Unconventional use of Invisalign® in the treatment of ectopic palatal maxillary canines

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Abstract

Background The proper development of the dental arches, including the eruption and correct positioning of the canines in the arch, is essential for the oral health of growing patients. Impacted canines not only give rise to functional challenges but also pose esthetic issues for patients. The aim of this article is to show if it is possible to benefit from the exclusive use of transparent aligners to guide the eruption of ectopic upper canines into the arch in the correct position.

Case report The subject of the study is the clinical case of a 13-year-old female growing patient who presented displaced upper permanent canines located in the palatal ectopic site. Following the surgical extraction of the retained deciduous elements, treatment with aligners for repositioning the ectopic canines in the arch was performed in two phases. At the end of the treatment, a Class I canine was achieved with satisfactory repositioning of the upper canines in the arch.

Conclusions The use of transparent aligners makes it possible, with some procedural precautions and in carefully selected cases, to reposition the ectopic palatal canines in the dental arch using a treatment that is both esthetic and effective.

KEYWORDS ectopic canine, malposition, transparent aligner, Invisalign®, orthodontic treatment, crossbite, retained tooth, occlusal build-up, malocclusion, Clincheck®, intraoral scanner.

Introduction

Following the lower third molar, the maxillary canine is the tooth most frequently impacted by disruptions in eruption timing and misalignment [Moyers, 1988]. Misalignment refers to an anomalous position of the canine within the maxillary bone before it is expected to naturally erupt. Inclusion, on the other hand, is characteristic of an element that is located within the bone structure with a closed root apex beyond the physiologically expected time for its appearance in the arch [Bishara, 1992; Dinoi et al., 2016; Pasini et al., 2020].

The maxillary canine undergoes the lengthiest period of formation and calcification among all dental elements. Additionally, it is distinguished by a complex sequence of movements as it migrates from its point of origin, which typically begins around the end of the first year of life and continues until it reaches the occlusal plane between 9 and 11 years of age [Dewel BF, 1949].

This developmental pattern increases the likelihood of abnormalities occurring due to the prolonged exposure of the developing canine to environmental factors. Consequently, there is a potential for deviation from its usual migration path [Peck et al., 1996, Rozylo-Kalinowska I et al., 2011; Mummolo et al., 2018].

Between the ages of 5 and 9 years, the movement of the permanent canine is oriented in the palatal direction and then, after the age of 10 years, it tends to move in the vestibular direction [McSherry and Richardson, 1999]. The complexity of the migration path of the maxillary canine, the close contiguous relationships with adjacent elements, an altered eruption sequence, abnormal position of the dental buds, and abnormalities of the adjacent lateral incisor may therefore result in a variation in the relationships between the position of the buds of the permanent canine and the first premolar or lateral incisor, resulting in an eruption disorder [Chalakkal et al., 2011].

If there is suspicion of a deviation in the eruption path, it becomes essential to employ radiographic assessments like orthopantomography, periapical radiographs, and CBCT scans. These diagnostic tools confirm the diagnosis and provide precise information about the tooth's positioning in all three dimensions of space [Yang et al., 2022].

In case of suspected alteration of the position of the canines, preventive approaches include the extraction of the corresponding deciduous element and rapid maxillary expansion (RME) with a rapid maxillary expander [Naoumova et al., 2015; Quinzi et al., 2020].

This interceptive treatment could, therefore, promote the spontaneous eruption of the suspected canine, but the eruption path could still be altered and the canine could erupt in a buccal or palatal position.

If the canine erupts in a palatal position, as in the case reported below in this article, a second clinical condition occurs, which is referred to as crossbite.

A crossbite is an aberrant occlusal relationship wherein a maxillary tooth is lingually positioned relative to its ideal position relative to an antagonist tooth (or teeth) or wherein the mandibular tooth is facially positioned relative to its ideal position relative to an antagonist tooth (or teeth). Crossbites can involve a single tooth or multiple teeth, can be bilateral or unilateral, and are often classified as anterior or posterior [Schupak et al., 2015].

The introduction of the Invisalign® System came with certain limitations, notably, the incapacity to manage root movement and relocate larger teeth over significant distances. However, recent enhancements, including innovative materials and attachments, improved software precision, the implementation of a new force system, and the accumulation of more extensive experience, have expanded the applicability of Invisalign® to handle more intricate clinical scenarios [Mampieri et al., 2021].

