 0.012-in. NiTi wire. (**c**) Eight months after bracketing, sufficient extrusion of tooth 22 is achieved so that a straight archwire can be inserted

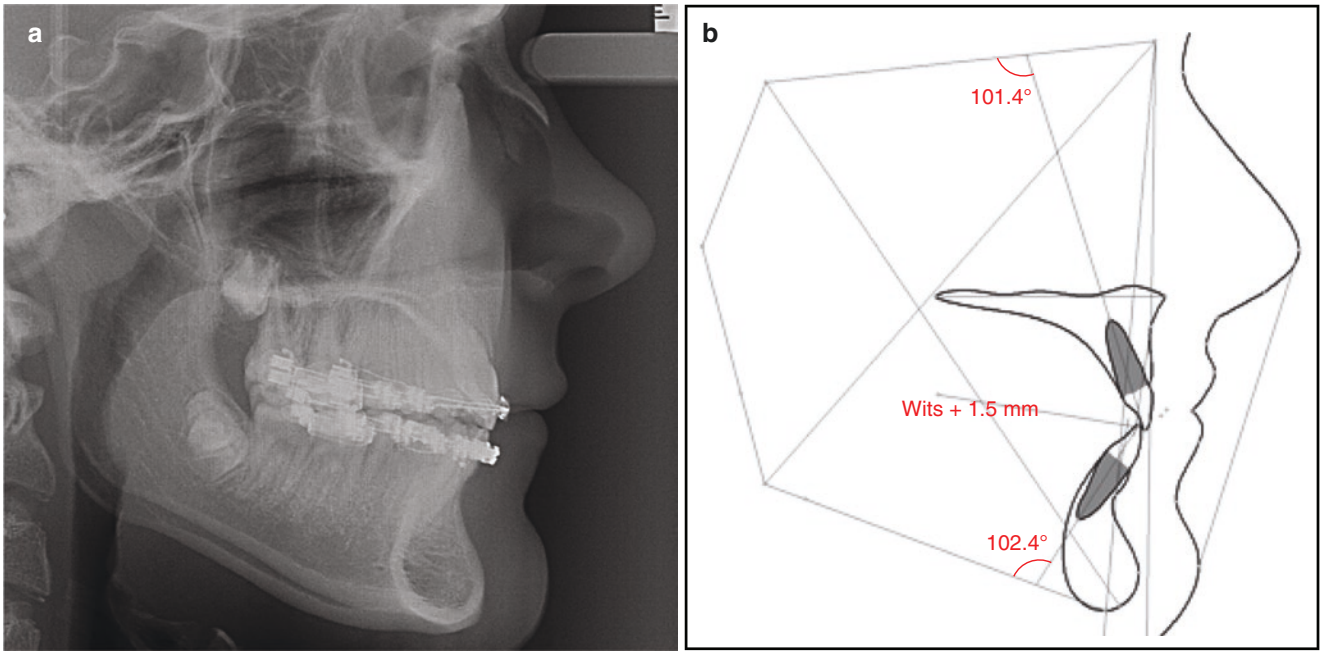

Fig. 5.17 (**a**, **b**)/patient #1. (**a**) Lateral cephalogram for control of incisor inclination in the final phase of multibracket therapy. (**b**) The tracing shows that axial the inclination of the upper central incisors agrees with the reference value (102°). As a side effect of the class II activator and class II elastics applied during multibracket therapy, the lower incisors proclined by approx. 10°. The ANB angle (4.1°) is very close to the individualized reference value (3.9°), and the Wits appraisal improved from 2.7 mm to +1.5 mm. Hence, the mild class II jaw base relationship which was initially present is corrected

Fig. 5.18 (**a**–**h**)/patient #1. Debracketing after fixed appliance treatment for only 15 months. (**a**, **b**) The deep overbite is slightly overcorrected to a value of 1 mm. (**c**, **d**) Neutral buccal occlusion is achieved on both sides. (**e**) The spikes bonded to the upper central incisors' palatal surfaces during multibracket therapy are not yet removed to prevent further bite opening due to the persisting viscero-somatic swallowing pattern. (**f**) Occlusal view on lower arch. (**g**, **h**) Acrylic plates are used in both jaws for retention. The patient is instructed to wear the retention appliances every night

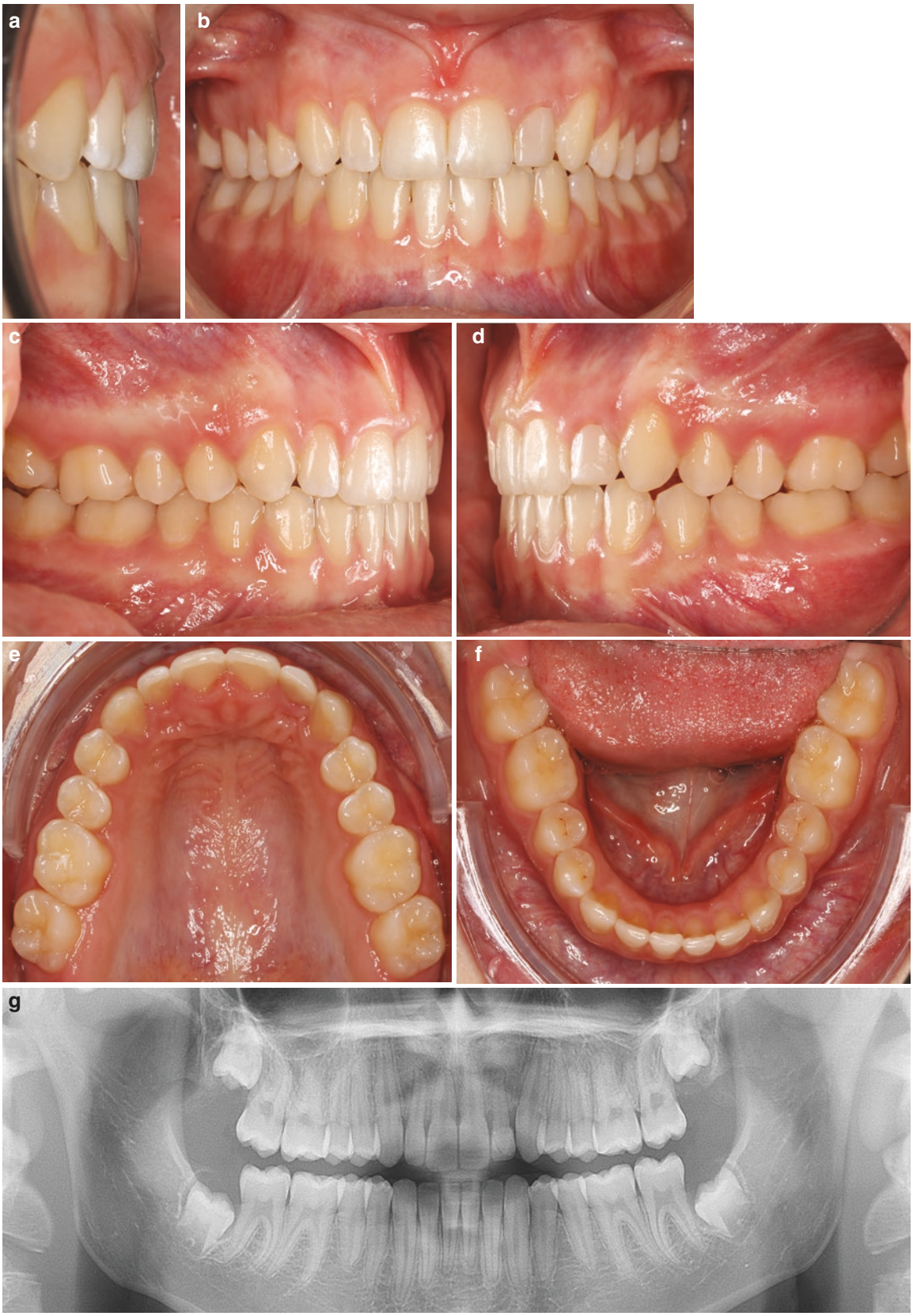

Fig. 5.19 (**a**–**g**)/patient #1. Dental images of patient #1 taken 12 months after debracketing. (**a**–**c**) The buccal occlusion has settled and the frontal overbite relapsed to a physiological value of 1.5 mm. The proclination of the upper centrals and the neutral buccal occlusion achieved during therapy remained stable. (**d**, **e**) Composite reconstruction of the left upper lateral incisor crown by the patient's general dentist. (**f**) Occlusal view on the lower dental arch. (**g**) The panoramic X-ray shows small root resorptions at teeth 12, 11, 31, and 45. The germs of the third molars are developing and show good axial inclinations so that their extraction is not indicated (at least at this stage)

Fig. 5.20 (**a**, **b**)/patient #1. Facial images of patient #1 associated with the dental records depicted in Fig. 5.19 taken after 12 months retention. (**a**) The patient shows a nice smile arc and buccal corridor and displays the full upper central incisor crowns during smiling. (**b**) Lateral view on the face showing the patient's inherited concave facial profile

Fig. 5.21 (**a**, **b**)/patient #1. Buccal and frontal occlusal interrelationships prior to (**a**) and after therapy (**b**)

5.6.2 Patient Example #2

This patient showed severe upper central incisor retroclination related to a high lip line before therapy, but the frontal overbite was only moderately deep (6 mm), and the class II component showed relatively slight manifestation (Table 5.2, Figs. 5.22 and 5.23). The treatment course in this patient proves the effectiveness of the utility arch for upper incisor intrusion and proclination (Figs. 5.24 and 5.25). Moreover, this patient example demonstrates how early therapeutic intervention may easily and effectively address a hereditary space discrepancy in the dental arch. Such space discrepancy may typically be reflected by undermining resorption of the deciduous canines during eruption of the lateral incisors—as present in the patient's lower dental arch. Utilizing the leeway space for anterior teeth requires the intervention of the clinician by means of prevention of the physiological mesial migration of the molars and by grinding or extraction of deciduous canines and molars which enables the eruption of the permanent canines and premolars more distally. As a result of the improved space conditions, transversal arch expansion or incisor protrusion during multibracket therapy and the corresponding relapse risk can be avoided or at least minimized.

The treatment of this patient has been still ongoing at publication date, so that posttreatment records have not been available. The latest dental images, however, taken in the final mixed dentition phase (Fig. 5.26) already demonstrate how a mild cover-bite can be effectively treated by early intervention, so that only very limited active-mechanical intervention is required in the permanent dentition—if at all.

Table 5.2 Problem list and conceptual treatment planning in patient #2

	Problem list and relevant collateral findings	**Conceptual treatment planning**
1.	Cover-bite-like malocclusion with • Retroclination of upper centrals by −15.5° • Deep frontal overbite of 6 mm with supraposition of upper centrals only • High lip line level of 7 mm • Smile with 3 mm maxillary gingiva display	Treatment in mixed + permanent dentition (a) Early active-mechanical correction of upper central incisors (utility arch) (b) Passive incisor intrusion (activator) (c) If required, subsequent multibracket therapy for additional incisor intrusion, palatal root torque for upper centrals
2.	Mild skeletal class II with physiological distocclusion of first molars	Slight mandibular advancement (activator)
3.	Midline deviation of 2 mm, due to combined • Latero-occlusion of 1 mm to right side (precontacts at 55/46 + 63/74) • Dental midline shift in lower arch of 1 mm to right side	Midline corrections by • Grinding of 55 distally and 63 palatally for elimination of precontacts • Early correction of the dental midline shift in the lower jaw
4.	Space discrepancy in lower jaw with undermined resorption of deciduous canines during eruption of lateral incisors → only 2 mm space for permanent canines	Utilizing the leeway space for anterior teeth • Successive grinding of deciduous molars • Prevention of mesial migration of upper and lower first molars in the late mixed dentition phase
5.	Mild symptoms for a temporo-mandibular disorder • Articular pain during compression of stratus superioris on right side • Muscle pain in masseter during palpation	Elimination of precontacts for reduction of the dorsal compression of the right temporo-mandibular joint in habitual occlusion
	Sequence of therapeutic measures (begin at the age of 8:06 years)	**Duration**
1.	Grinding of teeth 55 and 63	–
2.	Maxilla: Utility arch (two-by-two, later two-by-four) Mandibula: Plate for midline correction + prevention of leeway space	5 months
3.	Activator with • Anterior bite plates + stop loops for upper and lower first molars • Slight mandibular advancement	Ongoing since 1:06 years
	Reevaluation → palatal root torque necessary for upper centrals?	
4.	Multibracket or aligner therapy (depending on remaining tooth malpositions and patient's preference)	Forthcoming
5.	Retention using maxillary and mandibular plates	Forthcoming

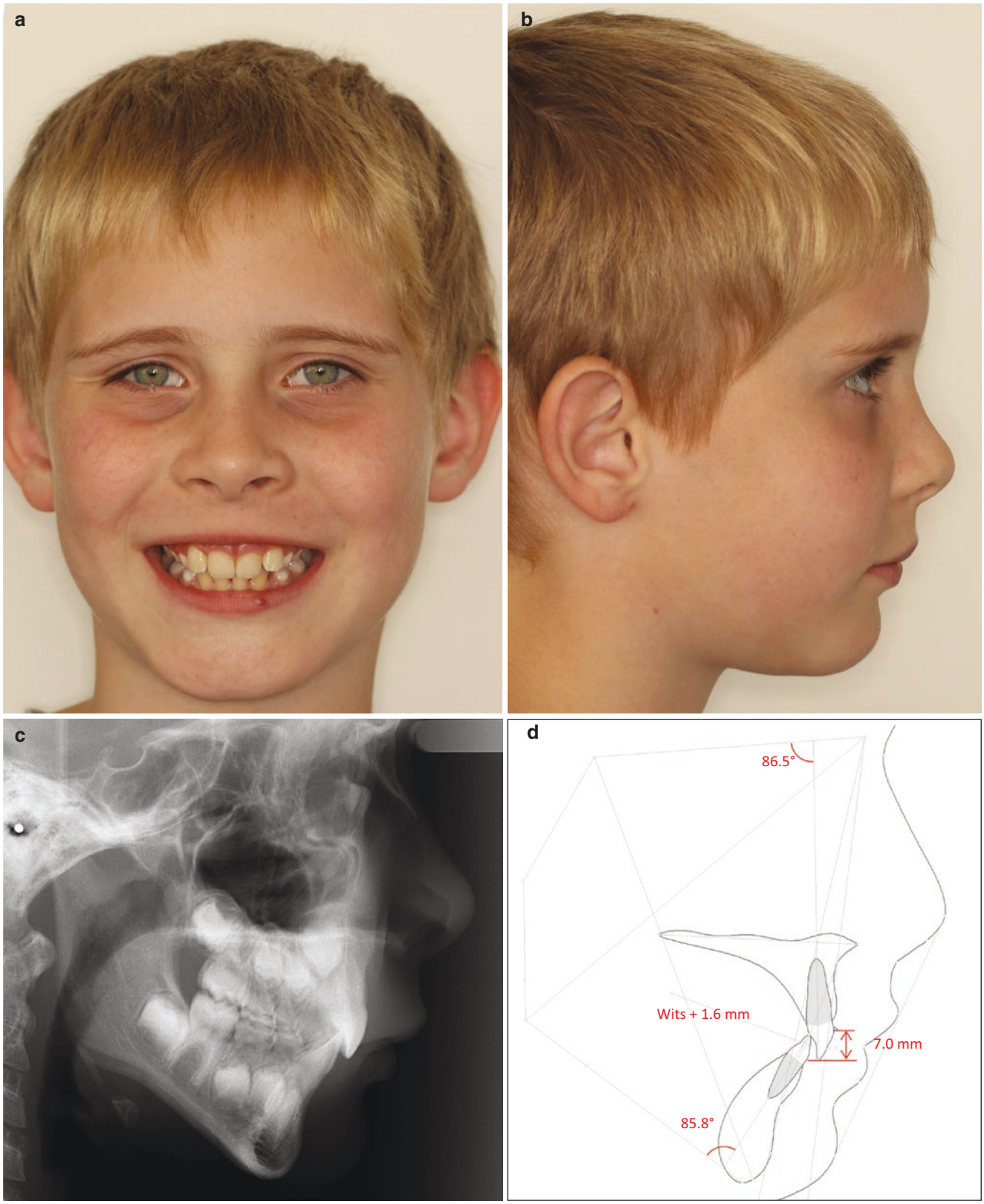

Fig. 5.22 (**a**–**d**)/patient #2. Initial facial images and cephalogram of patient #2 taken at age 8:02 years. (**a**) The frontal view of the face during smiling shows the significant maxillary gingiva display. (**b**) The facial profile is retrognathic. (**c**, **d**) Cephalometric analysis reveals the severe retroclination of the upper central incisors by 15.5° and the high lip line level of 7 mm. The mild class II jaw base relationship is indicated by the Wits appraisal of +1.6 mm

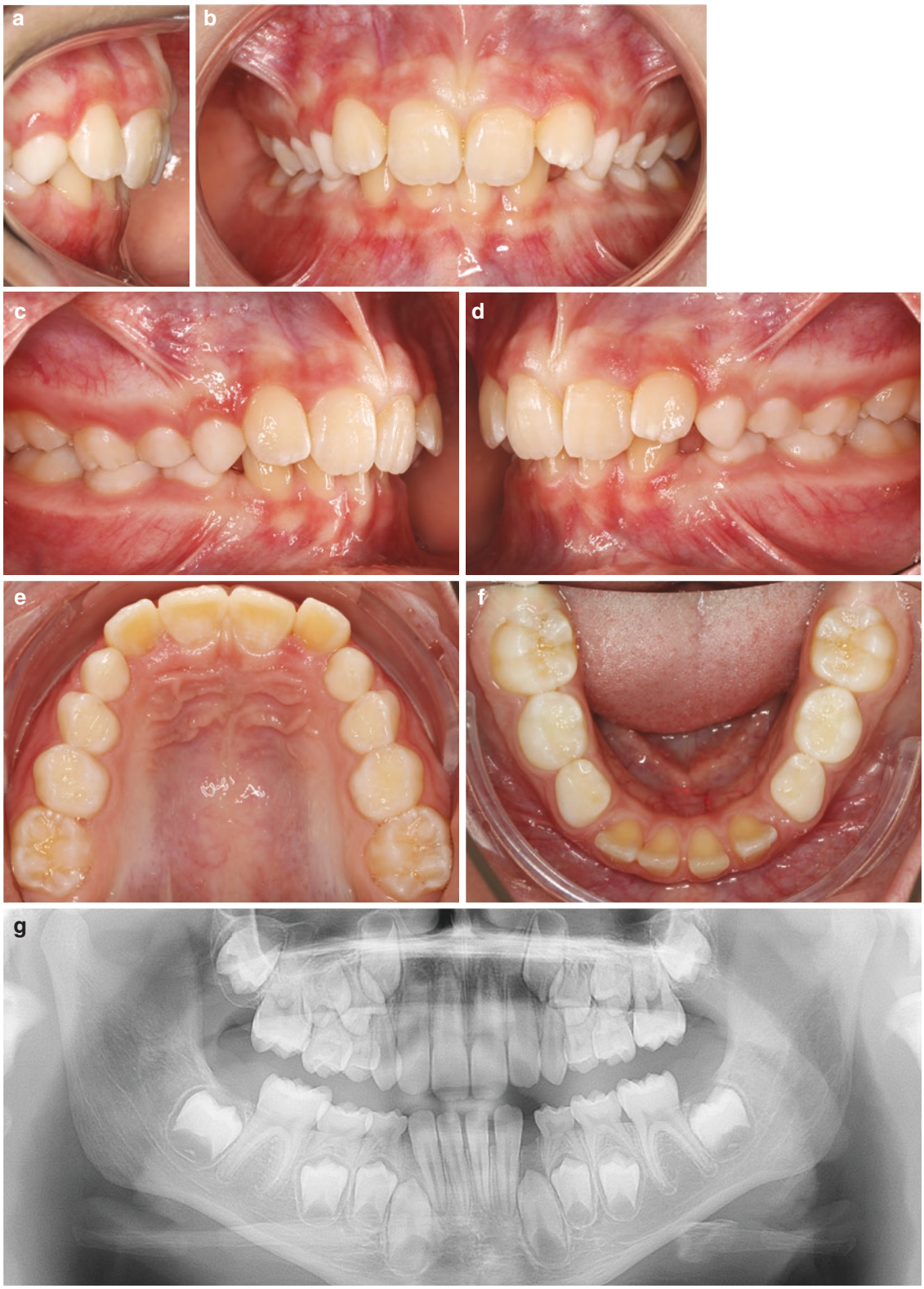

Fig. 5.23 (**a**–**g**)/patient #2. Dental images of patient #2 associated with the records depicted in Fig. 5.22. (**a**, **b**) Severe retroclination of the upper centrals combined with a moderately deep overbite. The midline deviation of 2 mm is related to mandibular latero-occlusion by 1 mm and a dental midline shift in the lower arch by 1 mm to the right side. (**c**, **d**) The slight distocclusion of the first molars may be considered physiological in this phase as canine relation is neutral. (**e**, **f**) Occlusal images of the dental arches. The early loss of the mandibular deciduous canines during eruption of the permanent lateral incisors indicates a hereditary crowding pattern. (**g**) Lateral cephalogram showing physiological dental development

