Management of Pediatric Mandibular Condyle Fracture and Malocclusion Using a Function-Generating Bite Appliance: A Case Report

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Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

AEF 1 **Eillyn Claudeth Leiva Ramirez***
BEF 1,2 **Samuele Avolese***
D 1 **Alessandro Tortarolo**
F 3 **Teresa Vallelonga**
FG 4 **Ingrid Tonni**
F 5 **Ludovica Nucci**
BDEF 1 **Maria Grazia Piancino**

1 Department of Surgical Sciences, C.I.R. Dental School, University of Turin, Turin, Italy
2 Department of Mechanical and Aerospace Engineering, Polytechnic University of Turin, Turin, Italy
3 Orthodontic Private Practice, Koelliker Hospital and Nursing Home, Turin, Italy
4 Department of Medical-Surgical Specialties, Radiological Sciences and Public Health, University of Brescia, Brescia, Italy
5 Multidisciplinary Department of Medical, Surgical and Dental Specialties, School of Medicine and Surgery, University of Campania – Luigi Vanvitelli, Naples, Italy

* Eillyn Claudeth Leiva Ramirez and Samuele Avolese contributed equally to the study

Corresponding Author: Eillyn Claudeth Leiva Ramirez, e-mail: eclr65@gmail.com
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Conflict of interest: None declared

Patient: Male, 9-year-old
Final Diagnosis: Unilateral fracture of the mandibular condyle
Symptoms: Chewing difficulty • pain
Clinical Procedure: —
Specialty: Dentistry

Objective: Management of emergency care

Background: This report describes the case of a 9-year-old boy with unilateral fracture of the mandibular condyle and malocclusion managed using a function-generating bite (FGB) orthodontic appliance. The mandible is a frequent site of trauma in children, occurring in 12-56% of facial fractures. Condylar fractures are about 29-52% of mandibular fractures, with high-neck fractures represent 9-12%. Maxillofacial surgery during growth remains controversial, and treatment typically requires not only addressing the fracture but also any associated malocclusion. If a condylar fracture is inadequately managed, irreversible long-term consequences can occur.

Case Report: A 9-year-and-7-month-old male patient was referred to the University of Turin Dental School with a right high-neck condylar fracture following a bicycle fall. He presented with significant right lateral deviation during mouth opening and pain, primarily when opening the mouth and chewing hard foods. Concurrently, an anterior crossbite was observed. We followed a conservative treatment approach suitable for growing patients with condylar fractures and malocclusions to be treated concurrently. We used a custom-made appliance, the FGB, built in acrylic resin with resilient stainless steel occlusal bite planes. This device prevents intercuspal contacts, aligns the occlusal plane, and allows mandibular self-repositioning in all 3 spatial planes. The treatment with the FGB restored the anatomy of the condyle during growth, improved the opening, solved the lateral deviation and the pain during chewing and concurrently corrected the malocclusion.

Conclusions: Conservative functional therapy with an FGB appears to be an effective option for the treatment of condylar fractures concurrently with the correction of malocclusions.

Keywords: Jaw Fractures • Malocclusion • Mandibular Condyle • Mandibular Fractures • Case Reports

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Introduction

Facial fractures in children represent 1% to 15% of all facial injuries [1]. The mandible is a frequent site of trauma in children, occurring in 12-56% of facial fractures [1,2]. Condylar fractures represent about 29-52% of all mandibular fractures, with high-neck fractures accounting for 9-12% [3,4]. Trauma is the leading cause in both adults and children [5].

In growing children, maxillofacial treatment is generally nonsurgical, and malocclusion often requires simultaneous treatment. If a condylar fracture is improperly managed, it can lead to irreversible consequences. High mandibular condyle fractures are particularly serious, requiring precise diagnosis and management during growth. These fractures can cause significant injury to the temporomandibular joint, leading to growth disturbances, bony ankylosis, facial asymmetry, malocclusion, limited mouth opening, and jaw dysfunction [1,2,5,6].

The treatment of high condylar fractures remains a controversial topic. Surgical repositioning of the condyle is complex and the results are not consistent [4,5,7,8]. Usually, remodeling of the condylar process in children with fractures can be achieved with a functional appliance. Remodeling of the distal portion can lead to the formation of a normally shaped condyle, with significant involvement of the articular disc and capsule. A positive conservative outcome depends on several factors, such as the patient's growth until puberty, the presence of a fragment within the joint space with minimal dislocation, and intact dentition [9]. Moreover, correction of malocclusion is often concurrently required with the treatment of condylar fracture in children.