The objective of this case report is to describe the protocol that allowed the repositioning of two palatally erupted maxillary canines in the arch, in crossbite with respect to the lower canines, through the sole use of Invisalign aligners.

Clinical report

The proposed clinical case concerns a 13-year-old growing female patient of Caucasian origin who presented with displaced elements 1.3 and 2.3 as evidenced by the pretreatment records obtained at the first visit (Fig.1a-1h).

Therefore, the patient underwent a comprehensive examination, and the required radiographs, including an orthopantomogram and a lateral skull teleradiograph (Fig. 2a-2b), were obtained for the case analysis.

Subsequently, an initial intraoral scan was also performed using an iTero intraoral Flex scanner (Align Technology Santa Clara, CA, USA) in order to obtain all the records necessary to design the case (Fig. 3a-3e).

Authorisation to process personal and sensitive data according to current regulations was requested and obtained, and explicit authorisation to disclose such data for purely scientific purposes was granted by the minor patient's responsible guardian.

The clinical examination showed a flat, mild hypodivergent profile; frontally, a harmonious facial oval was observed with a dimensional balance of the horizontal thirds. Intraoral examination showed complete permanent dentition, the presence of edentulous spaces in the arch corresponding to the previously extracted 5.3 and 6.3, a bilateral Class I molar, an overjet (OVJ) of 4.0 mm, and an overbite (OVB) of 3.1 mm. In the smile examination, we observed good symmetry with centered medians and complete tooth exposure of both the upper and lower arch. The palatine vault exhibited an ogival shape with inverted canine bone bulges on the palatal surface.

Cephalometric examination confirmed a skeletal Class I corresponding to a molar Class I (Tab 1).

The periodontal tissue appeared to be healthy with no radiological or clinical indications of active disease.