Fig. 5.24 (**a**–**f**)/patient #2. Situation 5 months after insertion of the mandibular plate and 2 months after begin of utility arch treatment. (**a**, **b**) Upper incisors are partially intruded and proclined, and the midline shift is already completely eliminated. (**c**, **d**) The clasp retentions of the mandibular plate barely interfere with habitual occlusion. (**e**) The utility arch follows the contour of maxillary arch form. (**f**) The mandibular dental midline has been corrected by successive activation of the finger spring distal to tooth 42. Incisors are partially uprighted by the active labial bow

Fig. 5.25 (**a**–**d**)/patient #2. Overview over the different stages during intrusion and proclination of the upper central incisors. (**a**) Situation at insertion of the mandibular plate. (**b**) Two months later, the utility arch (two-by-two configuration) is inserted. (**c**) Situation after treatment with the mandibular plate for 8 months and parallel utility arch treatment for 5 months. Active intrusion of the upper central incisors by approx. 2 mm is clearly recognizable. (**d**) Insertion of an activator after utility arch treatment to retain the correction of the upper incisor segment and to address the other treatment tasks planned in the second main stage of early treatment

Fig. 5.26 (**a**–**e**)/patient #2. Different stages during the second main stage of early treatment of patient #2 illustrating the utilization of the leeway space for the anterior teeth. (**a**) Activator in situ. The stop loops located directly mesial to the mandibular first molars prevent mesial migration of these teeth after subsequent loss of the deciduous molars. (**b**) For grinding of deciduous molars adjacent to permanent teeth, it is recommended to preserve a slice of enamel for absolute protection of the permanent tooth. (**c**) Situation after grinding of the first deciduous molars which provided space for the erupting permanent canine. (**d**) Both lower canines have migrated in distal direction so that their overlap with the lateral incisors is eliminated. The first deciduous molars are already exfoliated and the first premolars erupt direct distal to the canines into the space provided by grinding of the second deciduous molars at their mesial sides. (**e**) Situation after eruption of the lower second premolars. Although treatment has still been ongoing in this patient at publication date, it is demonstrated that the anterior space discrepancy has been completely eliminated by utilizing the leeway space for incisors, canines, and premolars

5.6.3 Patient Example #3

The class II div. 2 malocclusion in this patient may be characterized as moderate with respect to its vertical and sagittal manifestation (Table 5.3, Figs. 5.27 and 5.28). In Fig. 5.29 it is shown how a high-pull headgear has to be designed for achieving bodily distalization of upper first molars during utility arch treatment instead of distal tipping, and how the first early treatment stage may be used for early correction of a dental midline shift in parallel to the main intervention in the maxilla. The images taken at different times during the initial stage of early treatment (Fig. 5.30) again demonstrate the effectiveness of the utility arch for elimination of the typical cover-bite features by means of true incisor intrusion and first molar extrusion. More specifically, upper incisors are significantly proclined and the overbite is reduced by approx. 4 mm in only 4 months of treatment.

The specific problem in this patient, however, lies in the combination of the class II div. 2 pattern with mandibular laterognathism. The course of the treatment demonstrates how the latter problem may effectively be addressed parallel to the correction of the class II div. 2 features using an activator combined with differential crisscross elastics (Figs. 5.31 and 5.32). In this manner, it is possible to correct a laterognathic mandible causally during the growth period. In contrast, exclusive treatment in the permanent dentition would only have enabled the dentoalveolar compensation of the laterognathism.

Treatment has been still ongoing at publication date, but the main aspects of the initial malocclusion are already causally corrected by the early intervention in the mixed dentition phase. Hence after eruption of all permanent teeth, only a short final therapeutic phase using a multibracket appliance is to be expected.

Table 5.3 Problem list and conceptual treatment planning in patient #3

	Problem list and relevant collateral findings	**Conceptual treatment planning**
1.	Class II div. 2 malocclusion with • Retroclination of upper centrals by −14.5° • Deep frontal overbite of 6.5 mm • High lip line level of 7 mm • Smile with full crown display of upper centrals (but no maxillary gingiva display)	Treatment in mixed + permanent dentition (a) Early active-mechanical protrusion but limited intrusion of upper centrals (utility arch) (b) Passive incisor intrusion + molar extrusion (activator) (c) Multibracket therapy for active-mechanical incisor intrusion, palatal root torque for upper incisors
2.	Mandibular retro- and laterognathism • Asymmetric distocclusion (1/2-step right side/full-step left side) • Mandibular midline shift of 3 mm to left side	(a) Asymmetric mandibular advancement after adaptation of transversal occlusion of molars (activator) (b) (If required) further active-mechanical distalization (using skeletal anchorage) (c) (If required) dentoalveolar compensation of mandibular laterognathism (multibracket appliance + mini screw for temporary anchorage in third quadrant)
4.	Two supernumerous maxillary molars	Extraction before treatment start
5.	Proclined lower incisors by 6° with fragile labial gingiva and gingiva recessions at teeth 31 + 41	Utilizing leeway space for anterior teeth • Grinding of deciduous canines and molars mesially • Prevention of mesial migration of all 4 first molars in late mixed dentition phase
	Sequence of therapeutic measures (begin at the age of 9:08 years)	**Duration**
1.	Extraction of supernumerous maxillary molars	
2.	Maxilla: Utility treatment (two-by-two) + high-pull headgear Mandible: Plate for uprighting incisors + prevention of leeway space	4 months
3.	Activator with asymmetric mandibular advancement, anterior bite plates and stop loops for upper and lower first molars; the posterior acrylic part of the activator is reduced so that it can be combined with differential crisscross elastics at right and left first molars	11 months
4.	Standard activator with mandibular advancement and corrected midline	Ongoing since 3 months
	Reevaluation → further asymmetric distalization in upper jaw and/or dentoalveolar compensation of mandibular laterognathism required?	
5.	Multibracket therapy (with skeletal anchorage if required for further correction of asymmetry)	Forthcoming
6.	Retention using maxillary and mandibular plates	Forthcoming

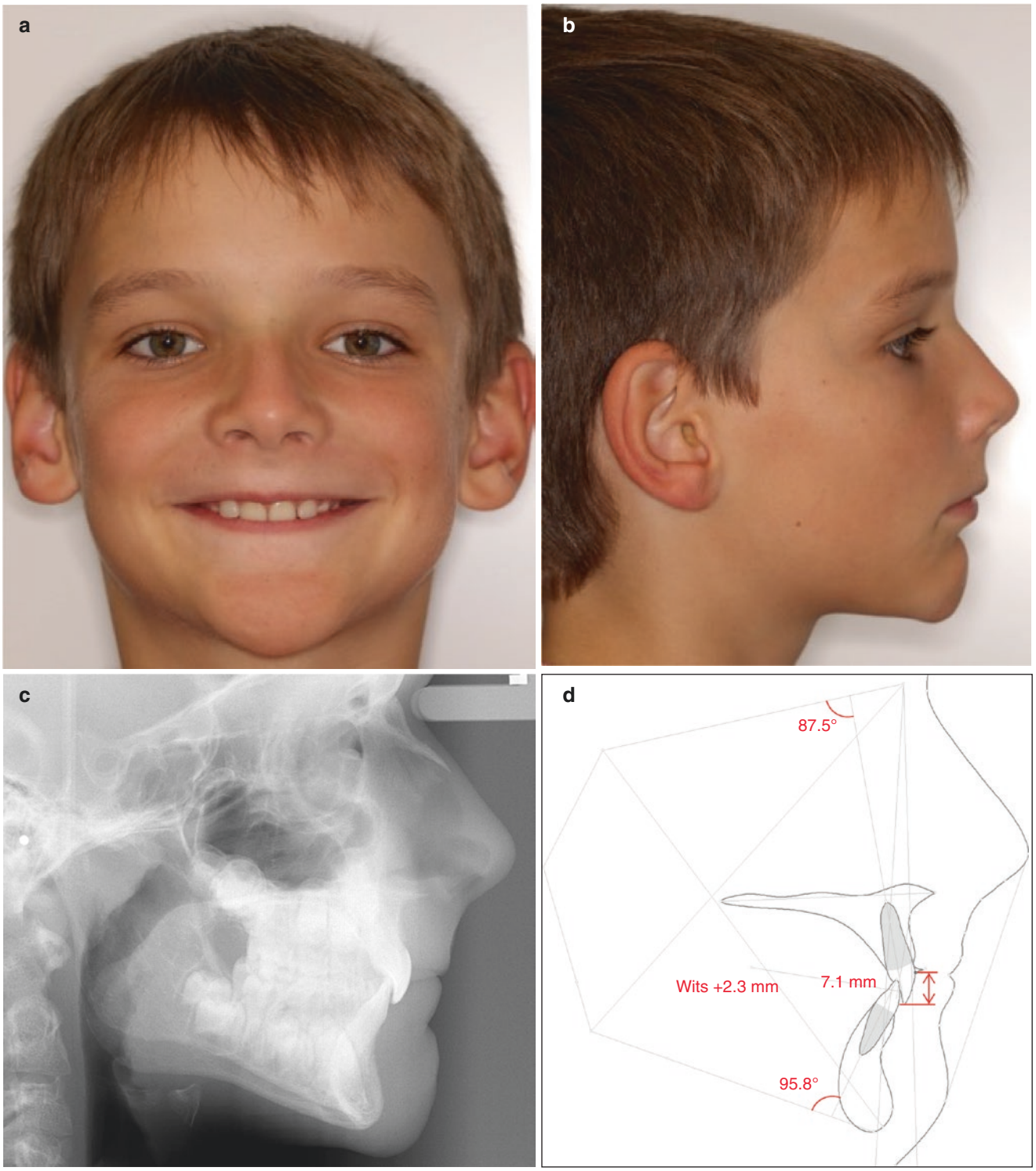

Fig. 5.27 (**a**–**d**)/patient #3. (**a**, **b**) Facial images of patient #3 taken at the age of 9:08 years before treatment begin. The patient displays the cervical regions of the upper central incisors' crowns during smiling but not their incisal edges. The facial profile is orthognathic. (**c**, **d**) Cephalogram showing severe retroclination of the upper central incisors (−14.5°) and a high lip line level (7.1 mm). The jaw bases show a moderate skeletal class II pattern (Wits appraisal: +2.3 mm, deviation ANB/individualized reference: 2.1°) with a prominent chin. The lower incisors are proclined (+5.8°)

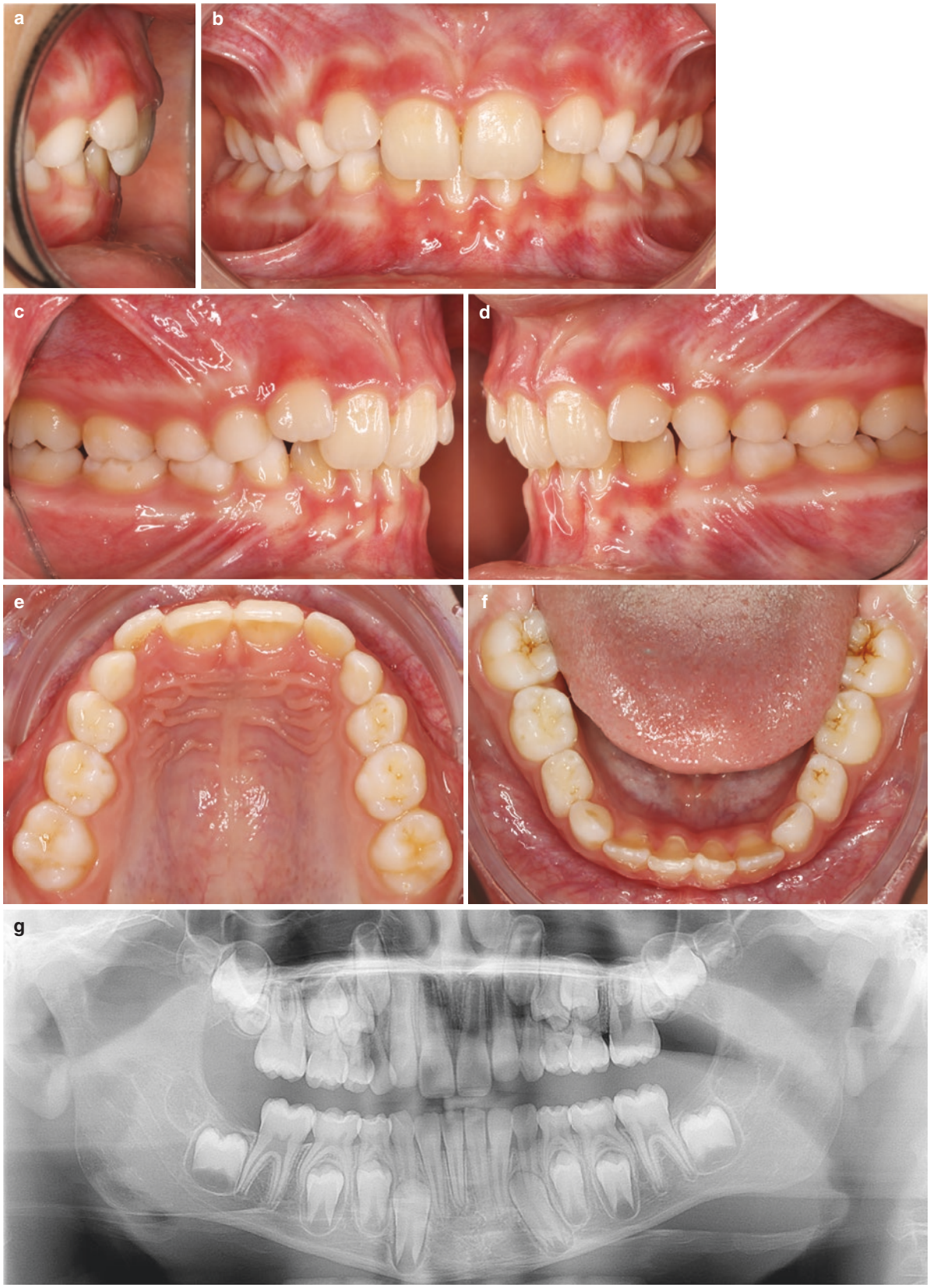

Fig. 5.28 (**a**–**g**)/patient #3. Initial dental images associated with the records depicted in Fig. 5.27. (**a**) Lateral view on the incisor segment. (**b**) The 3-mm midline deviation before treatment start is related to a laterognathic mandible (2 mm to left side) combined with a dental midline shift in the maxilla (1 mm to right side). (**c**, **d**) As a result of the mandibular laterognathism, the distocclusion is asymmetric (half-step at right first molars and full-step at left first molars). (**e**, **f**) Occlusal views on the dental arches. (**g**) The panoramic X-ray reveals two supernumerous molars in the first and second quadrants. Deciduous canines and molars show insufficient root resorption

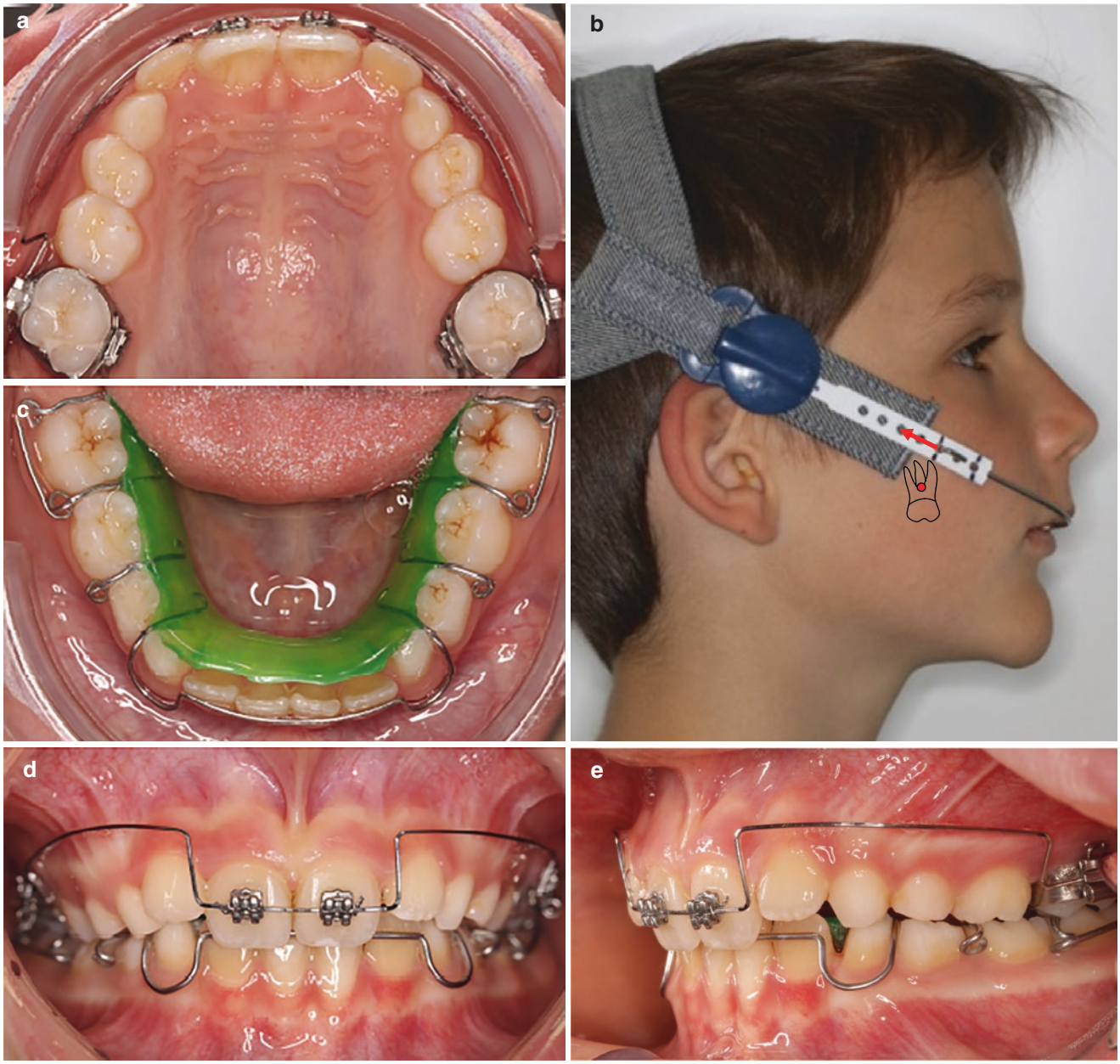

Fig. 5.29 (**a**–**e**)/patient #3. First stage of early treatment of patient #3. (**a**) Intervention in the maxilla comprises the intrusion and proclination of upper central incisors using a two-by-two utility arch. (**b**) The utility arch is combined with a high-pull headgear (to be worn only during bedtime) for preventing the distoangulation of the first molars. The outer headgear bow is angulated in dorso-cranial direction so that the force vector passes above the first molars' center of resistance (red dot on the schematic tooth). In this manner, the utility arch's distally tipping effect on the first molars (see Fig. 5.6) may be neutralized. (**c**) In the lower jaw, the deciduous canines are ground mesially to provide space for uprighting of the incisors using a plate with an active labial bow. Before fabrication of the acrylic part on the cast model, a 2-mm thick dental wax plate was positioned on the incisor's lingual crown surfaces. Thus, grinding of the plate before insertion is not needed which may decrease the risk of breakage of the plate. (**d**, **e**) The optimal design and fabrication of the clasps' retentions minimizes their interference in habitual occlusion