The function-generating bite (FGB) appliance is individually manufactured and made of acrylic resin and resilient stainless steel, with posterior metallic bite planes preventing the teeth from intercuspal contact. At the end of treatment, the buccal cusps of the upper teeth, which were previously in crossbite, overlapped the lower teeth, thus providing the appropriate physiological stimuli from peripheral receptors and proprioceptors [10,11]. The FGB is an orthognathodontic functional appliance able to correct, in a growing child, not only malocclusion [12,13], but also masticatory function [9]. It can also improve muscular balance [14] and temporomandibular function [15]. It is a gnathological appliance and for this reason it was used in a case of a child with high condylar fracture and malocclusion [16].

The aim of presenting this case is to show a conservative approach using an FGB which is able to give optimal results for the treatment of high condyle fracture and malocclusion. This report describes the case of a 9-year-old boy with unilateral right high-neck condylar fracture and malocclusion managed using a conservative functional therapy approach with an orthodontic appliance.

Case Report

A male patient aged 9 years and 7 months was referred to the Dental School at the University of Turin, with right high-neck condylar fracture resulting from a fall off a bike. No orthodontic appliance was used before the trauma.

The patient underwent an initial orthodontic evaluation with photographs, radiographs (orthopantomography; teleradiograph in latero-lateral view and in postero-anterior view), chewing pattern, cephalometries and digital study models, and a magnetic resonance imaging (MRI) scan for bilateral temporomandibular junction (TMJ) evaluation.

The patient showed a severe right lateral deviation during maximum opening, with pain, mainly when opening and eating hard foods. He was in mixed-phase dentition and occlusally he showed an anterior crossbite of 12/42, bilateral neutral angle molar class, crowding with a healthy periodontium but carious lesions on 4 teeth: 55, 54, 65, and 64 (**Figures 1, 2**) [6,7]. The orthopantomography showed a high fracture of the right condyle with displacement of the fractured portion (**Figure 3**). The MRI confirmed the right high fracture of the condyle with a displacement of the fractured portion (**Figure 4**). Latero-lateral teleradiography showed that the patient was classified as being in the early stages according to the cervical vertebral maturity index (CVMI). A Class II skeletal pattern was observed (ANB angle: 6°, Wits: 0 mm, SNA angle: 86°, SNB angle: 80°) with a normal occlusal plane and a normal vertical divergency (**Figures 5, 6 and Table 1**).

The patient's masticatory function was assessed by having him chew both soft and hard boluses before and after therapy, as described by Piancino et al [17,18]. The patient, comfortably seated and instructed to focus on a target 90 cm in front of him, was asked to avoid head movements. The tests were conducted in a quiet, comfortable environment. Each recording began from the maximal intercuspation position, which was determined by lightly tapping and clenching the opposing teeth while holding the test bolus on the tongue. The patient chewed a soft bolus (chewing gum) and a hard bolus (wine gum), using both the right and left sides of the mouth. Each test lasted 10 seconds and was repeated 3 times. The soft and hard boluses had identical dimensions (20 mm in length, 1.2 mm in height, and 0.5 mm in width) but differed in weight, with the soft bolus weighing 2 g and the hard bolus 3 g. A kinesiograph (K7, Myotronics Inc.) recorded mandibular movements with an accuracy of 0.1 mm, using a lightweight array of Hall effect sensors and a magnet placed on the lower incisors. The

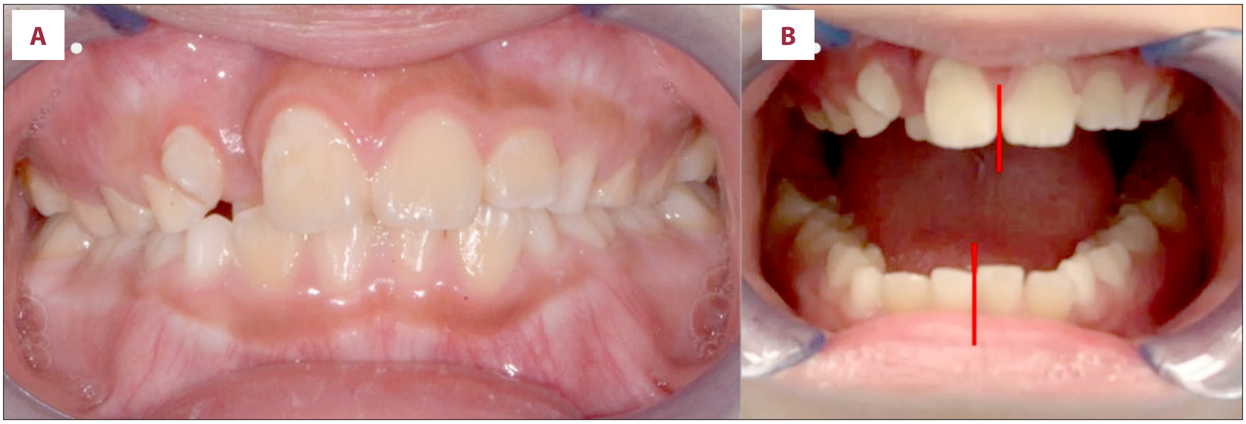

Figure 1. Pre-treatment oral examination: (**A**) anterior crossbite malocclusion, and (**B**) severe right lateral deviation during mouth opening.