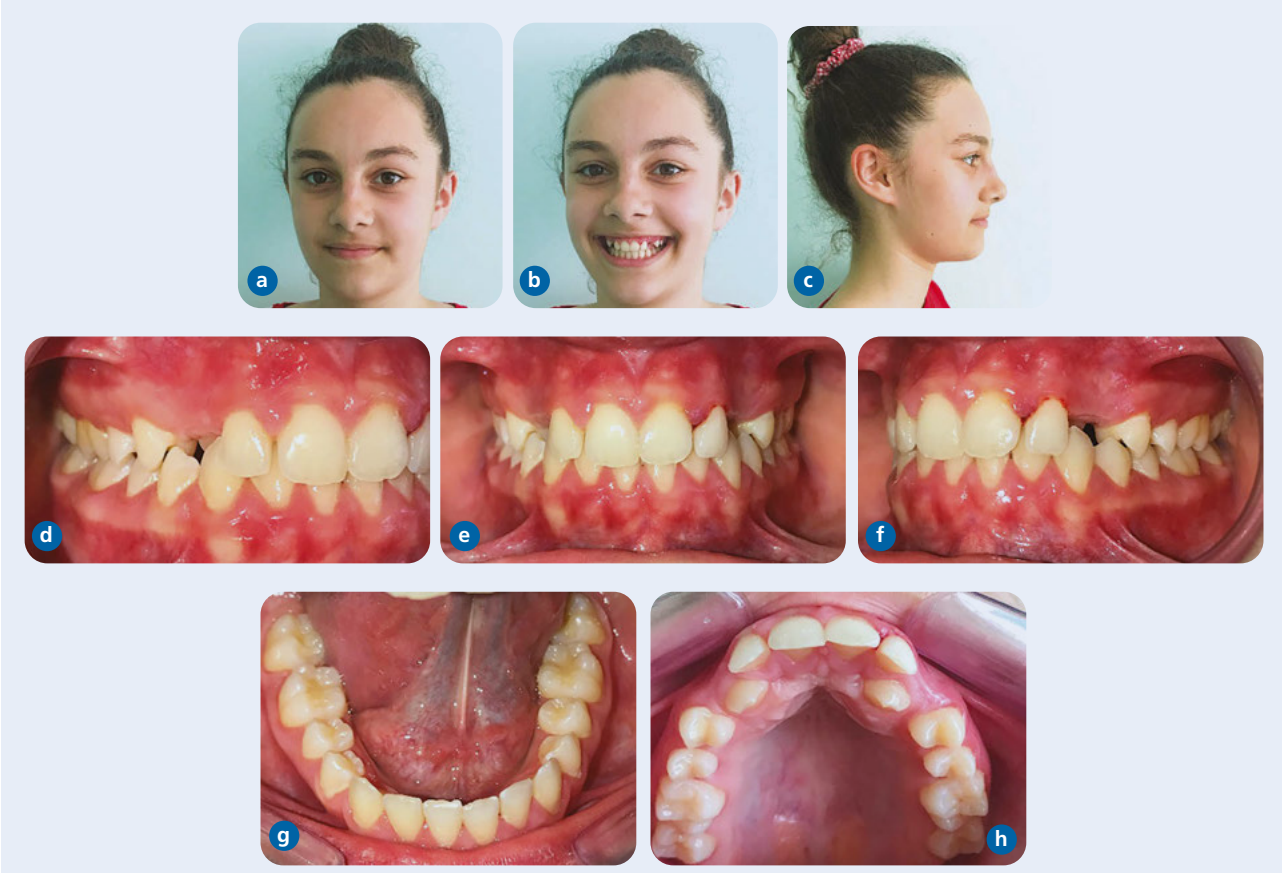

FIG. 1A-1H Pre-treatments records.

CHEPHALOMETRIC ASSESSMENT	T0	T1
SNA	78.8°	84°
SNB	74.2°	82.0°
ANB	4.4°	1.3°
OVJ	4.0 mm	2.8 mm
OVB	3.1 mm	3.0 mm
Wits	1.0	1.5
Upper incisal axis on ANS-PNS	112.1°	109.4°
IMPA	104.3°	86.8°

TABLE 1 Comparison values of cephalometries performed at the beginning (T0) and end (T1) of therapy.

The primary objective of the treatment was the repositioning of the canines in the arch and the achievement of a Class I canine. Secondary outcomes were maintenance of the Class I molar, mesial-out molar rotation, correction of the OVB and OVJ, mild dentoalveolar expansion, creation of an ovoid arch shape, flattening of the Curve of Spee, and closing spaces between teeth.

A valid therapeutic alternative is represented by the use of a rapid maxillary expander with molar bands, subsequent multibracket therapy with arches and auxiliary tools for canine traction, and intermaxillary rubber bands. The treatment plan was the rounding of the arch form by expansion and the extrusion and vestibularisation of the canines followed by levelling and alignment. The treatment plan involved the development of three steps of aligners, each with a different purpose: the first Clincheck® was developed to expand the upper arch shape and create adequate spaces to accommodate the upper canines. In this phase, the space between the canines was widened using pontics, which did not require the accommodation of any teeth, as the canines were not included in the aligners because they were too ectopic and poorly erupted at the time of application (Fig. 4). To achieve this objective, seven aligners were used, each worn for a duration of 10 days (Fig. 5). The second Clincheck® was performed at the conclusion of the initial phase, when teeth 1.3 and 2.3 had fully erupted but their positioning was extremely palatal, resulting in them being significantly overlapped with the lower arch antagonists with bilateral crossbite (Fig 6a-6e). Consequently, a decision was made to

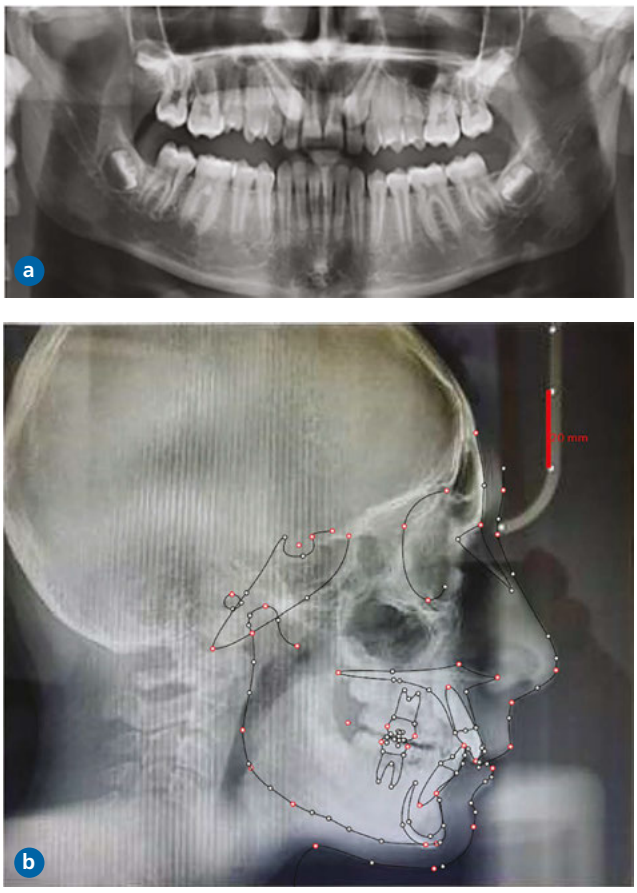

FIG. 2A-2B Pre-treatment x-ray records.