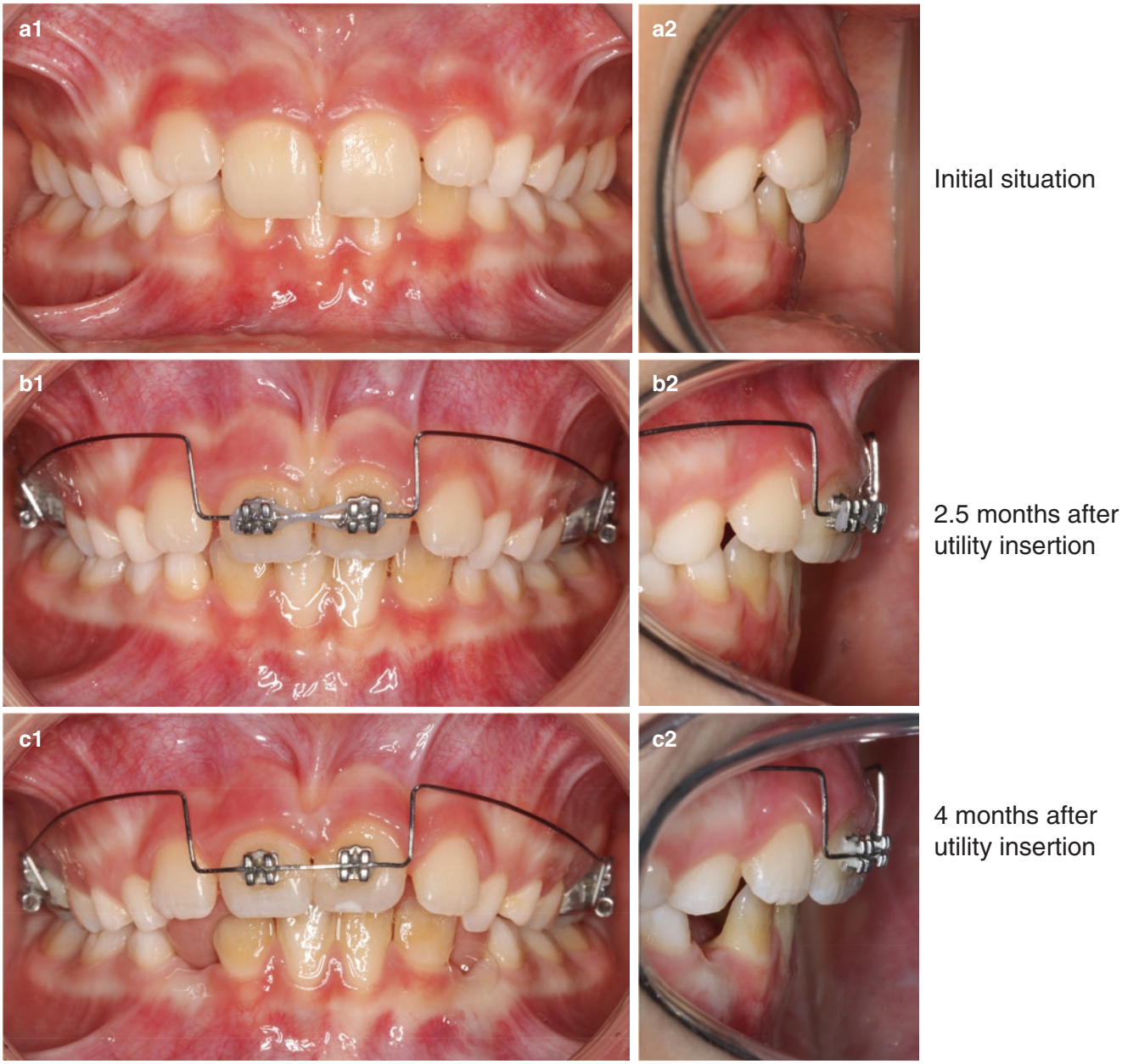

Fig. 5.30 (**a**–**c**)/patient #3. Dental images taken during the utility arch treatment showing the continuous, efficient intrusion and proclination of the upper central incisors. (**a**) Initial situation. (**b**) 2.5 months ongoing intrusion and protrusion of upper central incisors. Slight asymmetric sagittal activation of the utility's step bends in the first quadrant provides space for the erupting tooth 12 and eliminates the slight dental midline shift in the upper jaw. (**c**) Sufficient correction of the upper frontal incisors is already achieved after 4 months utility arch treatment. The creation of an overjet with sagittal spacing of 3–4 mm between the upper and lower incisors enabled the subsequently planned mandibular enhancement

Fig. 5.31 (**a**–**h**)/patient #3. Second stage of early treatment. (**a**, **b**) After treatment with the utility arch, buccal occlusion has been neutral on the right but half-step distocclusion on the left side resulting from a 2-mm skeletal mandibular shift to the left side. (**c**) The deep bite and upper central incisor retroclination are already corrected. (**d**) The construction bite for fabrication of the subsequent activator was taken in a slightly overcorrected mandibular position (1 mm to right side) (**e**) Criss-cross elastics in situ without (e1) and with activator (e2 - e4). The activator's posterior acrylic part is reduced to avoid interference with the crisscross elastics to be worn full-time for adaptation of transversal first molar occlusion. Additional grinding of the acrylic lingual to the molars of the second and fourth quadrant is required to allow lingual movement of these teeth; the mesiobuccal cusps of teeth 26 and 36 must maintain vertical support to avoid excessive extrusion by the crisscross elastics

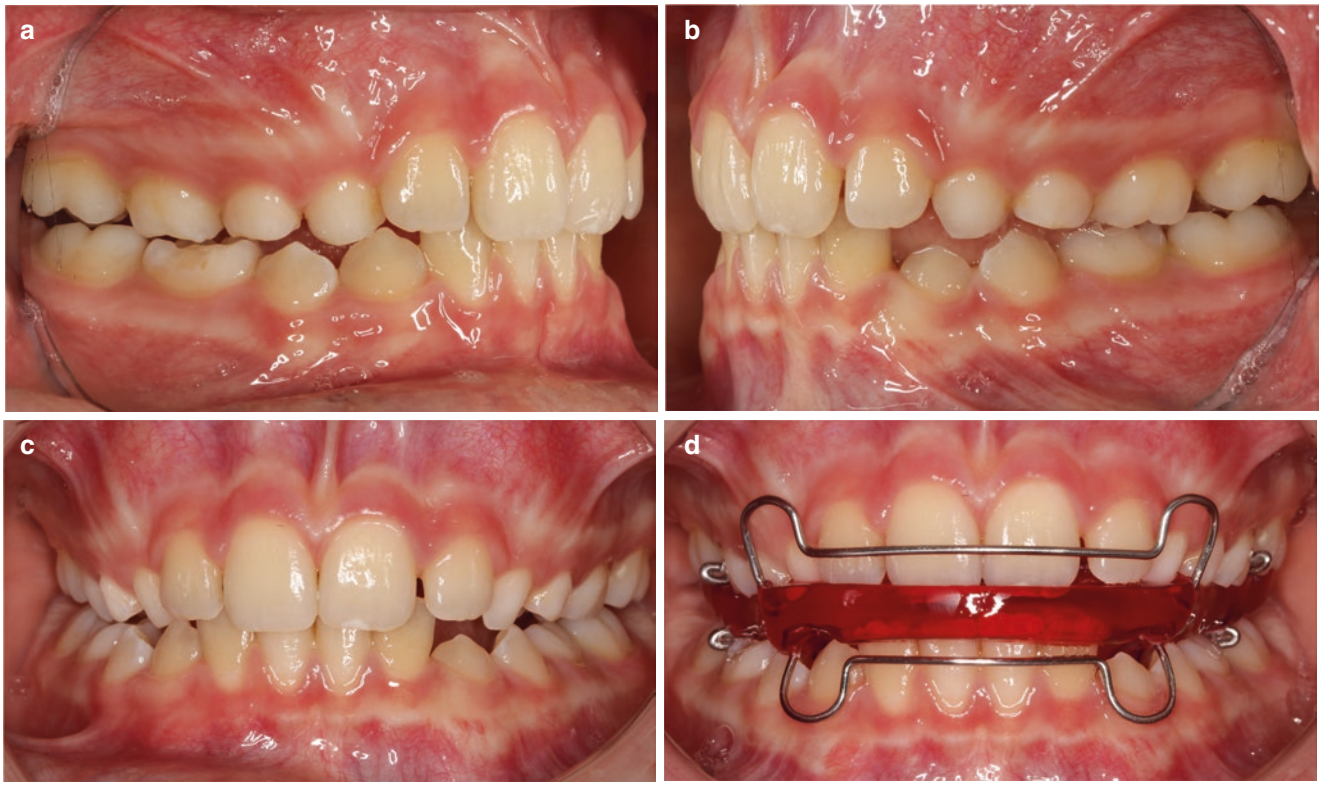

Fig. 5.32 (**a**–**d**)/patient #3. Situation after parallel neuromuscular intervention with the functional appliance and active-mechanical adaptation of transversal first molar occlusion using differential crisscross elastics. (**a**–**c**) Both, the distocclusion and mandibular midline shift are largely corrected. (**d**) A new activator with a centric construction bite and complete posterior acrylic extension is inserted for neuromuscular stabilization and guided fine adjustment and settling of the transversal occlusion by targeted removal of acrylic. At publication date, functional appliance treatment was still ongoing in this patient. Subsequent multibracket therapy may comprise differential class II elastics (force on left side > right side) to stabilize the sagittal and transversal correction of the centric mandibular position

5.6.4 Patient Example #4

The malocclusion of this patient example is characterized by manifestation of cover-bite-like incisor malpositions combined with dental midline shifts in both dental arches and a mandibular space discrepancy (Figs. 5.33 and 5.34). Due to the fact that the frontal overbite is only moderately increased, and only little maxillary gingiva is displayed during smiling, active-mechanical intrusion of the upper central incisors using a utility arch was avoided (Table 5.4). Instead, an active maxillary plate with finger springs has been used in the first stage of early treatment for upper central incisor proclination (Fig. 5.35). Also the concept applied during the multibracket phase for correction of the deep frontal overbite aimed at the preservation of the harmonic lip-incisor relationship during smiling. This exemplifies that therapeutic planning in patients with a class II div. 2 or a cover-bite has to consider both treatment stability and smile esthetics which is not always as easy as in this patient example. Figures 5.36, 5.37, 5.38, 5.39, 5.40, 5.41, and 5.42 show the records made during and post treatment. Figure 5.43 shows the buccal and frontal occlusal relationships prior to and after therapy.

Table 5.4 Problem list and conceptual treatment planning in patient #4

	Problem list and relevant collateral findings	**Conceptual treatment planning**
1.	Cover-bite-like malocclusion with • Retroclination of upper centrals by −5° • Deep frontal overbite of 4.5 mm with supraposition of both upper centrals • Smile with 1 mm maxillary gingiva display and complete display of maxillary central incisors (lip line level cannot be determined as lateral cephalogram was taken with a protruded mandible)	Treatment in mixed + permanent dentition (a) Early active-mechanical protrusion of upper centrals (maxillary plate) (b) Passive incisor intrusion (activator) (c) (If required) further active-mechanical intrusion of upper and/or lower incisors, palatal incisor root torque
2.	Midline deviation of 2 mm, due to • Slight maxillary dental midline shift of 1 mm to left side • Mandibular dental midline shift of 1.5 mm to right side	Early correction of midline shifts in both jaws with maxillary and mandibular plates
3.	Moderate space discrepancy in lower arch	Utilizing leeway space for anterior teeth • Grinding of deciduous molars mesially • Prevention of mesial migration of upper and lower first molars in late mixed dentition
	Sequence of therapeutic measures (begin at the age of 8:01 years)	**Duration**
1.	Maxillary + mandibular plates for dental midline correction and proclination of upper central incisors	1:10 years
2.	Activator with slight mandibular advancement + anterior bite plates + stop loops for upper and lower first molars	1:07 years
	Reevaluation of lip line level + smile esthetics → further incisor intrusion to be performed in maxilla and mandible	
3.	Multibracket appliance	1:11 years (max.), 1:03 years (mand.)
4.	Maxillary and mandibular plates for retention	

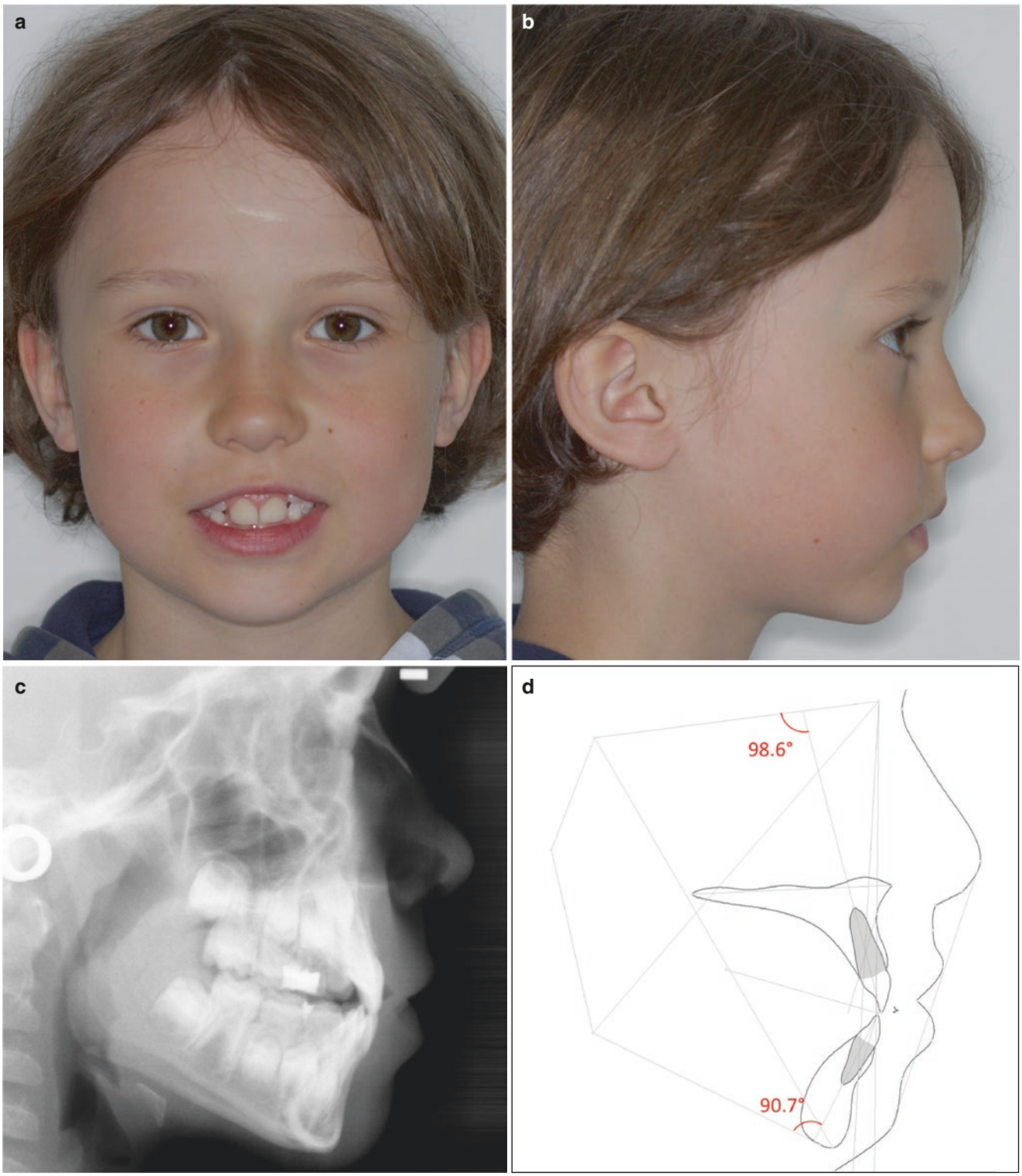

Fig. 5.33 (**a**–**d**)/patient #4. Initial facial images and cephalogram of patient #4 taken at age 7:09 years, 4 months prior to treatment begin. (**a**) He displays approx. 1 mm maxillary gingiva and the complete upper central incisor crowns during smiling. Thus, only minor intrusion of the upper incisors should be planned. (**b**) Facial profile. (**c**, **d**) The lateral cephalogram reveals only mild retroclination of the upper central incisors, although the cover-bite-like appearance of the front teeth seems more severe on the corresponding intraoral images. (The sagittal and vertical jaw base relationship is not evaluable on this cephalogram, because the patient protruded the mandible during the recording)

Fig. 5.34 (**a**–**g**)/patient #4. Initial dental images of patient #4 associated with the records depicted in Fig. 5.33. (**a**, **b**) The patient shows the typical cover-bite-like features in the final phase of the early mixed dentition. (**c**, **d**) First molars and canines are in neutral occlusion. (**e**, **f**) The dental midline shift has a maxillary (1 mm to the left) and a mandibular component (1.5 mm to the right). The latter is related to an asymmetric space discrepancy in the anterior lower arch of approx. 4 mm in total. (**g**) Panoramic X-ray showing physiological dental development