temporarily apply composite build-ups on teeth 3.6 and 4.6 (Fig. 7a-7c). These build-ups were applied solely for the purpose of further intraoral scanning and were promptly removed afterward (Fig.8). This step allowed us to obtain a series of aligners designed to increase the posterior vertical dimension without the real presence of bonded occlusal elevations on the posterior teeth. The aim was to facilitate the resolution of the crossbite by gradually moving teeth 1.3

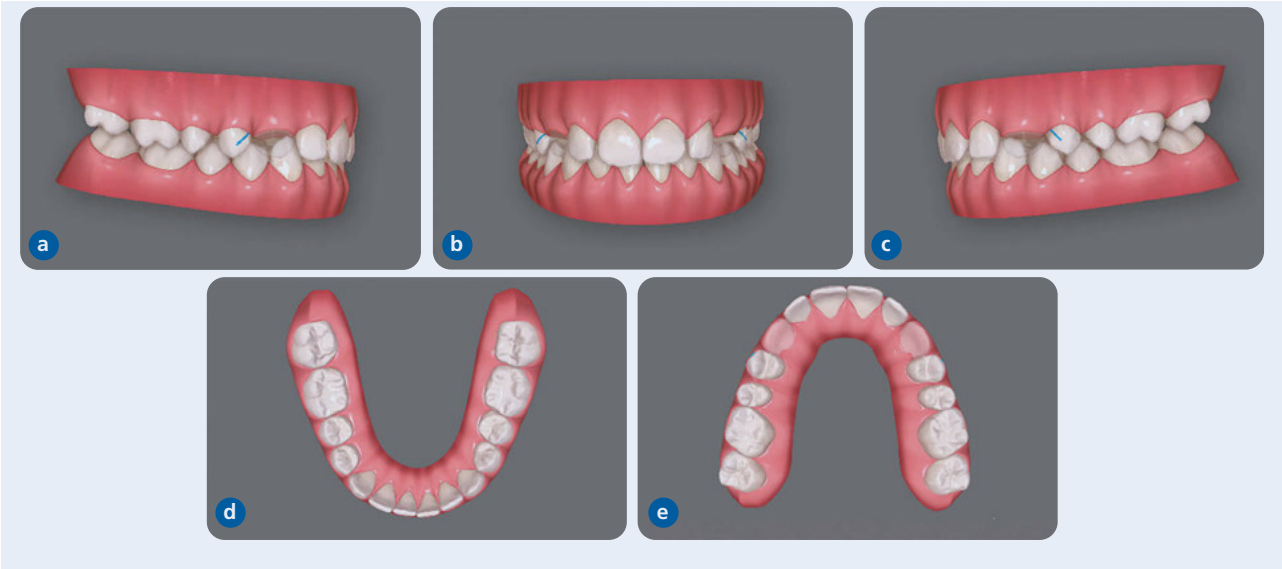

FIG. 3A-3E Pre-treatment iTero scans.

FIG. 4 (Upper aligner during arch space regaining phase of ectopic canines; canines were not included in aligners at this stage).

and 2.3 into their correct vestibular position, reducing or even eliminating pre-contacts of the canines themselves during their advancement (Fig. 9). This was made possible by temporarily blocking the movement of the upper molars in maximum posterior anchorage and engaging the upper canines with rectangular attachments (Fig. 10). The second phase of treatment involved the use of 31 aligners, each worn for a period of 10 days.

The third and final Clincheck® was developed when teeth 1.3 and 2.3 were appropriately positioned within the dental arch, and the crossbite issue was successfully resolved to conclude the case and refine the occlusal relationships. Additionally, molar mesial-out derotation was planned, and the canine class was improved by implementing intermaxillary elastics (sized at 3/16" and 4.5 ounces) applied between teeth 1.3 and 4.4 and between teeth 2.3 and 3.4. This phase of treatment utilised 26 aligners, each worn for a period of 10 days. The case was successfully addressed through three Clinchecks® for a total of 64 aligners and 21 months of therapy.

The orthodontic treatment was performed using the Invisalign® system and was designed to solve the bilateral crossbite of the 1.3 and 2.3 elements erupted at the palatal ectopic site, preventing eruptive anomaly that could result in occlusal interference and functional alterations [22].

Throughout the treatment, a Class I molar relationship was maintained, and a Canine Class I alignment was achieved (Fig.11a-11h). At the end of the treatment, an orthopantomography and a lateral–lateral radiograph were performed (Fig.11). The OPT examination highlights correct root alignment of the upper canines with the other dental elements. The comparative analysis of the cephalometric measurements obtained at the beginning and the end of the therapeutic intervention showed that, despite having no skeletal effects, the alignment allowed us to correct the overbite and overjet, improving the sagittal relationship between the arches by optimising leveling and coordination. This reduced the proinclination of the incisors and, finally, achieved the correct repositioning of both upper canines, ensuring the presence of correct canine guidance on laterality without interference (Tab.1).

Discussion

Inadequate space in the apical region, preventing proper alignment of the lateral incisors, leads to the permanent canine's crown applying pressure on the distal surface of the neighboring lateral incisor. As a consequence, a natural gap, known as a diastema, forms due to the abnormal tilt of the lateral incisors, which defines the "ugly duckling" phase. The closure of this diastema happens naturally as the permanent canine gradually slides along the distal surface of the adjacent lateral incisor [McSherry, 1998]. Despite all the above considerations in identifying mechanical factors involved in the etiology of canine malposition, the literature places significant emphasis on genetic factors. Scientific evidence indicates that canine malposition frequently reoccurs among various family members who also exhibit congenital absence of other dental elements, such as lateral incisors and/or second premolars [Baccetti, 1988]. Moreover, this condition tends to affect more females. These findings point toward a genetic hypothesis potentially implicating sex chromosomes in its development [Peck et al., 1996]. Clinical experience together with the knowledge acquired over the years regarding etiology, pathogenesis, and the ability to read and interpret

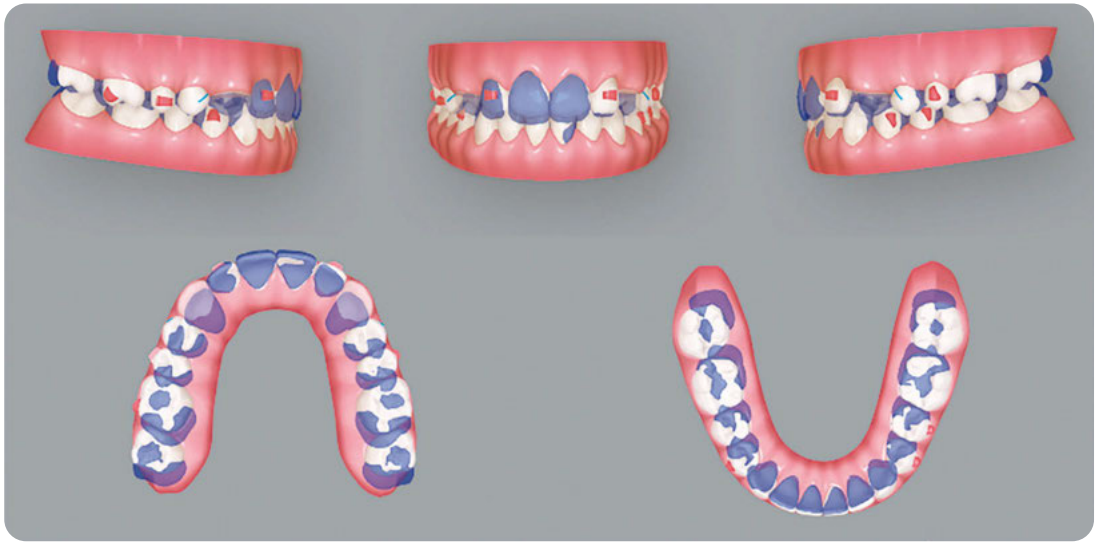

FIG. 5
First Clin Check Virtual Planning: Phase 0 and final superimposition.