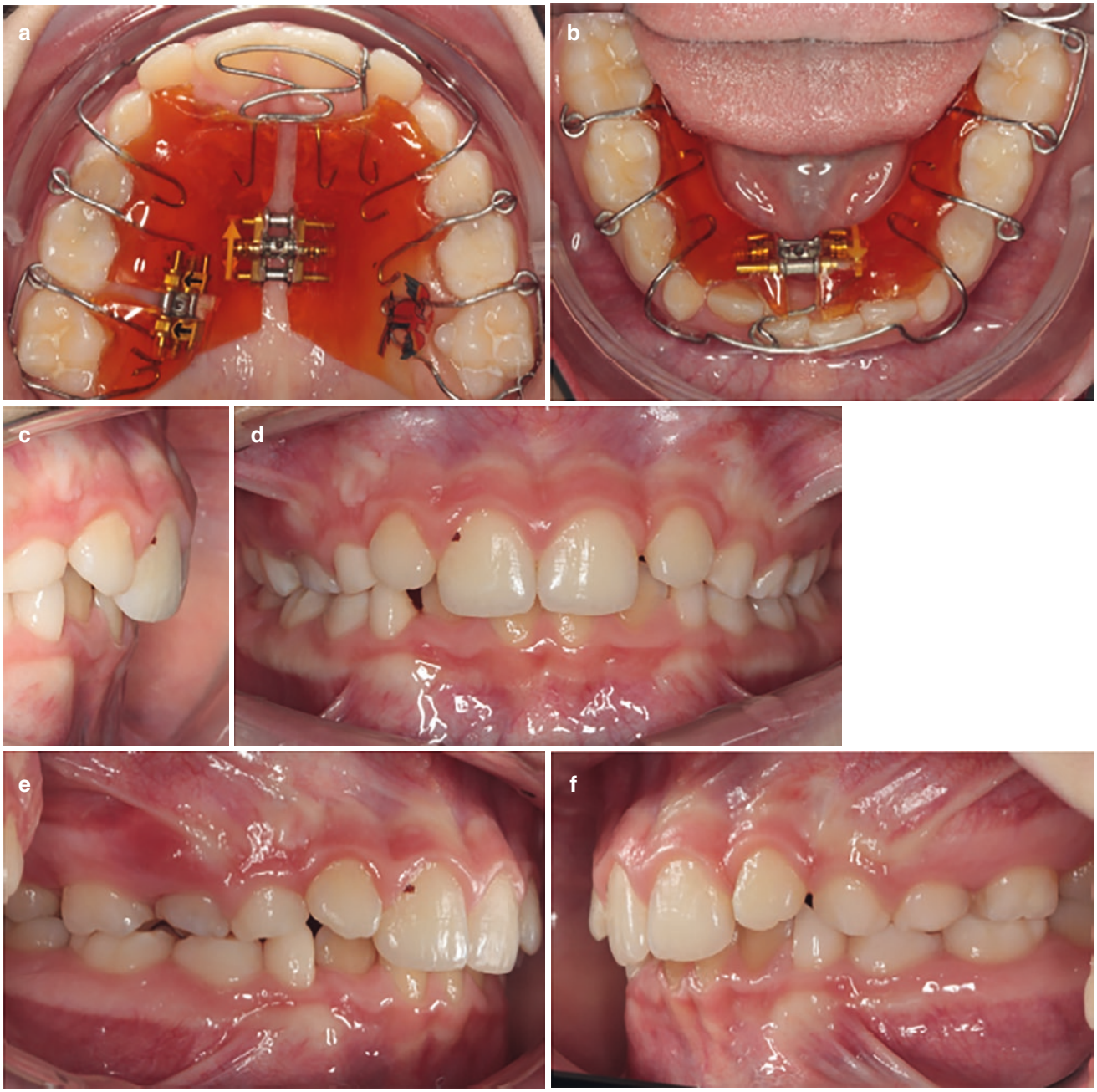

Fig. 5.35 (**a**–**f**)/patient #4. Situation after 9 months treatment with maxillary and mandibular plates. (**a**) The upper central incisors have been protruded using a protrusion spring crossing the midline; the active finger spring distal to tooth 21 has shifted the dental midline to the right side. Both arches are slightly expanded. (**b**) The space provided by grinding of both lower deciduous canines is occupied by the lateral incisors. The finger spring distal to tooth 41 has its retention in the plate's left segment, so that it is continuously activated during transversal arch expansion. (**c**, **d**) The frontal overbite has clearly aggravated when compared to the records prior to treatment (see Fig. 5.34). The midline shifts in the upper and lower dental arches, however, are already slightly overcorrected. (**e**, **f**) Views on the right and left lateral segments

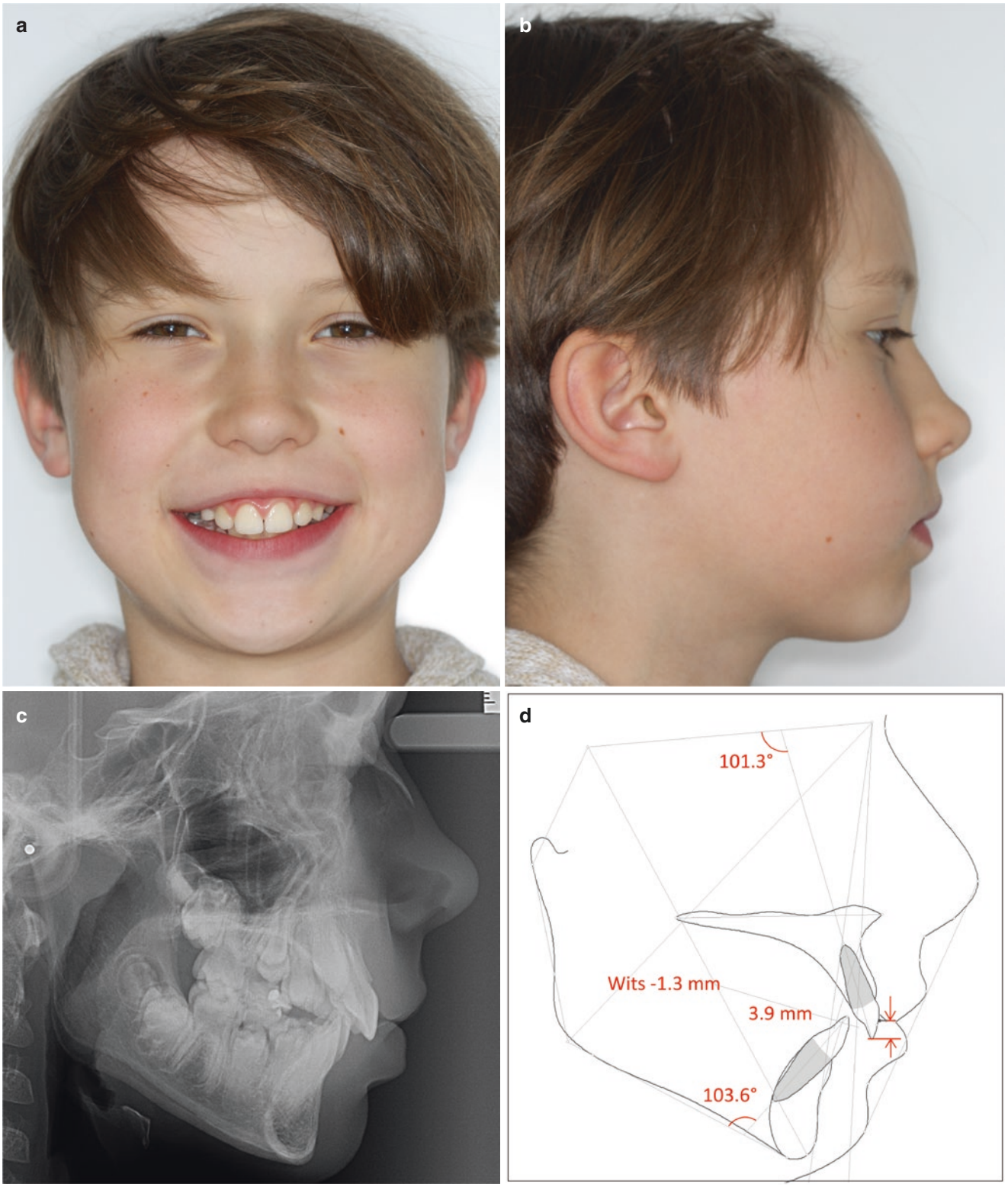

Fig. 5.36 (**a**–**d**)/patient #4. Reevaluation at age 9:11 years after treatment with maxillary and mandibular plates for 1:08 years. (**a**, **b**) The smile esthetics and the facial profile are unchanged. (**c**, **d**) The Wits appraisal indicates a very mild skeletal class III jaw base relationship. The lip line level is approx. 4 mm. The very pronounced proclination of the lower central incisors by +13.6° is related to their integration in the dental arch. Consequently, during the subsequently planned activator treatment, the remaining leeway space in the lower arch has to be preserved for uprighting lower incisors

Fig. 5.37 (**a**–**g**)/patient #4. Dental images corresponding to the facial images and cephalogram depicted in Fig. 5.36. (**a**–**d**) The cover-bite characteristics are no longer recognizable. (**e**) All four upper incisors are integrated in the dental arch. (**f**) Anterior crowding in the lower anterior region is reduced. (**g**) The panoramic X-ray shows physiological dental development in the late mixed dentition. All third molar germs can be recognized

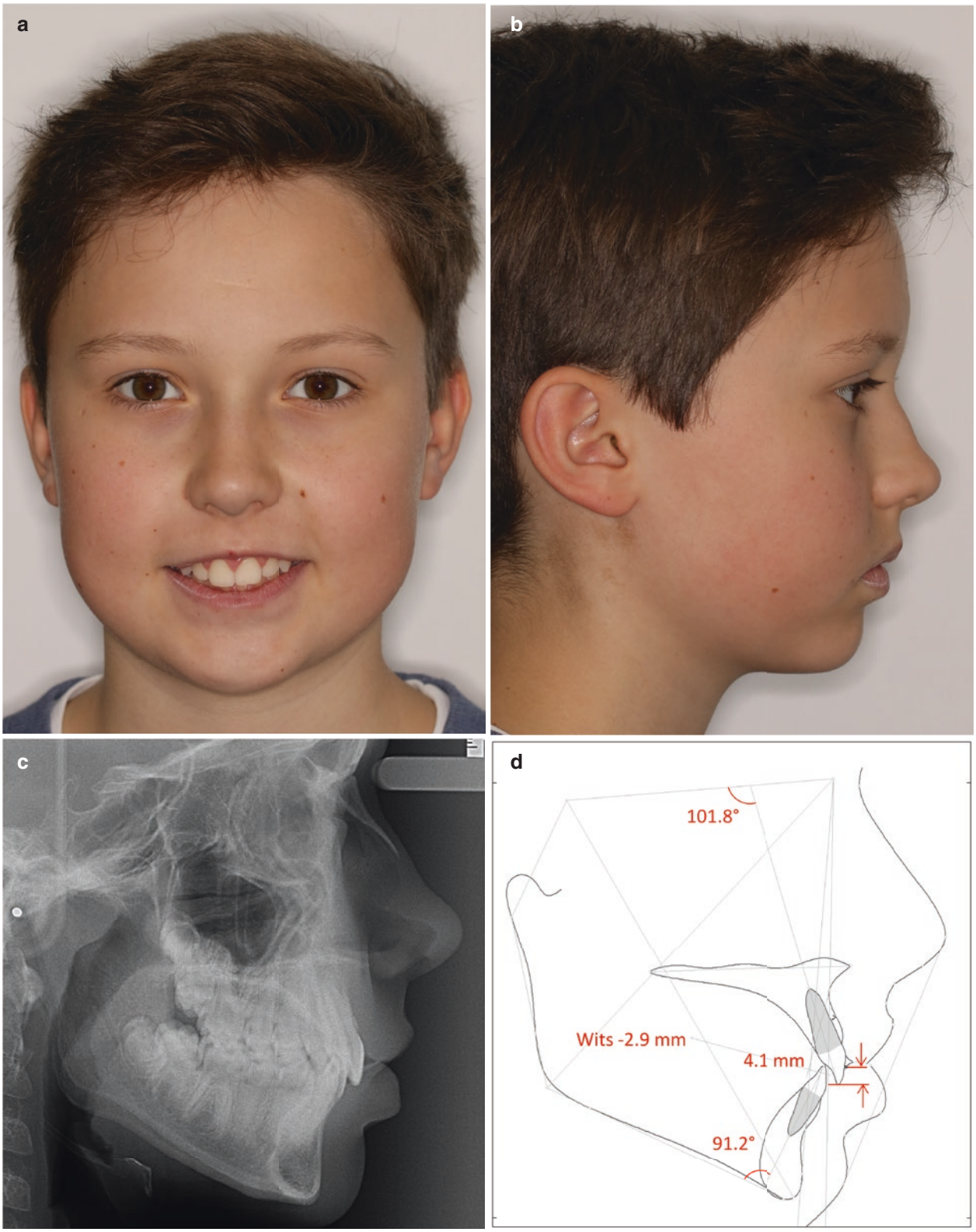

Fig. 5.38 (**a**–**d**)/patient #4. Facial images and lateral cephalogram for reevaluation of the treatment plan after activator therapy for 1:07 years. The activator's construction bite has been taken in neutral sagittal mandibular position due to the neutral buccal occlusion and was equipped with stop loops for the four first molars to prevent the mesial migration of these teeth during the late mixed dentition phase. (**a**) The lip-incisor relationship during smiling tolerates correction of the deep frontal overbite by equal intrusion of the upper and lower incisors. (**b**) Facial profile. (**c**, **d**) The tracing of the cephalogram shows that the inclination of the upper central incisors agrees with the reference value of 102° (angle U1/SN). Successive activation of the labial bow of the activator and preservation of the lower leeway space respectively resulted in uprighting of the lower incisors by 12°

Fig. 5.39 (**a**–**f**)/patient #4. Dental images associated with the records depicted in Fig. 5.38. (**a**, **b**) The frontal overbite shows little improvement as it decreased only by approx. 1 mm when compared to the records before activator insertion. (**c**, **d**) Neutral buccal occlusion is achieved on both sides. (**e**) Good alignment of all permanent teeth is to be observed in the upper arch. (**f**) The anterior space discrepancy is slightly reduced by occupation of the leeway space by the lower incisors

Fig. 5.40 (**a**–**d**)/patient #4. Different stages during multibracket therapy. (**a**) Due to the slight supraposition of the upper incisors, 1-mm steps between upper laterals and canines are bent into the 0.012 and 0.016-in. NiTi leveling wires to prevent extrusion of the canines. Steps are fabricated using a "Nice-End-Plier" (Hammacher, Germany). Their height can be precisely adjusted by changing the steps' angulation after bending. Bracketing in the lower arch is planned after slight protrusion and intrusion of the upper frontal segment to avoid precontacts between upper incisors and lower incisor brackets. (**b**) After 4 months leveling, a 0.016 × 0.022 TMA overlay wire is inserted in the upper arch for frontal intrusion. (**c**) One month later, the three segments are replaced by a full 0.016 × 0.016 SS wire; the overlay intrusion arch is left for another 3 months until lower brackets could be bonded. (**d**) Situation during the finishing phase, after leveling the deep curve-of-Spee in the lower arch; the deep overbite is already eliminated by equal intrusion of the upper and lower frontal segments

Fig. 5.41 (**a**–**f**)/patient #4. Dental images taken 1:01 years after debracketing. (**a**, **b**) Both, the corrections of the midline shifts in the upper and lower jaw and the deep frontal overbite (to a physiological value of 2 mm) are stable. (**c**, **d**) Neutral buccal relationships were achieved with settling of the occlusion. (**e**, **f**) Occlusal views on upper and lower dental arches

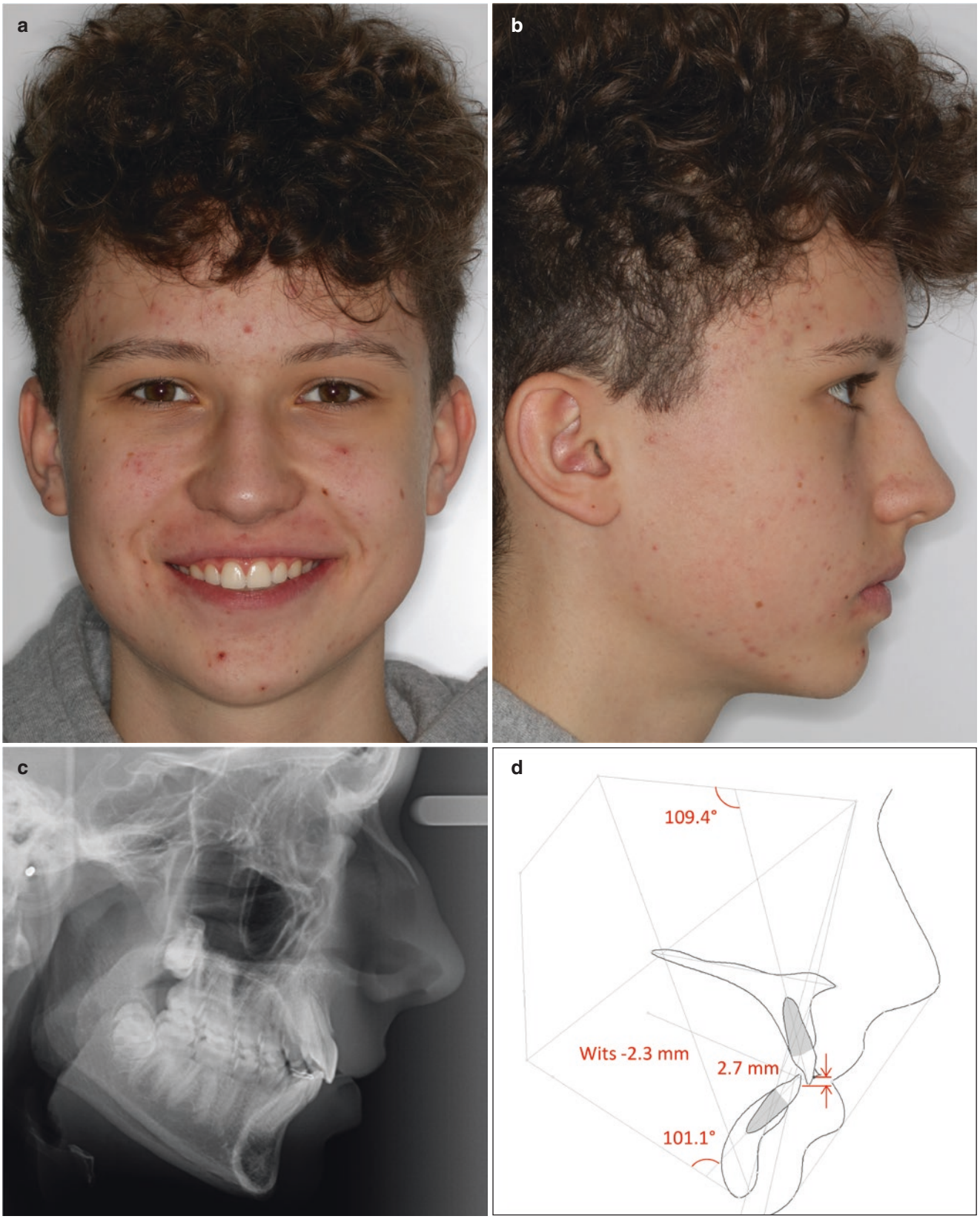

Fig. 5.42 (**a**–**d**)/patient #4. Facial images and cephalogram corresponding to the records depicted in Fig. 5.41. (**a**) The patients slightly displays the maxillary gingiva so that the smile esthetics is not compromised by the concept of equal intrusion of upper and lower frontal segments. (**b**) The facial profile is harmonic. (**c**, **d**) The tendency toward a skeletal class III has slightly weakened. The proclination of upper and lower central incisors may result from the intrusive mechanics acting anterior to the incisor's center-of-resistance; in the lower arch, the space discrepancy contributed to incisor proclination. From the low post-therapeutic lip line level, high treatment stability is to be expected

Fig. 5.43 (**a**, **b**)/patient #4. Buccal and frontal occlusal interrelationships prior to (**a**) and after therapy (**b**)

5.6.5 Patient Example #5

This patient exemplifies that in specific manifestations of class II div. 2 malocclusions it may be reasonable to omit the first main stage of early treatment. In this specific patient, the main arguments for this decision were that the lip-incisor relationship during smiling seemed to be quite well-balanced and did not suggest any therapeutical change (Fig. 5.44). Moreover, the sagittal component of the class II div. 2 (i.e., the distocclusion) was obviously more pronounced than the frontal component; concretely, upper central incisor retroclination by only 7° and a frontal overbite of 5 mm may be considered as a mild cover-bite-like manifestation (Fig. 5.45). The deep overbite was mainly due to the supraposition of the lower anterior segment. Based on these diagnostic findings, it was concluded that the major effects of a maxillary utility arch, i.e., significant intrusion and protrusion of upper incisors, were not needed or were even disadvantageous. Consequently, the decision was taken to focus early treatment of this patient on class II correction, and to address the deep frontal overbite mainly in the permanent dentition by segmented intrusion of the lower frontal segment (Table 5.5).

The decision to start the therapeutic intervention with a cervical-pull headgear for upper first molar distalization also considered the bite-opening effect of this appliance related to the application of a dorso-caudally directed force (Fig. 5.46). The extrusive effect on the upper first molars led to the reduction of the frontal overbite without changing the well-balanced lip-incisor relationship present in this patient at begin of the treatment. The second stage of early treatment was conducted in the classical manner using an activator for mandibular advancement and for further overbite reduction (Figs. 5.46, 5.47, and 5.48).

Figure 5.49 comprising different stages during multibracket therapy shows a consistent and systematic approach for segmented intrusion of the lower frontal segment. Moreover, the treatment results depicted in Figs. 5.50 and 5.51 demonstrate that asymmetric activation and/or localization of the intrusive force enables the correction of a canted suprapositioned lower anterior segment. Figure 5.52 shows the buccal and frontal occlusal relationships prior to and after therapy.

Table 5.5 Problem list and conceptual treatment planning in patient #5

	Problem list and relevant collateral findings	**Conceptual treatment planning**
1.	Class II div. 2 malocclusion with • Retroclination of upper centrals by −7° • Deep frontal overbite of 5 mm with – Supraposition of all 4 upper incisors – Deep curve-of-Spee in lower arch • Moderately increased lip line level of 3.8 mm • Smile with full crown display of maxillary central incisors (no maxillary gingiva display)	Treatment in mixed + permanent dentition (a) Extrusion of upper molars for bite opening (cervical-pull headgear) (b) Passive incisor intrusion + molar extrusion for further bite opening (activator) (c) Leveling of mandibular curve-of-Spee + (if required) palatal root torque of upper incisors and further active-mechanical incisor intrusion (multibracket appliance)
2.	Significant distocclusion of 2/3-step at first molars	(a) Early active-mechanical distalization of upper first molars (cervical-pull headgear). (b) Mandibular advancement (activator)
3.	Mild space discrepancy in lower arch due to proclined lower incisors	Utilizing the leeway space for anterior teeth • Grinding of deciduous molars mesially • Prevention of mesial migration of upper and lower first molars in late mixed dentition • Uprighting of lower incisors
4.	Tooth size discrepancy with mesiodistal width of lower teeth 2 mm larger (acc. to Bolton's reference values)	(If required) Tooth size reduction in lower jaw
	Sequence of therapeutic measures (begin at the age of 10:03 years)	**Duration**
1.	Cervical-pull headgear	8 months
2.	Activator with slight mandibular advancement + anterior bite plates + stop loops for upper and lower first molars	2:03 years
	Reevaluation of smile esthetics and lip line level → overbite correction is to be completed primarily by further intrusion of lower frontal segment	
3.	Multibracket appliance	1:05 years
4.	Maxillary and mandibular plates for retention	

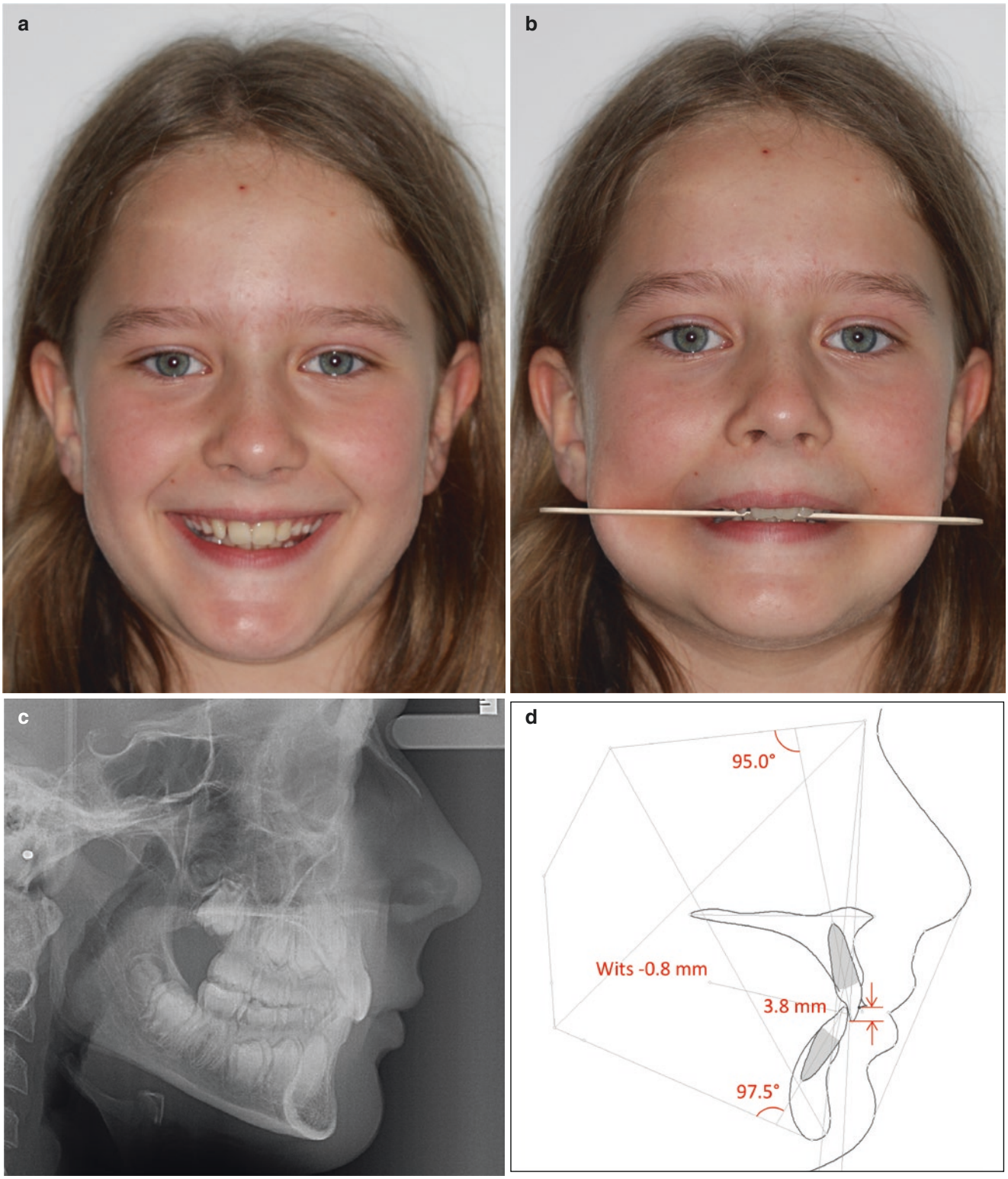

Fig. 5.44 (**a**–**d**)/patient #5. Facial images and lateral cephalogram of patient #5 taken at age 10:01 years prior to treatment begin. (**a**) The frontal facial view shows nearly complete display of upper central incisor crowns during smiling. (**b**) The occlusal plane shows a slight canting, i.e., right buccal teeth are in a more cranial position in both jaws. (**c**, **d**) The lip line level is only moderately high and upper centrals show reclination by 7.0°. Lower incisors are proclined by 7.5°

Fig. 5.45 (**a**–**g**)/patient #5. Initial dental images of patient #5 corresponding to the records depicted in Fig. 5.44. (**a**, **b**) The lateral and frontal views reveal the typical features of a class II div. 2 in the mixed dentition. (**c**, **d**) First molars show slight distocclusion (quarter-step). (**e**, **f**) The large deciduous lower molars may provide sufficient leeway space for uprighting the proclined lower incisors. (**g**) Development of tooth 25 is delayed

Fig. 5.46 (**a**–**g**)/patient #5. Situation after 8 months cervical-pull headgear treatment. (**a**, **b**) The frontal overbite is slightly decreased by approx. 1 mm. (**c**, **d**) Upper first molars are distalized into neutral occlusion. (**e**, **f**) Occlusal views on upper and lower dental arches. Passive distal migration of the deciduous molars and canines can be observed. (**g**) At this stage, an activator with anterior bite plates and stop loops for retention of maxillary first molars is inserted

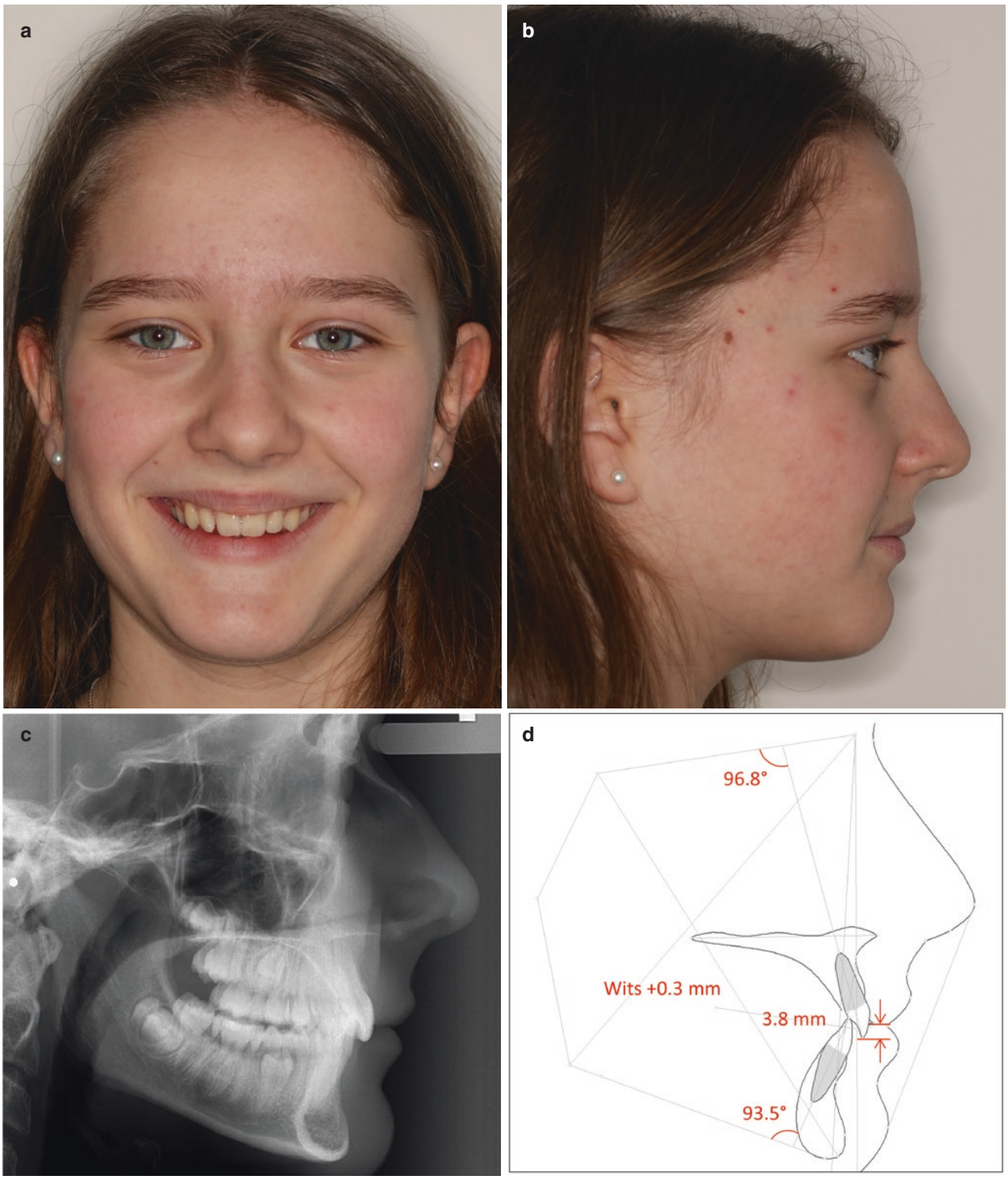

Fig. 5.47 (**a**–**d**)/patient #5. Reevaluation during the final early treatment stage with ongoing activator therapy for 1:10 years; treatment is monitored only every 3 months. (**a**, **b**) The harmonic smile esthetics suggests to keep the vertical position of the upper incisal segment at this level. (**c**, **d**) The lip line level is only slightly increased so that upper incisor intrusion is also not required with respect to treatment stability issues. The lower centrals are slightly uprighted (by 4.0°) when compared to the initial cephalogram. The initial, mild retroclination of the upper central incisors has only been reduced by 2°, although it has to be noted that the remaining deviation from the reference value of 102° is only 5°

Fig. 5.48 (**a**–**f**)/patient #5. Dental images corresponding to the records shown in Fig. 5.47. (**a**) Frontal view. (**b**, **c**) Neutral buccal occlusion has been achieved by the cervical-pull headgear. (**d**, **e**) Subsequent activator therapy has been successful in the retention of the neutral buccal occlusion and in preserving the mandibular leeway space. The space provided by grinding of tooth 85 mesially is already occupied by tooth 44 (tooth 85 is to be extracted now). (**f**) Due to late development of tooth 25 and incomplete root development of teeth 35 and 45, the start of multibracket therapy is postponed by approx. 6 months

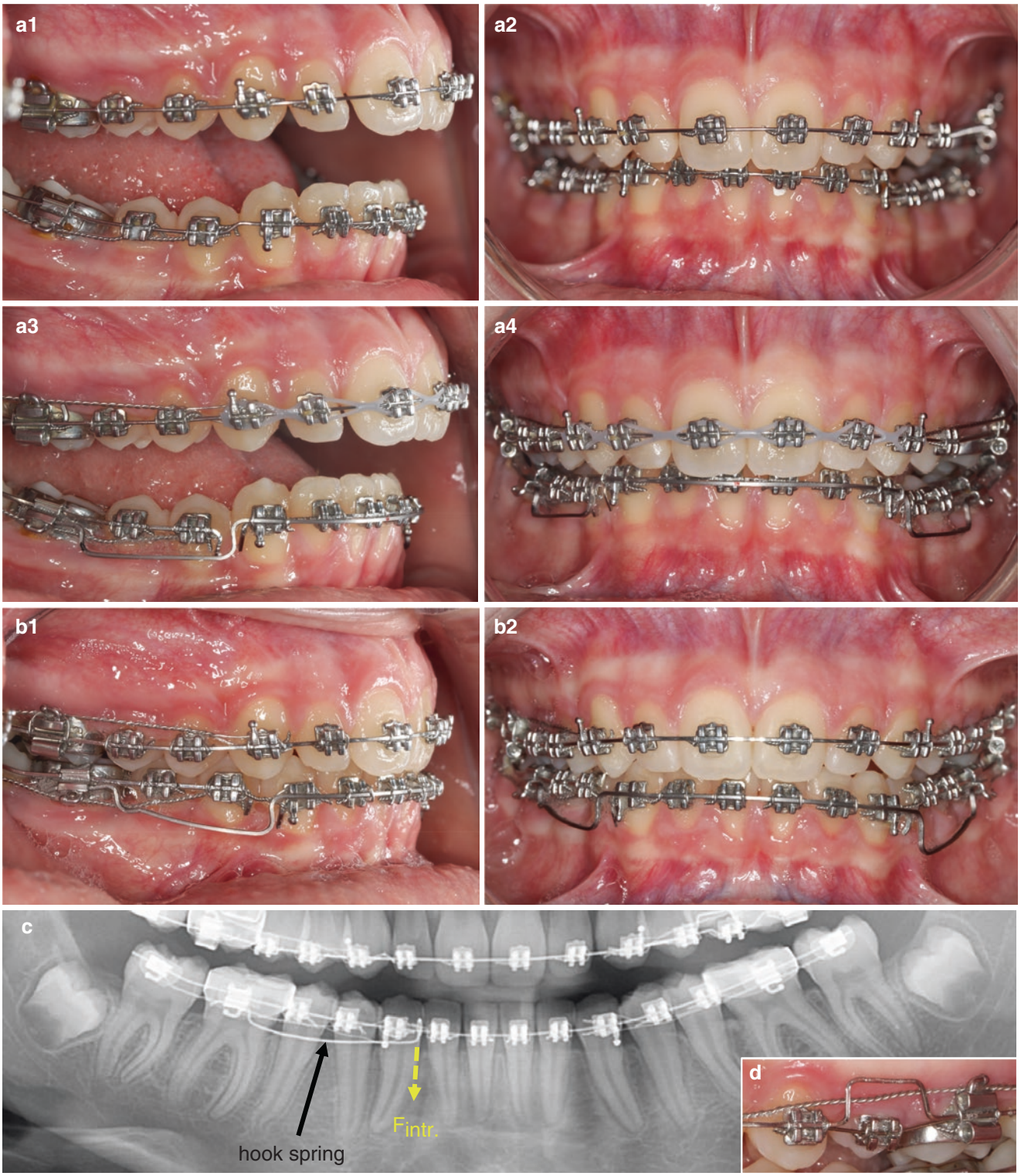

Fig. 5.49 (**a**–**d**)/patient #5. Different stages during multibracket therapy. (**a**) Situation after separate leveling of the frontal and lateral segments using 0.012- and 0.016-in. NiTi wires with step bends (**a1** and **a2**). At this stage, leveling wires are replaced by three 0.016 × 0.022-in. segment steel wires and a 0.016 × 0.022-in. TMA overlay intrusion arch (**a3** and **a4**) with slightly asymmetric activation (35/25 cN at right/left sides). (**b**) Situation after intrusion of the lower anterior segment for 4.5 months. The mandibular occlusal plane is still canted as indicated by the oblique course of the frontal wire segment and the supraposition ed lower right premolars. (**c**) The panoramic X-ray shows the inserted spring attached to 46 and hooked in between 42/43 to correct the canting by further unilateral intrusion. No significant root resorptions are to be observed which may be also due to the careful monitoring of the intrusion force during reactivation of the mechanics. (**d**) Integration of late developed tooth 25 using an underlay NiTi leveling wire

Fig. 5.50 (**a**–**h**)/patient #5. Dental images of patient #5 taken 2 weeks after debracketing. The fixed appliance was in situ for 1:07 years. (**a**, **b**) All major problems, i.e., the retroclination of the upper incisors, the deep frontal overbite, the canting of the mandibular occlusal plane, and the midline shift, are successfully corrected. The overbite is even slightly overcorrected to a value of 1.5 mm to account for a possible slight relapse. (**c**, **d**) Neutral occlusion of canines and molars and a physiological incisal occlusion are achieved. (**e**, **f**) Occlusal views on the dental arches. (**g**, **h**) Maxillary and mandibular plates with acrylic-covered labial bows combined with a flattened 8-braided steel wire in the lower anterior segment are used for retention. Further settling of the occlusion is to be expected

Fig. 5.51 (**a**, **b**)/patient #5. Frontal images corresponding to the dental records shown in Fig. 5.50. The occlusal plane runs now parallel to the bipupilar line. Cervical regions of the upper central incisors are only slightly covered by the upper lip and the smile arch appears harmonic. This outcome seems to confirm the concept chosen for this patient consisting of overbite correction primarily by intrusion of the lower frontal segment instead of intrusion of upper incisors. Since, the lip line level prior to multibracket therapy was only barely increased (value: 3.8 mm, see Fig. 5.47), the proclination of the upper incisors is expected to be stable

Fig. 5.52 (**a**, **b**)/patient #5. Buccal and frontal occlusal interrelationships prior to (**a**) and after therapy (**b**)

5.6.6 Patient Example #6

The records of this male patient prior to treatment reveal a severe class II div. 2 combined with a complete cover-bite (Table 5.6, Figs. 5.53 and 5.54). Since the extremely deep overbite of 10 mm and the large interincisal angle was not only due to supraposition and retroclination of the upper central incisors but also of all four lower incisors, it was decided to apply a partial fixed appliance technique for active-mechanical intrusion and proclination of the anterior teeth not only in the upper arch (Figs. 5.55 and 5.56) but (as soon as bracketing has been possible) also in the lower anterior segment.