FIG. 6A-6E Records after the first set of aligners.

radiographic investigations allow us today to detect, at an early stage of development, malposition of the maxillary canine and to intervene to correct this dental anomaly [Okeson, 2007]. The discovery of a malpositioned or included tooth is often accidental; in fact, these abnormalities are not accompanied by pain, discomfort, or swelling [Katiyar et al., 2013]. The current guidelines recommend palpating the bulge where the canine is expected to emerge in growing patients. This practice helps monitor the gradual eruption of the permanent tooth while also observing the color and mobility of the corresponding deciduous tooth [Counihan et al., 2013].

Periapical radiographs can provide a preliminary indication of the position of an impacted tooth using Clarke's rule, helping differentiate between a buccal or palatal placement [Dinu et al., 2022]. In contrast, orthopanoramic radiographs have led to the development of several classifications over time. These classifications establish correlations between the canine's position in relation to various reference points and the likelihood of successfully repositioning the tooth in its correct location within the dental arch, thereby determining its prognosis. Examples of such classifications include assessing the degree of overlap between the crown of the impacted canine and the root of the adjacent lateral incisor, measuring the vertical distance between the crown of the impacted canine and the CEJ (cement–enamel junction) of the lateral incisor, and calculating the angle formed by the axis of the impacted canine in relation to the upper midline [Bedoya and Park, 2009]. Deciduous element extraction is reported in the literature to be 80% effective if performed when the patient is between 10 and 13 years of age, mainly with respect to palatal inclusions, and is an undoubtedly advantageous technique from the point of view of low cost and simplicity of execution [Naoumova et al., 2015]. Orthodontic expansion of the upper jaw by RME can increase the chances of eruption of the permanent canine by up to three times [Sigler et al., 2011]. The correct arch positioning of permanent canines, especially upper canines, has both an important esthetic and functional significance. From an esthetic point of view, the upper canine, when correctly positioned and appropriately shaped and sized, contributes to giving the smile a pleasing line and continuity with respect to the adjacent anterior elements. Moreover, being in close proximity to the alar base of the nose and the upper lip, it is able to support these soft tissues, also participating in the esthetics of the central portion of the face [Cruz, 2019]. As far as the functional aspect is concerned, in lateral movements the correctly positioned canine is able to guide the posterior disclusion protecting the entire arch through canine guidance [Oltramari et al., 2007].

In cases of canine displacement, early diagnosis and timely treatment are necessary [Almasoud, 2017], therefore, both to avoid esthetic and functional problems and to prevent the onset of related pathological conditions such as displacement and loss of vitality of adjacent elements, arch length discrepancies, median shifts, internal and external resorptions, etc. [Grisar et al., 2021].

The proposed clinical case led to the resolution of the bilateral canine palatal displacement by means of an extremely

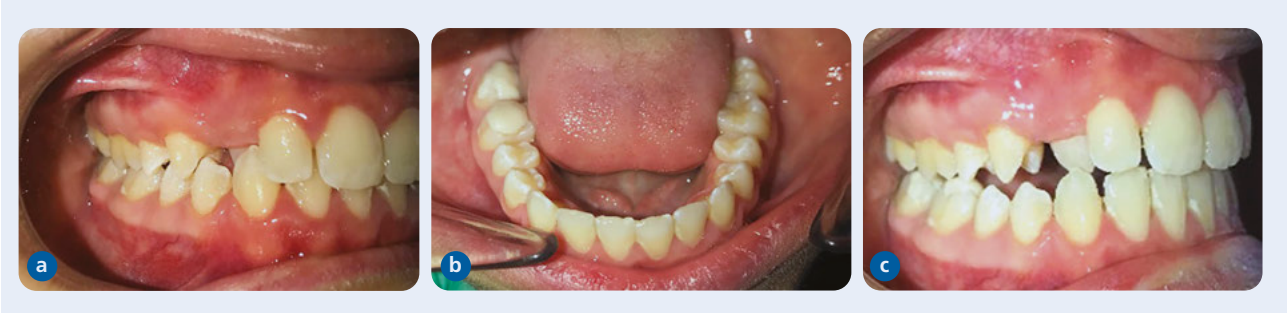

FIG. 7A-7C Placement of temporary posterior composite occlusal build-ups on molars for intraoral scanning.

FIG. 8 Aligners with unfilled lower build-ups.