As treatment has begun in the late mixed dentition phase at the age of 12, and the permanent canines and premolars already erupted during the correction of the upper and lower incisor segments, it was decided to omit the originally planned functional appliance treatment. Instead, permanent canines and premolars were integrated step by step into the multibracket appliance (Fig. 5.57) so that total treatment duration was not unnecessarily prolonged. Nevertheless, approx. 4.5 years of partial and full-fixed appliance treatment were required in total to successfully correct all aspects of this severe malocclusion (Figs. 5.58 and 5.59). Figure 5.60 shows the buccal and frontal occlusal relationships prior to and after therapy.

Table 5.6 Problem list and conceptual treatment planning in patient #6

	Problem list and relevant collateral findings	**Conceptual treatment planning**
1.	Severe class II div. 2 malocclusion with a complete cover-bite • Retroclination of upper centrals by −16.5° • Deep frontal overbite of 10 mm with – Supraposition of all upper incisors (U1 > U2) – Supraposition (+6 mm) and severe retroclination (−15°) of all 4 lower incisors • High lip line level of 7 mm • Maxillary gingiva display of 4 mm during smiling	Treatment in mixed + permanent dentition (a) Early active-mechanical intrusion + protrusion of upper incisors (utility arch) (b) Segmented active-mechanical intrusion of lower incisors (partial multibracket appliance) (c) (If sufficient time) further passive anterior bite opening (activator) (d) Further active-mechanical incisor intrusion, retraction of upper incisors with palatal root torque, lingual root torque for lower incisors (full multibracket appliance)
2.	Severe class II pattern • Severe asymmetric distocclusion (full-step on right side, 1/2-step on left side) • Skeletal class II (Wits + 2.8 mm)	(a) Early distalization parallel to utility arch (high-pull headgear) (b) (If sufficient time) mandibular advancement (activator) (c) (If required) further distalization of upper molars before multibracket phase (skeletally anchored distalslider) OR correction of remaining small distocclusion (multibracket appliance + class II elastics)
3.	Severe ankylosis of multiple deciduous molars • Particularly severe in teeth 55, 84, 85 • Resulting mesial migration/tipping of teeth 16 + 46	• Extraction of ankylosed deciduous molars at appropriate times (begin with tooth 55) • Asymmetric distalization of upper first molars, uprighting of lower molars as collateral effect of incisor intrusion
	Sequence of therapeutic measures (begin at the age of 12:0 years)	**Duration**
1.	Maxilla: Utility arch (two-by-two)	3.5 months
2.	Maxilla: Utility arch (two-by-four)	6 months
	Reevaluation → decision was taken to omit functional appliance treatment	
3.	Maxilla: Step-by-step transition to full multibracket appliance + cervical-pull headgear Mandible: Utility arch (two-by-six)	10 months
4.	Maxilla: Segmented multibracket appliance + high-pull headgear during bedtime Mandible: Transition to full multibracket appliance + overlay intrusion arch	3:00 years
5.	Maxillary and mandibular plates for retention	

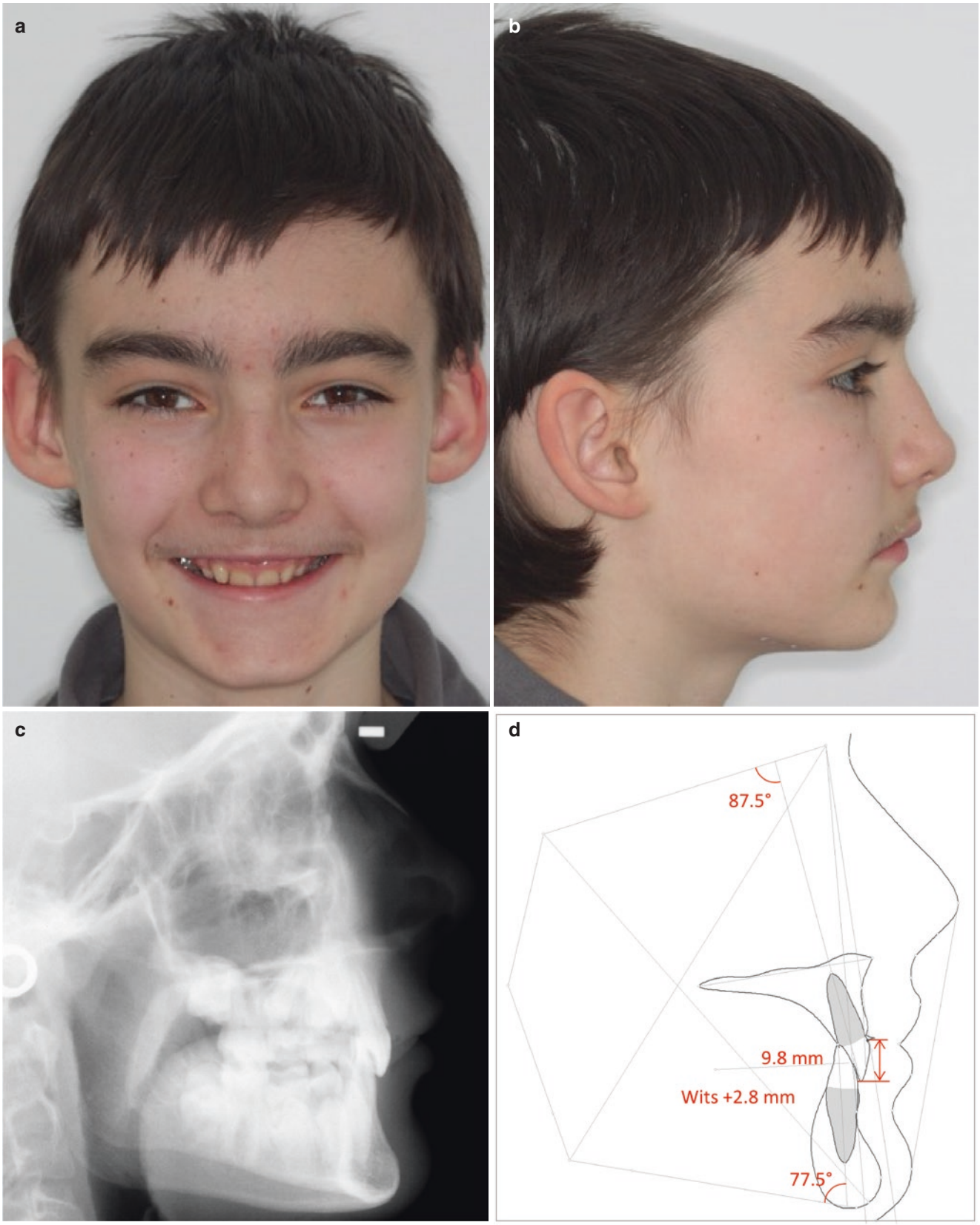

Fig. 5.53 (**a**–**d**)/patient #6. Facial images and lateral cephalogram of patient #6 taken at age 11:08 years, 4 months prior to treatment begin. (**a**, **b**) The significant maxillary gingiva display during smiling is due to the extreme supraposition of the upper central incisors. The facial profile indicates mandibular retrognathism. (**c**, **d**) The lateral cephalogram reveals the typical characteristics of a severe cover-bite, i.e., pronounced upper central incisor retroclination (−14.5°) combined with an extremely high lip line level (9.8 mm). The jaw bases show a clear skeletal class II pattern (Wits appraisal: +2.8 mm, deviation ANB/individualized reference: 2.7°). The lower incisors are also retroclined (by 12.5°)

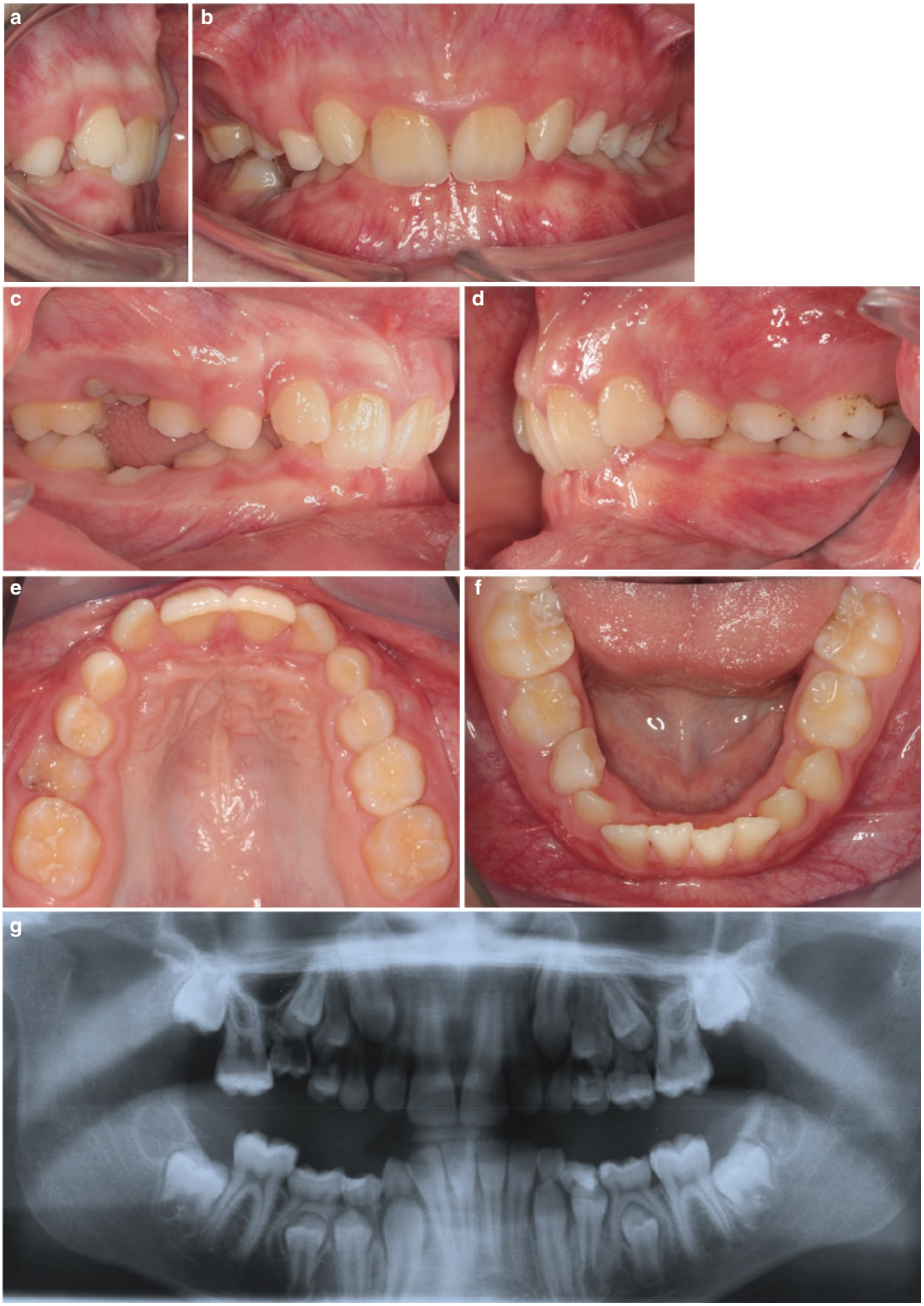

Fig. 5.54 (**a**–**g**)/patient #6. Initial dental images of patient #6 associated with the records depicted in Fig. 5.53. (**a**, **b**) The lateral and frontal view reveal a complete cover-bite in the late mixed dentition. (**c**, **d**) The cover-bite is combined with asymmetric distocclusion. The severe ankylosis of the second deciduous molars in first and fourth quadrants started already in the primary dentition. (**e**, **f**) Occlusal views on dental arches. (**g**) The panoramic X-ray taken 6 months before the other initial records reveals insufficient resorption of all second deciduous molars

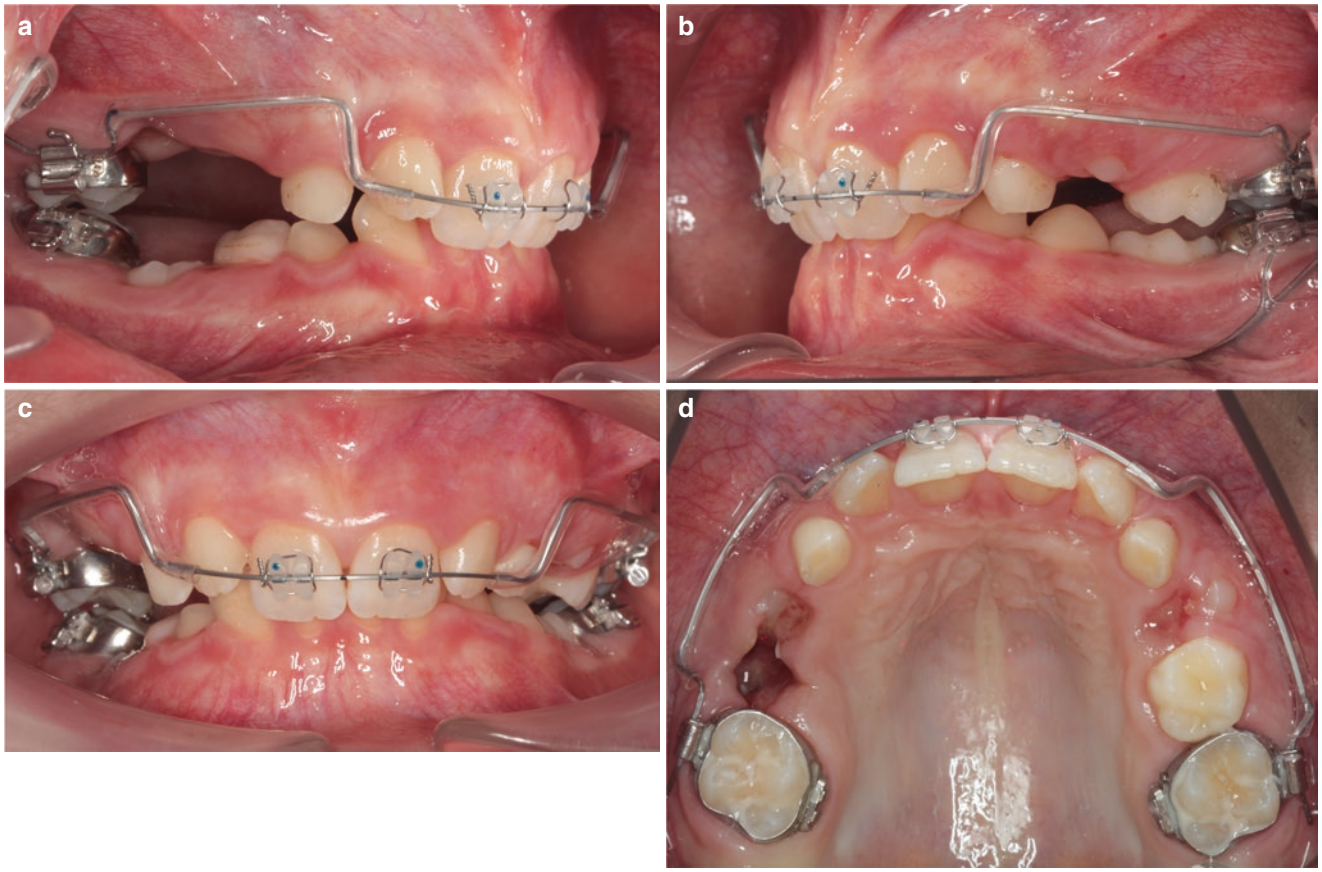

Fig. 5.55 (**a**–**d**)/patient #6. (**a**–**c**) The first early treatment stage is started after extraction of the two ankylosed deciduous molars in the first quadrant. It comprises intrusion and proclination of the maxillary central incisors using a two-by-two utility arch. This arch is designed to allow integration of the lateral incisors at a later stage. The partial multibracket appliance is not combined with a high-pull headgear at this stage, because some distal tipping of upper first molars is desired (particularly, in tooth 16). (**d**) The occlusal view on the upper arch shows the severe alveolar bone loss after extraction of teeth 54 and 55

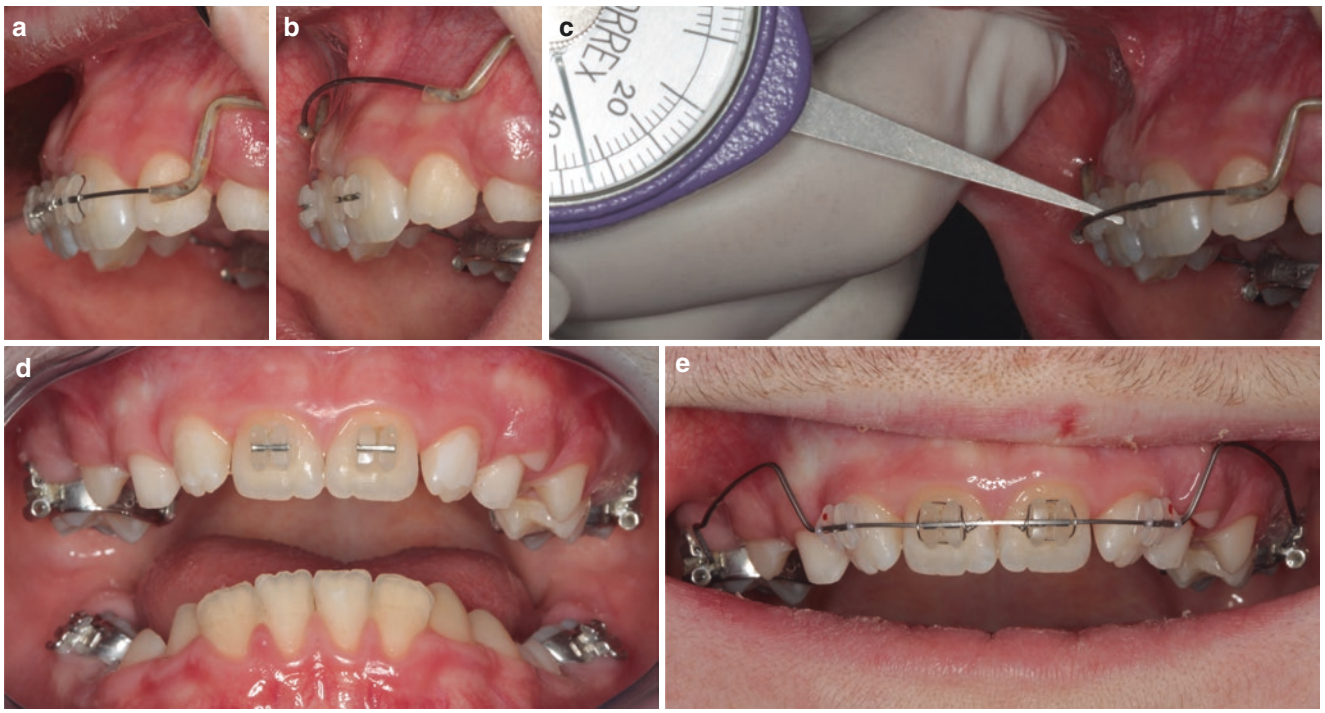

Fig. 5.56 (**a**–**e**)/patient #6. (**a**–**c**) The monitoring of the intrusive force requires detachment of the utility arch's frontal segment. The tip-back bends into the most distal part of the bypass wire are slightly increased on both sides to achieve a total intrusive force of 30 cN. (**d**, **e**) Inclusion of the two lateral incisors 3.5 months after treatment start. Bracketing in the lower frontal segment is not yet possible at this stage due to the remaining deep overbite and contacting between upper and lower incisors

Fig. 5.57 (**a**–**d**)/patient #6. Intermediate stages of multibracket therapy. (**a**) Intrusion of the maxillary and mandibular front teeth using two-by-four and two-by-six utility arches in the upper and lower jaw, respectively. (**b**) After sufficient intrusion of upper incisors, a segmented technique was applied for bodily retraction of these teeth using bilateral superelastic coil springs generating force vectors passing approximately through the incisor segment's center of resistance and parallel to the occlusal plane. Simultaneously, both upper canines are intruded and retracted using a segmental T-loop wire. In the lower arch, a 0.016-in. NiTi leveling archwire is combined with a 0.016 × 0.022-in. TMA overlay intrusion arch. (**c**) During subsequent leveling of the frontal and the two lateral segments in the upper arch using a 0.016 round NiTi full arch, the incisal part of the 0.016 × 0.016 stainless steel segmental wire is maintained as underlay wire to avoid overloading of the lateral incisors. (**d**) Situation after further bite opening. The remaining distocclusion has been corrected using class II elastics and a cervical-pull headgear worn during bedtime

Fig. 5.58 (**a**–**g**)/patient #6. (**a**–**f**) Dental images taken after 3:00 years full multibracket therapy and subsequent 1:02 years of retention. The extremely deep overbite of 10 mm which was initially present is corrected to 3.5 mm. (**g**) The panoramic X-ray reveals no sign of apical root resorptions. Due to compromised space conditions for the upper and lower third molars and the absence of any restoration, extraction of all third molars is recommended to the patient

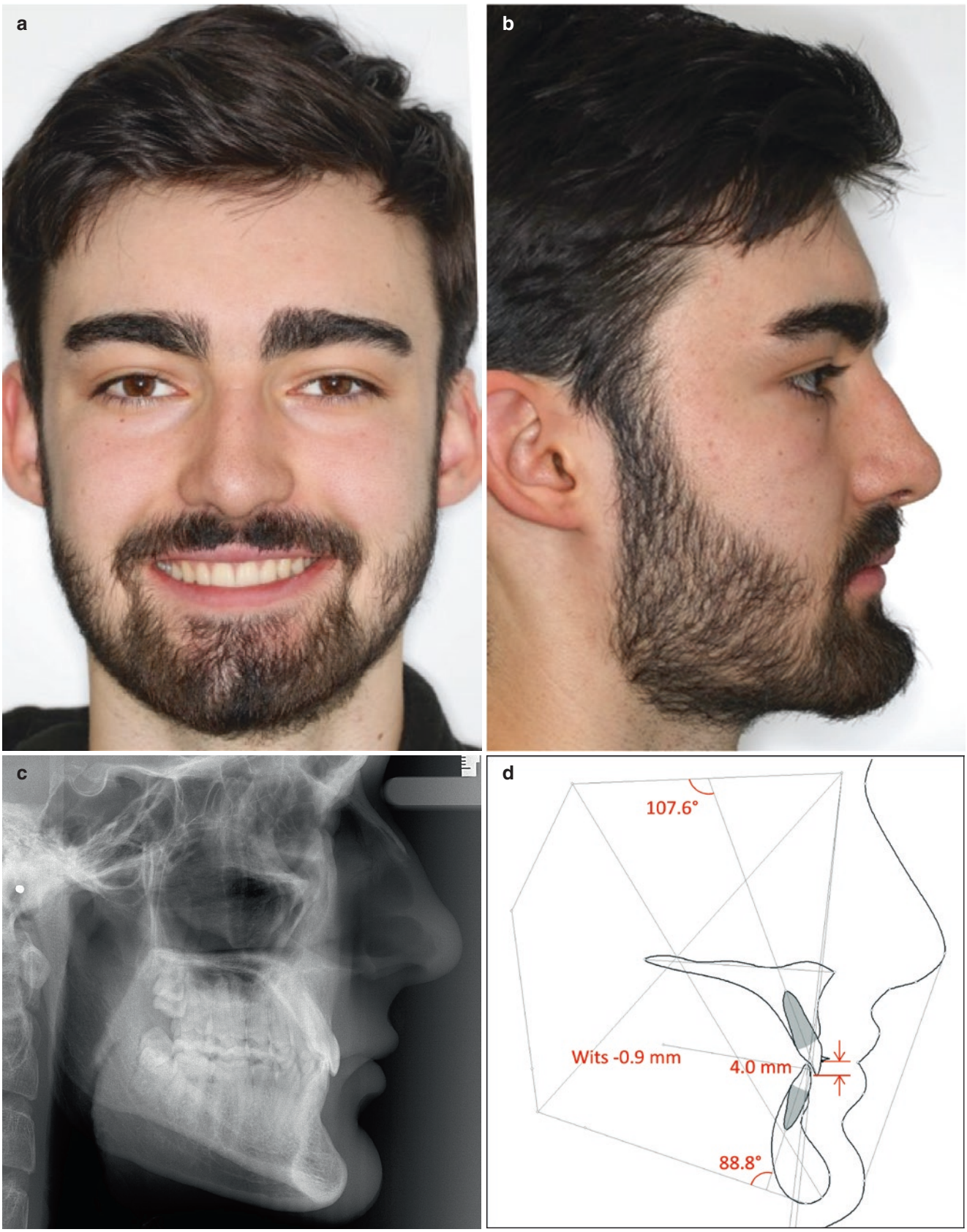

Fig. 5.59 (**a**–**d**)/patient #6. Facial images and cephalogram of patient #6 associated with the dental records shown in Fig. 5.58. (**a**, **b**) The patient's nice smile is related to the correction of the high lip line to only 4 mm (initial level: 10 mm). The facial profile is harmonic. (**c**, **d**) Both upper and lower incisors are significantly proclined with some over-correction in the upper arch. The skeletal class II pattern is completely corrected as indicated by the neutral Wits appraisal

Fig. 5.60 (**a**, **b**)/patient #6. Buccal and frontal occlusal interrelationships prior to (**a**) and after therapy (**b**)

5.6.7 Patient Example #7

The original treatment plan of this patient comprised only a short phase for upper incisor proclination using a utility arch to create the conditions for subsequent mandibular advancement for causal (and at least partial) correction of the malocclusion's severe sagittal component reflected by distocclusion of first molars of more than one full step (Table 5.7, Figs. 5.61 and 5.62).

The treatment documentation of this patient (Figs. 5.63, 5.64, 5.65, and 5.66), however, demonstrates that—e.g., in case of severe distocclusion and a relatively late treatment begin in the final mixed dentition phase combined with insufficient patient compliance—the second stage of early class II div. 2 treatment may not always be effective enough for achieving at least a nearly neutral occlusion of the buccal segments before multibracket therapy is started—which is generally the goal.

Based on the patient's relatively poor compliance with removable appliances, the almost completed eruption of the upper second molars at the time of reevaluation (approx. 1 year after treatment begin) and lower incisor proclination, it was decided to apply a skeletally anchored distalslider for correction of the class II molar relationship. Six months later, the appliance was extended to a full multibracket appliance in both jaws. Concrete tasks were bodily retraction of upper incisors and additional palatal torque of upper incisor roots using a segmented arch technique and intrusion of the lower anterior teeth using an overlay wire. All treatment goals were successfully achieved (Figs. 5.67, 5.68, and 5.69). Figure 5.70 shows the buccal and frontal occlusal relationships prior to and after therapy.

Table 5.7 Problem list and conceptual treatment planning in patient #7

	Problem list and relevant collateral findings	**Conceptual treatment planning**
1.	Severe class II div. 2 malocclusion with • Retroclination of upper centrals by −13° • Deep frontal overbite of 6.5 mm with supraposition of upper centrals by 2 mm • Incomplete display (ca. ¾) of maxillary incisor crowns during smiling (lip line level cannot be determined on the lateral cephalogram, because the interlabial border was not visible)	Treatment in mixed + permanent dentition (a) Early active-mechanical protrusion + limited intrusion of upper incisors (utility arch) (b) Segmented active-mechanical intrusion of lower incisors (partial multibracket appliance) (c) (If sufficient time) further passive anterior bite opening (activator) (d) Further active-mechanical retraction of upper incisors with palatal root torque, lingual root torque and intrusion of the lower anterior segment (segmented multibracket appliance)
2.	Severe class II pattern with • Distocclusion (1+1/2-step of right first molars, full-step of left first molars) • Skeletal class II (Wits appraisal + 2.3 mm)	(a) Mandibular advancement (activator) (b) (If required) active-mechanical distalization of upper molars (skeletally anchored distalslider)
3.	Significant proclination of lower incisors (+13°)	Utilizing remaining leeway space in lower arch for incisor uprighting (mandibular plate parallel to utility arch)
	Sequence of therapeutic measures (begin at the age of 11:0 years)	**Duration**
1.	Grinding of tooth 75 mesially	
2.	Maxilla: Utility arch (two-by-two) + high-pull headgear during bedtime Mandible: Plate with positive labial bow	3 months
3.	Activator with mandibular advancement + anterior bite plates + positive lower labial bow	8 months
	Reanalysis → headgear + activator were not effective enough due to poor compliance → non-compliance approach for distalization in upper arch required	
4.	Skeletally anchored distalslider with extrusive direction of guiding wires + mandibular plate with lateral bite plates for uncoupling the buccal occlusion and uprighting of lower incisors	4 months
5.	Full multibracket appliance (with distalslider maintained until debracketing) • Bodily retraction of upper incisors and additional palatal root torque • Overlay intrusion of lower anterior segment	1:11 years
6.	Maxillary and mandibular plates for retention	

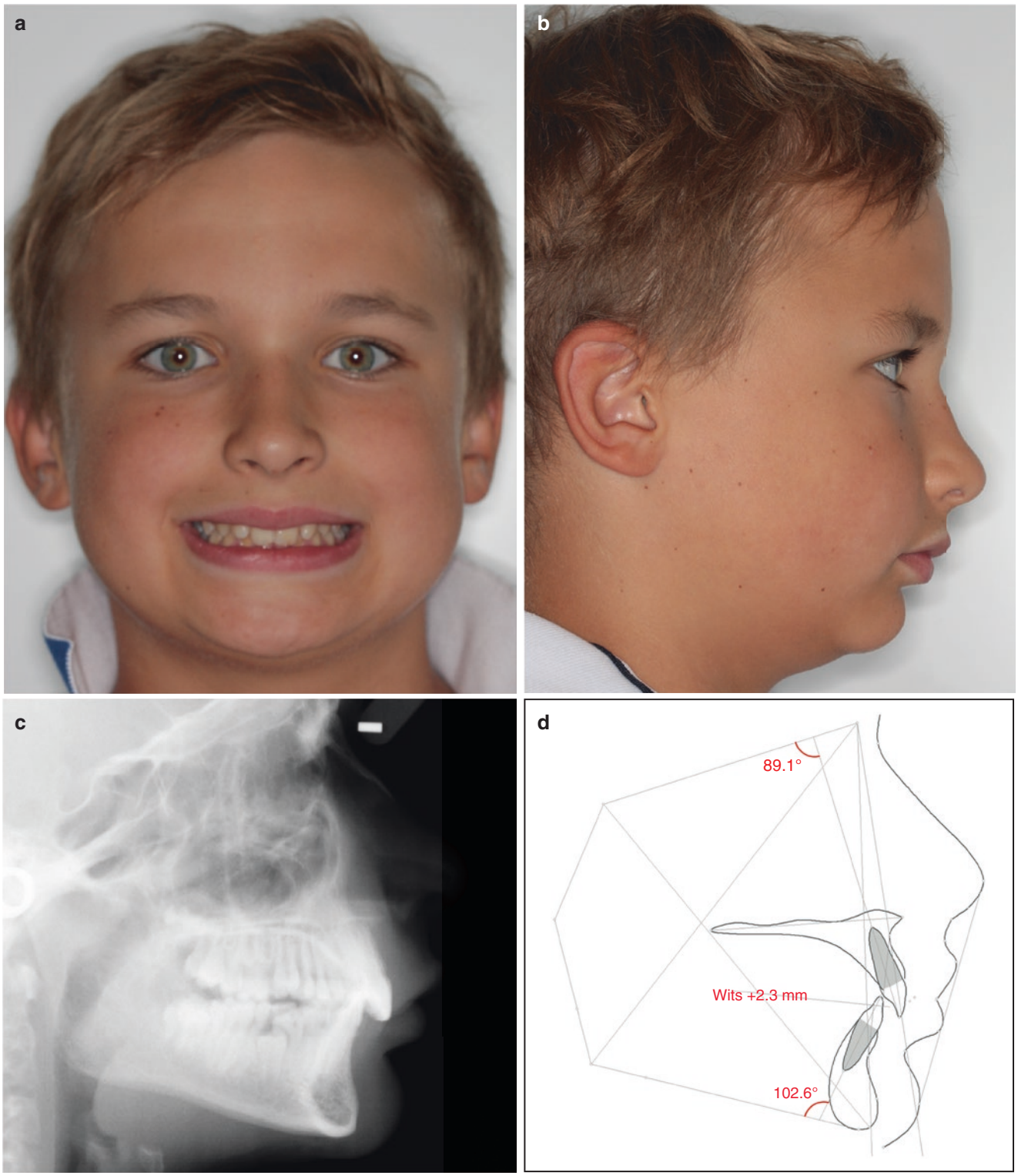

Fig. 5.61 (**a**–**d**)/patient #7. Facial images and cephalogram of patient #7 taken at age 10:09 years, 3 months prior to treatment begin. (**a**, **b**) Frontal and lateral facial views. Upper central incisor crowns are incompletely displayed during smiling. The facial profile is characterized by the retrognathic mandible. (**c**, **d**) The lateral cephalogram indicates retroclination of the upper central incisors by 12.9°, and significant proclination of the lower incisors by 12.6°. The lip line level is not recognizable on this cephalogram. The clear skeletal class II pattern is reflected by the Wits appraisal of +2.3 mm and the deviation of the ANB angle from the individualized reference by 3.3°. The mandible is retrognathic (SNB 74°) and the maxilla is orthognathic (SNA 80.7°). The decreased angle between upper and lower jaw bases of 17.4° (reference: 25°) indicates a skeletal deep bite

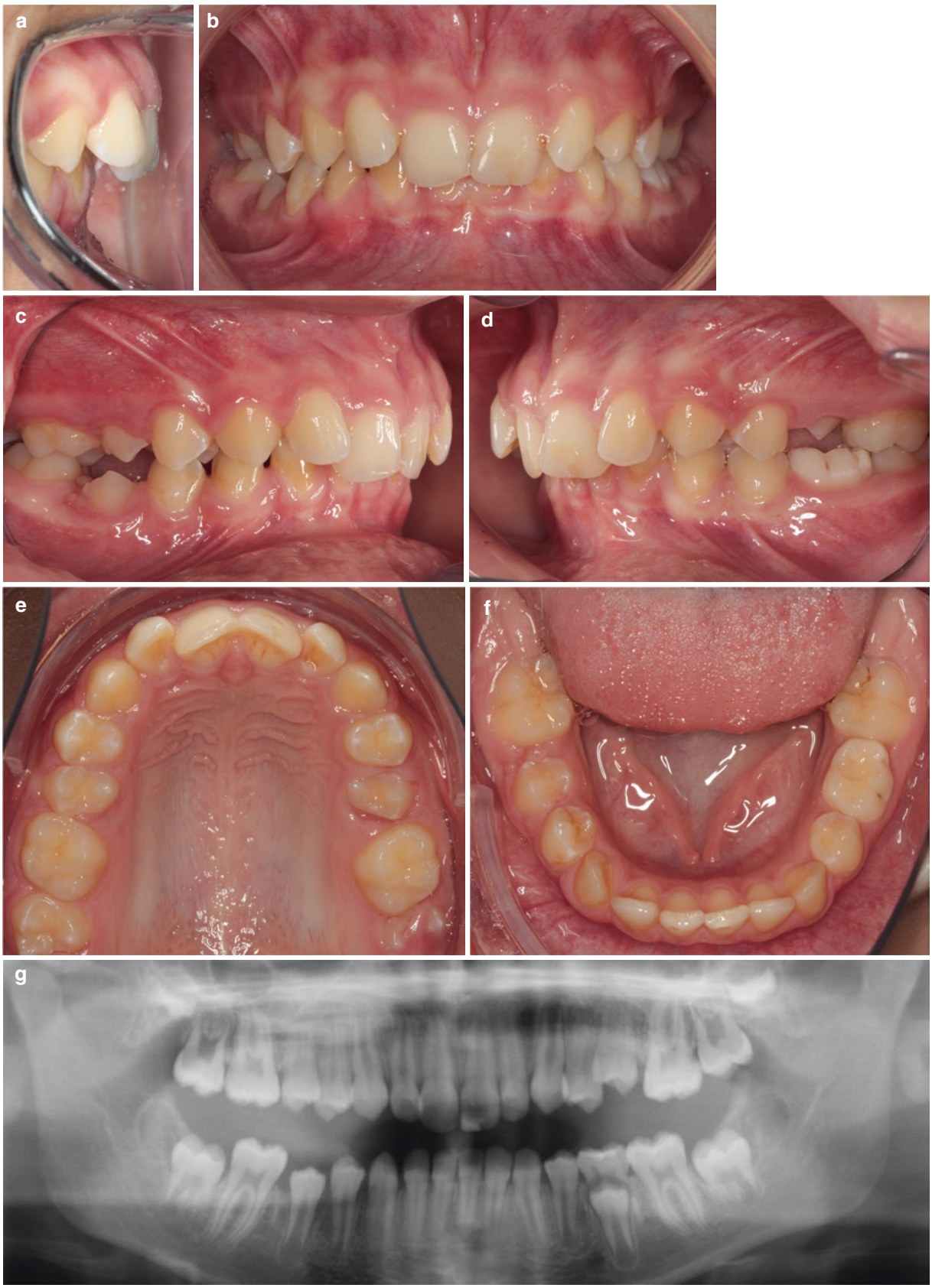

Fig. 5.62 (**a**–**g**)/patient #7. Initial dental records associated with the facial images and cephalogram depicted in Fig. 5.61. (**a**, **b**) The patient shows the typical features of a severe class II div. 2 with isolated supraposition and retroclination of the two upper central incisors in the late mixed dentition. (**c**, **d**) First molars show one-and-a-half-step distocclusion of right first molars and full-step distocclusion of left first molars. (**e**, **f**) Eruption of the upper second molars is almost completed and tooth 75 is the only deciduous tooth present intraorally. Mesial migration of lower molars into the leeway space did not yet occur. (**g**) The panoramic X-ray reveals the composite restoration of tooth 21 after trauma at age 7