FIG. 9 Permanent canine engaged in the aligner during the phase of resolution of the cross-bite by increasing temporary posterior vertical dimension.

conservative and atraumatic approach, thanks to the preventive approach adopted by the clinician, which provided for the extraction of the deciduous elements in order to increase the available space in the maxillary arch [Almasoud, 2017].

This therapeutic decision was supported by the literature. In fact, Ericson and Kurol report that extraction of the deciduous canine corresponding to the malpositioned canine results in a positive change in position in 50% of cases as early as 6 months after extraction; after 12 months, this percentage reaches 78% [Ericson and Kurol, 1988].

The authors, considering the results obtained, suggest this procedure as the treatment of choice for subjects 10-13 years of age in whom the permanent canine maxilla presents a direction of palatal eruption. The proposed case report involved the resolution of the bilateral crossbite of the upper canines, erupted in the palatal ectopic site, using Invisalign® clear aligners. The use of temporary non-bonded composite occlusal elevations made it possible to include posterior bite planes in the templates, thus prevent patient discomfort due to the elevations during chewing and the demineralisation of the occlusal surfaces of the lower sixths resulting from the etching procedure. It was thus possible, in 10 months, to bring the 1.3 and 2.3 elements back into the arch while maintaining good anchorage control thanks to the possibility of dissipating the force used for vestibularisation of the canines on all the other elements solidified inside the template [Giancotti et al., 2012]. The use of false elevations on the lower molars and the use of a "segmented technique" that blocked the position of the upper-posterior sectors during the alignment of the canines proved to be the winning strategy for resolving the case [Giancotti et al., 2012]. The success of the therapy with aligners was also possible because the case was carefully selected and because it showed certain characteristics that made it attractive for therapy with only aligners. First of all, the patient has completed deciduous exfoliation; therefore, all the definitive elements were present in the arch and completely erupted, apart from the canines which are the object of the study [Mampieri et al., 2022, Mampieri et al., 2023]. The permanence of deciduous elements that exfoliate forces the clinician to prepare further sets of aligners that adapt to the dynamic and evolving situation. This fact dramatically lengthens orthodontic treatment times with the risk of not obtaining the desired results and decreasing patient compliance [Memè et al., 2022; Daniele et al., 2022].

Second, but no less important, is the absence of malocclusions of a skeletal nature which would not have been

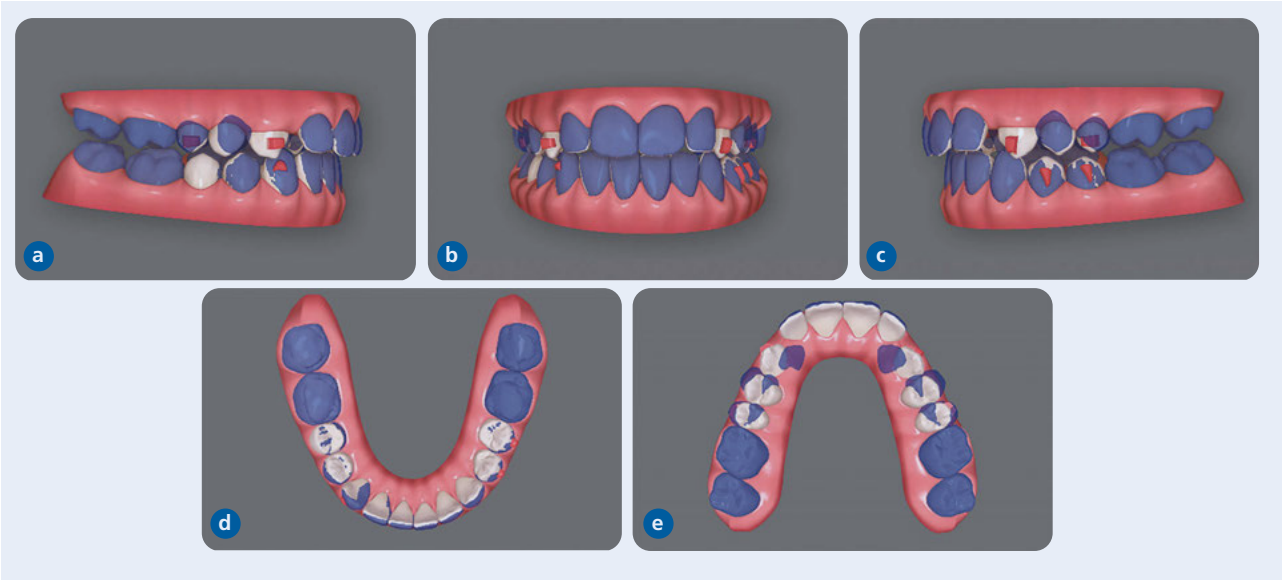

FIG. 10 Second Clin Check Virtual Planning: Phase 0 and final superimposition, as showed posterior sectors were temporarily blocked.