Fig. 5.63 (**a**–**d**)/patient #7. (**a**) Insertion of the utility arch (0.016 × 0.016-in. stainless steel) to correct the malposition of the two upper centrals. Since this patient does not display the maxillary gingiva during smiling, it was planned to limit active-mechanical intrusion of the upper central incisors to approx. 2 mm. (**b**) Control measurement to ensure the application of 30 cN in total onto both upper centrals. (**c**) Occlusal view on the maxillary arch. (**d**) Reclination of lower front teeth using a plate with active labial bow. Before manufacturing the acrylic part of the plate, 2-mm thick dental wax is applied to the lingual surfaces of incisors and canines to provide the space for uprighting

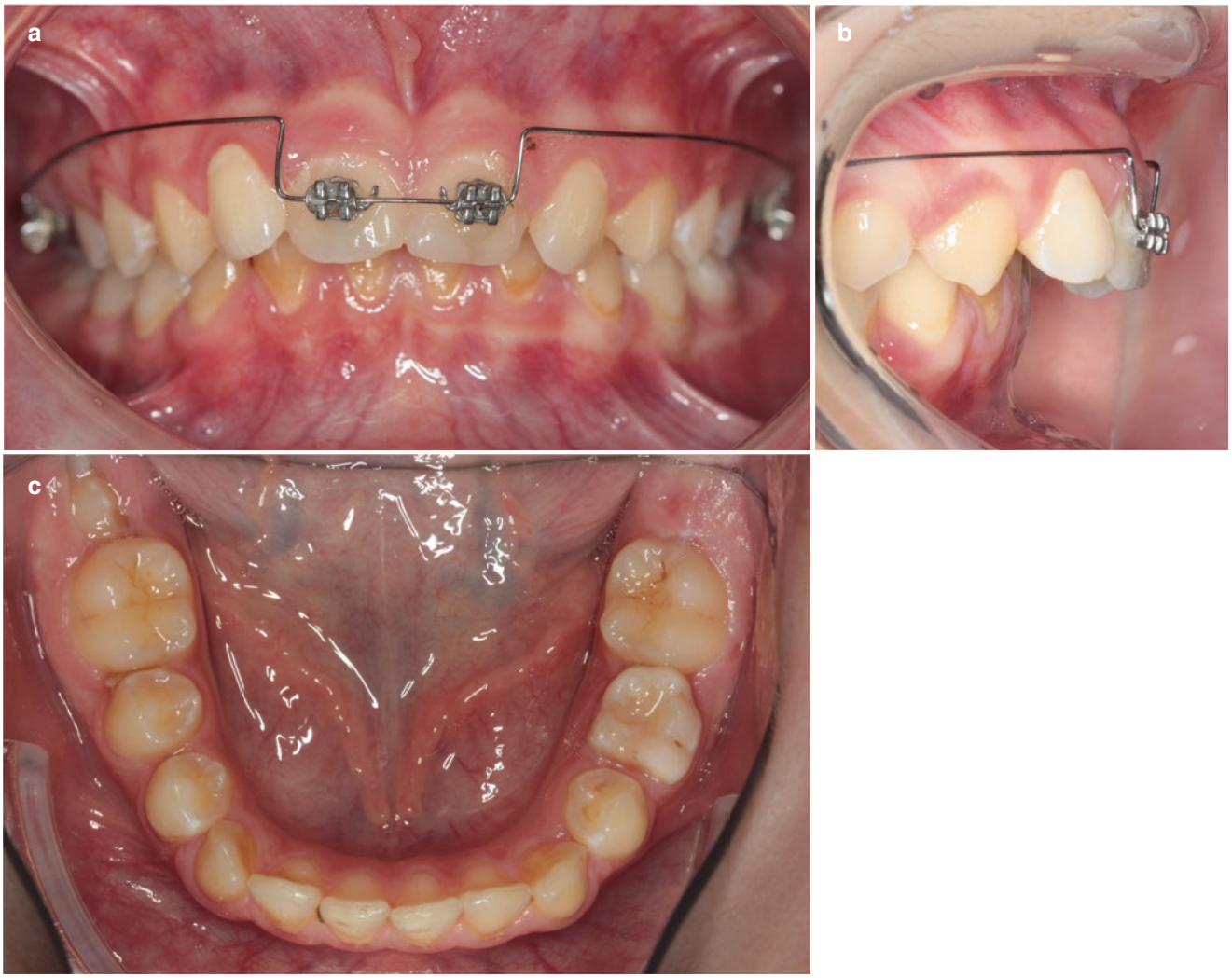

Fig. 5.64 (**a**–**c**)/patient #7. Situation after 3 months early treatment with the utility arch and the mandibular plate. (**a**) Intrusion of the upper central incisors by approx. 2 mm and sufficient proclination of these teeth is achieved. (**b**) The lateral view on the incisor segment shows the sagittal distance between the upper and lower incisors which is the important regarding the planned subsequent mandibular advancement using an activator with anterior bite blocks. (**c**) The lower incisors are slightly retruded. Tooth 75 is ground mesially to allow further distal migration of tooth 34

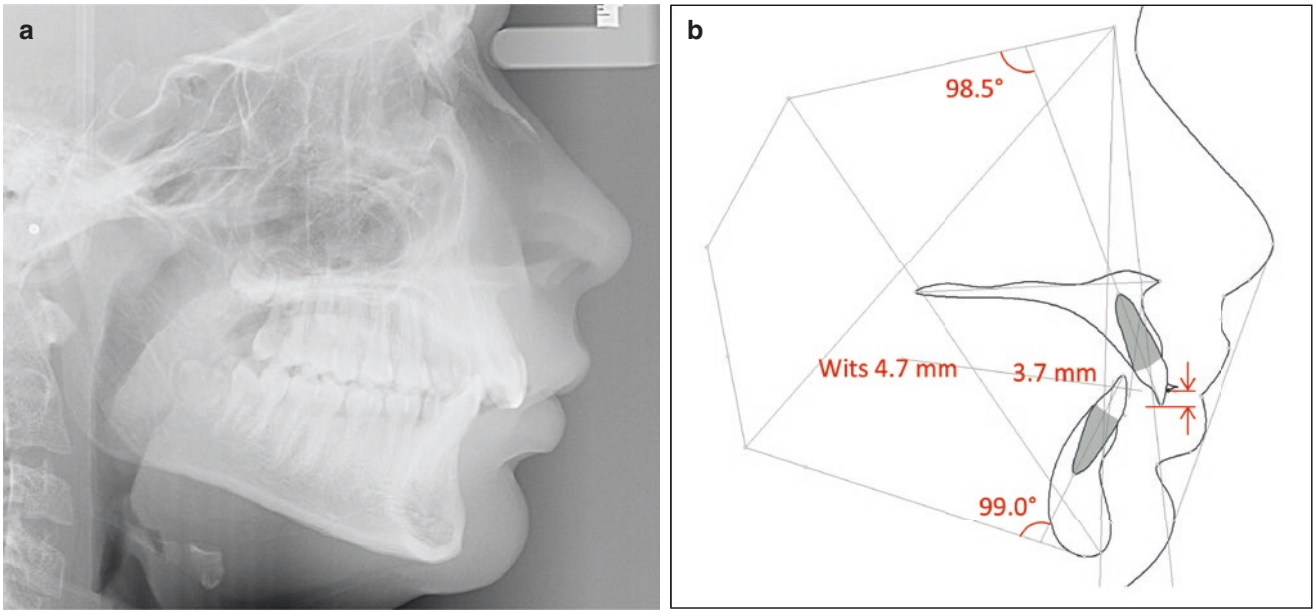

Fig. 5.65 (**a**, **b**)/patient #7. (**a**, **b**) Cephalometric analysis after finishing both main stages of early treatment, i.e., 3 months utility arch and 8 months activator treatment. The proclination of the upper incisors by 9.4° (initial value: 89.1°) and the uprighting of the lower incisors by 3.6° (initial value: 102.6°) demonstrates the significant improvement of the frontal features of the malocclusion by the early treatment in the late mixed dentition. The increase of the Wits appraisal from 2.3 to 3.7 mm and the stable deviation of the ANB angle from the individualized reference of 3.2° (compared to 3.3° initially), however, indicate that mandibular growth could not be stimulated sufficiently. This may be explained by the relatively late begin of functional appliance therapy at the age of 11:09 years and the patient's poor compliance during this treatment phase

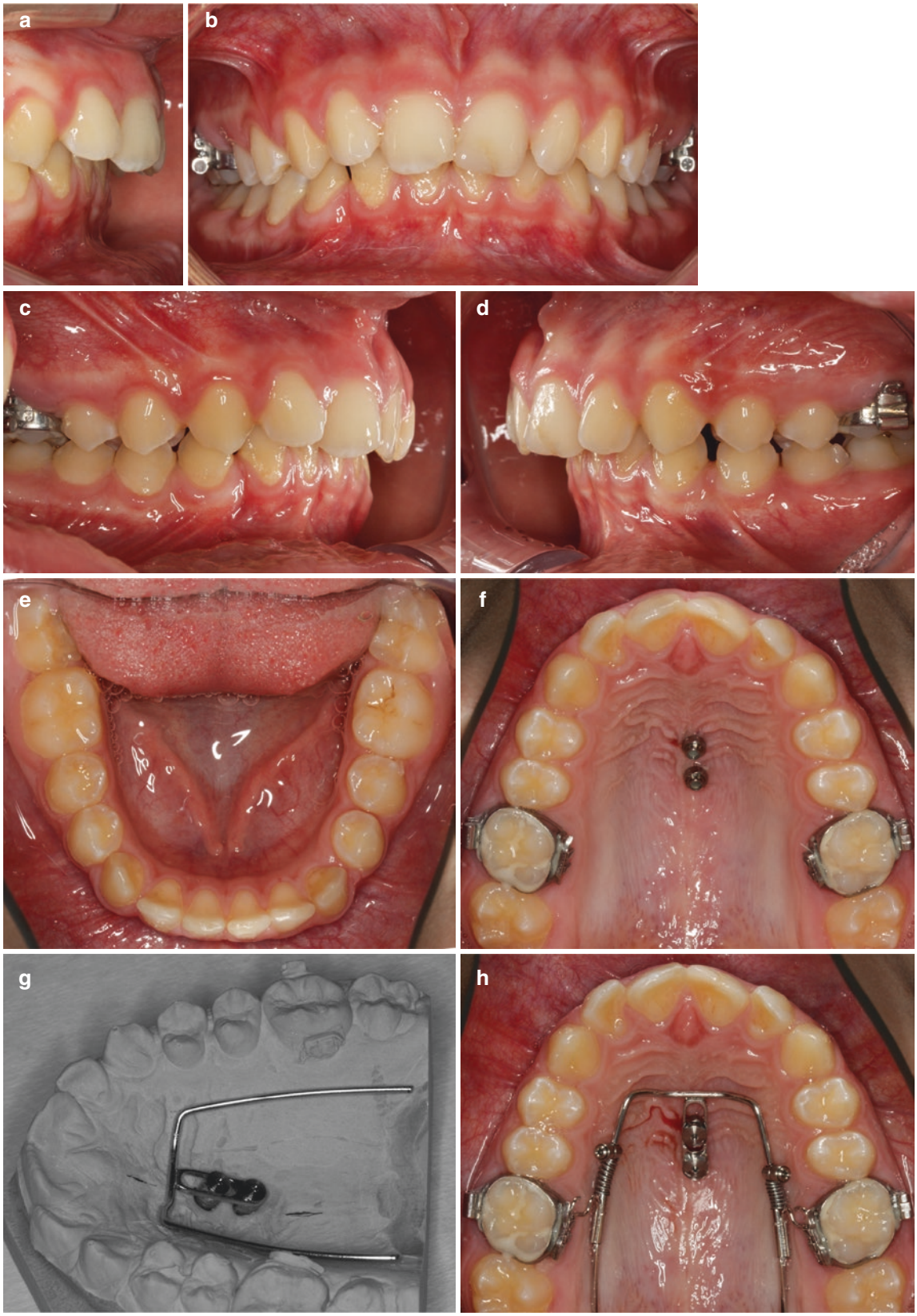

Fig. 5.66 (**a**–**h**)/patient #7. Dental situation 2 months after the cephalogram depicted in Fig. 5.65 has been taken. (**a**, **b**) Lateral and frontal images showing that the deep overbite is only partly corrected. (**c**, **d**) First molars are still in approx. 2/3-step distocclusion after full eruption of permanent canines and premolars. (**e**) In the lower arch, these teeth migrated into the leeway space. (**f**–**h**) Insertion of a skeletally anchored distalslider (Wilmes and Drescher 2010) for distalization of upper molars comprising two mini screws in the anterior palate before multibracket therapy

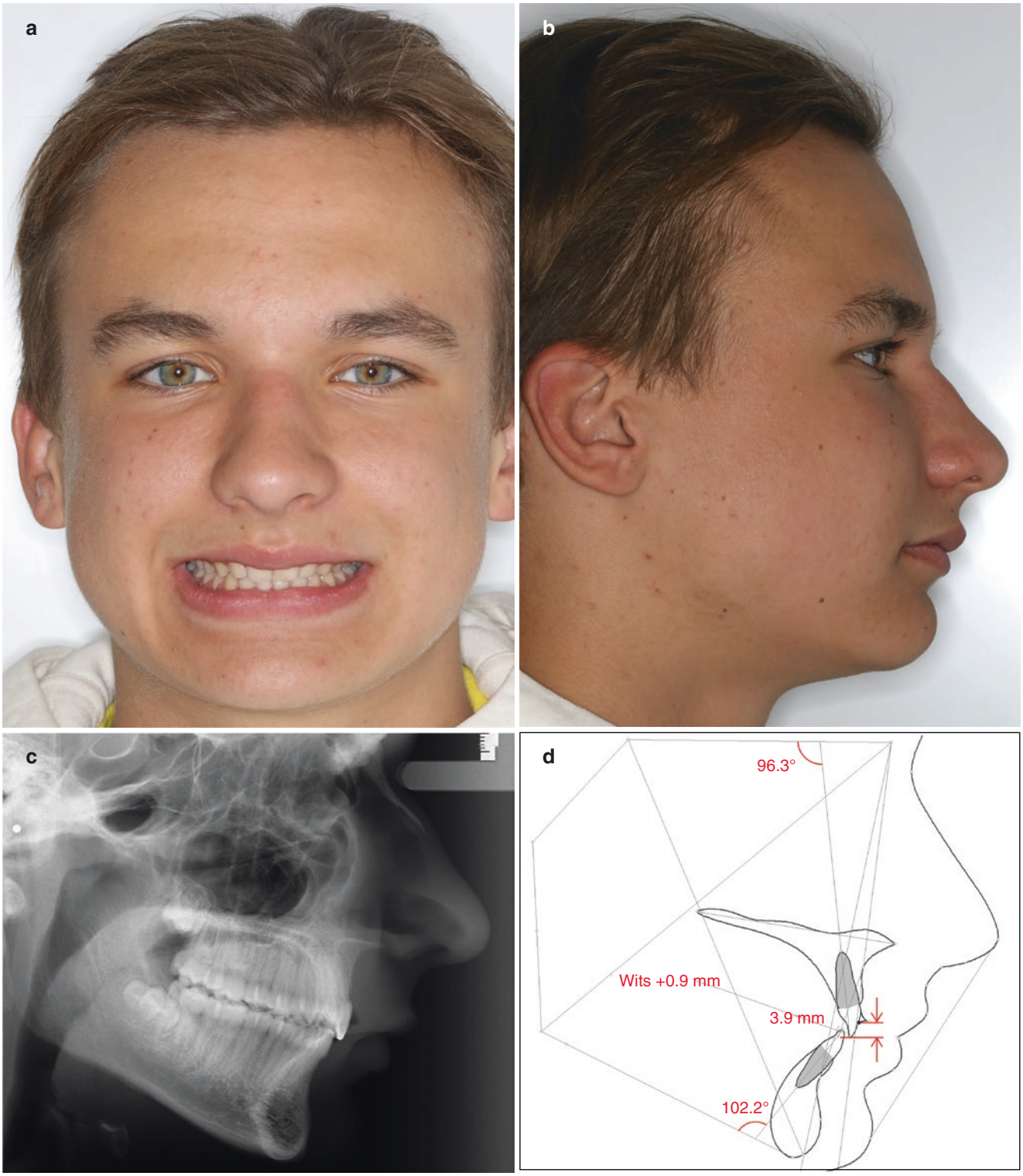

Fig. 5.67 (**a**–**d**)/patient #7. Facial images and lateral cephalogram taken after 6 months skeletally anchored distalization and subsequent 1:11 years therapy with a segmented full multibracket appliance. (**a**, **b**) Frontal and lateral facial views. The patient still displays only incisal halves of upper central incisor crowns. (**c**, **d**) Lateral cephalogram. The Wits appraisal of +0.9 mm and the remaining deviation of only 1.2° between the ANB angle and its individualized reference indicates an almost neutral sagittal jaw base relationship. The distalization of the complete maxillary dentition by approx. 5 mm comprised bodily retraction of the upper frontal segment with additional palatal root torque, i.e., large incisor root movement. This may explain the persisting mild retroclination of the upper central incisors

Fig. 5.68 (**a**–**h**)/patient #7. Dental images after debracketing associated with the records depicted in Fig. 5.67. (**a**, **b**) The frontal overbite is 1.5 mm, and upper and lower incisors show good axial inclinations and mutual support. (**c**, **d**) Molars and canines show neutral occlusion and optimum intercuspidation. (**e**, **f**) Occlusal views on both dental arches. (**g**, **h**) The patient is asked to wear maxillary and mandibular plates at night for retention. The distal extensions of the double-loop clasps for lower first molars and the recesses in the acrylic coverage of the labial bow (mesial to the canines) allow the insertion of light class II elastics for retention of the achieved neutral sagittal occlusion

Fig. 5.69 Patient #7. Panoramic X-ray of patient #7 at the age of 15:06 years (i.e., 1:03 years after debracketing). Angulations of the third molars seem favorable for eruption, but spatial conditions for teeth 38 and 48 are still unclear

Fig. 5.70 (**a**, **b**)/patient #7. Buccal and frontal occlusal interrelationships prior to (**a**) and after therapy (**b**)

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