FIG. 11A-11H Post-treatments records.

possible to intercept or resolve with the exclusive use of aligners [Haouili et al., 2020].

The notable advancement of the SNB point is probably attributable to a repositioning of the mandible forward and in a repositioning, to a more central location, of the condyle inside the glenoid fossa. Such significant residual pubertal growth of the mandible would be almost unjustifiable. Therefore, it is conceivable that the crossbite of the canines blocked the lower arch in a more retruded position.

In the case report described, an unconventional use of the Invisalign® aligner system was proposed for the treatment of two elements of the permanent series (1.3-2.3) that were ectopically erupted in the palatal region. The now well-known advantages of the orthodontic use of transparent templates were therefore exploited; these advantages include greater esthetics, greater comfort for the patient, and greater ease in performing daily home hygiene procedures compared to the fixed appliance, obtaining an extremely satisfactory result from both an esthetic and functional point of view. Moreover, the case resolution time (24 months in total) reflects the average duration of treatment of similar cases.

Further investigations could focus on the application of photobiomodulation (PBM) as an orthodontic tooth movement acceleration technique for reducing treatment time, even in cases of canine ectopic eruption, based on the encouraging results obtained from the 2022 study by Memè et al. [Memè et al., 2022; Fani et al., 2023].

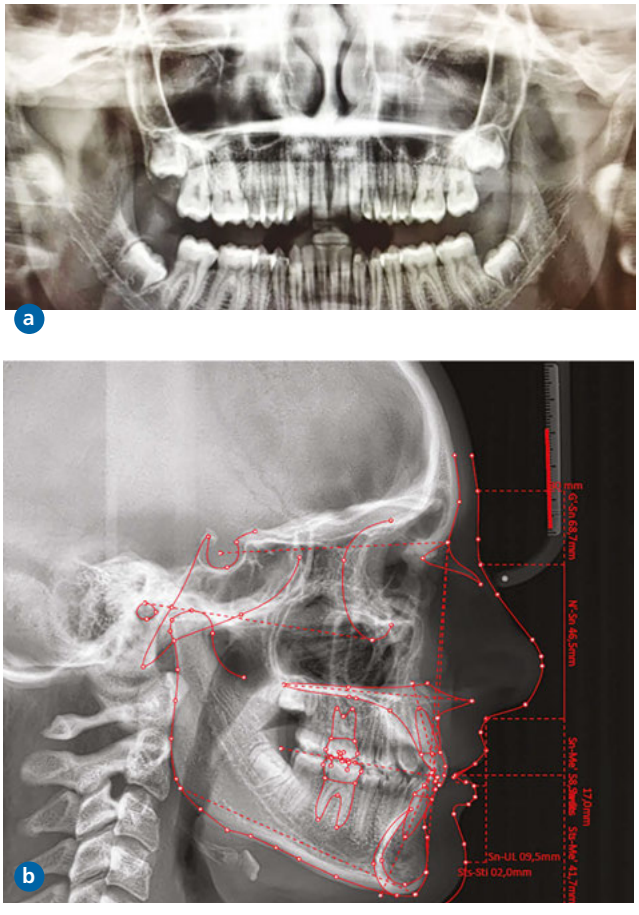

FIG. 12A-12B Post-treatment x-ray records.

Conclusions

Aligners are today an effective tool if used sensibly in both

young people and adults. Like all orthodontic appliances, they present some essential indications that, if ignored, risk making them ineffective and inefficient.

Today, patient demand is oriented towards increasingly esthetically acceptable, less invasive, and, no less importantly, short-term therapies. The reckless use of aligners that are produced without correct planning, en masse, and in a transversal manner will inevitably lead to the failure of this type of therapy. Therefore, adequate preparation and careful evaluation of the case by the orthodontist is necessary to successfully plan orthodontic treatment with aligners in growing patients who present malocclusions as significant as the one described in this case report.

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