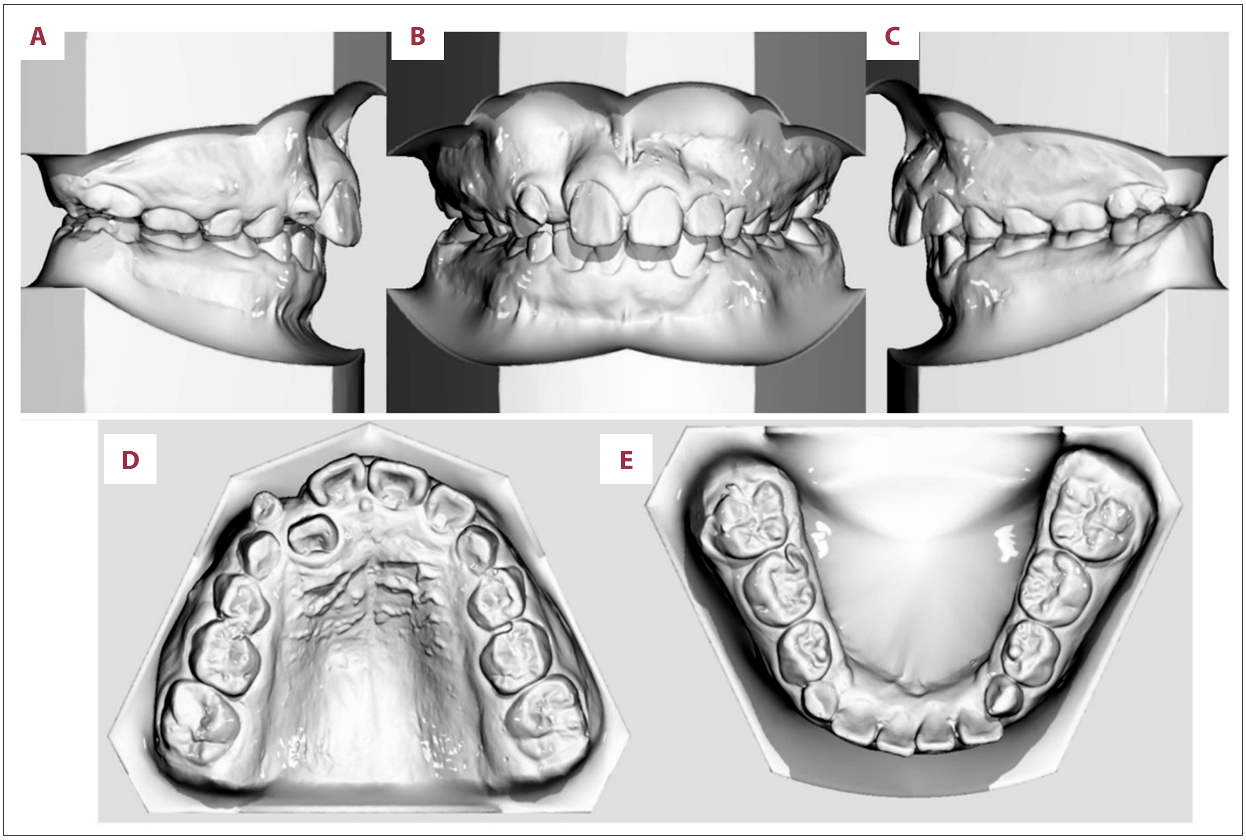

Figure 2. Pre-treatment virtual casts/e-models: (**A**) right lateral occlusion, (**B**) frontal view of both arches in occlusion, (**C**) left lateral occlusion, (**D**) maxillary arch, and (**E**) mandibular arch.

data were stored on a computer and analyzed using custom software developed at the University of Turin's Department of Orthodontics and Gnathology. The first chewing cycle, when the bolus was transferred from the tongue to the dental arches, was excluded from the analysis. The chewing cycles were categorized as non-reverse or reverse based on the vector direction of closure [19].

Before therapy, the recording of the chewing patterns with hard and soft boluses showed a severe asymmetry with lateral displacement on the right side only, even during chewing on the left side.

The patient was treated at the Dental School of the University of Turin using a custom-made functional appliance, the FGB [12]. This device was made from acrylic resin and durable stainless

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Figure 3. Pre-treatment orthopantomography showing the high fracture of the right condyle with displacement of the fractured portion.

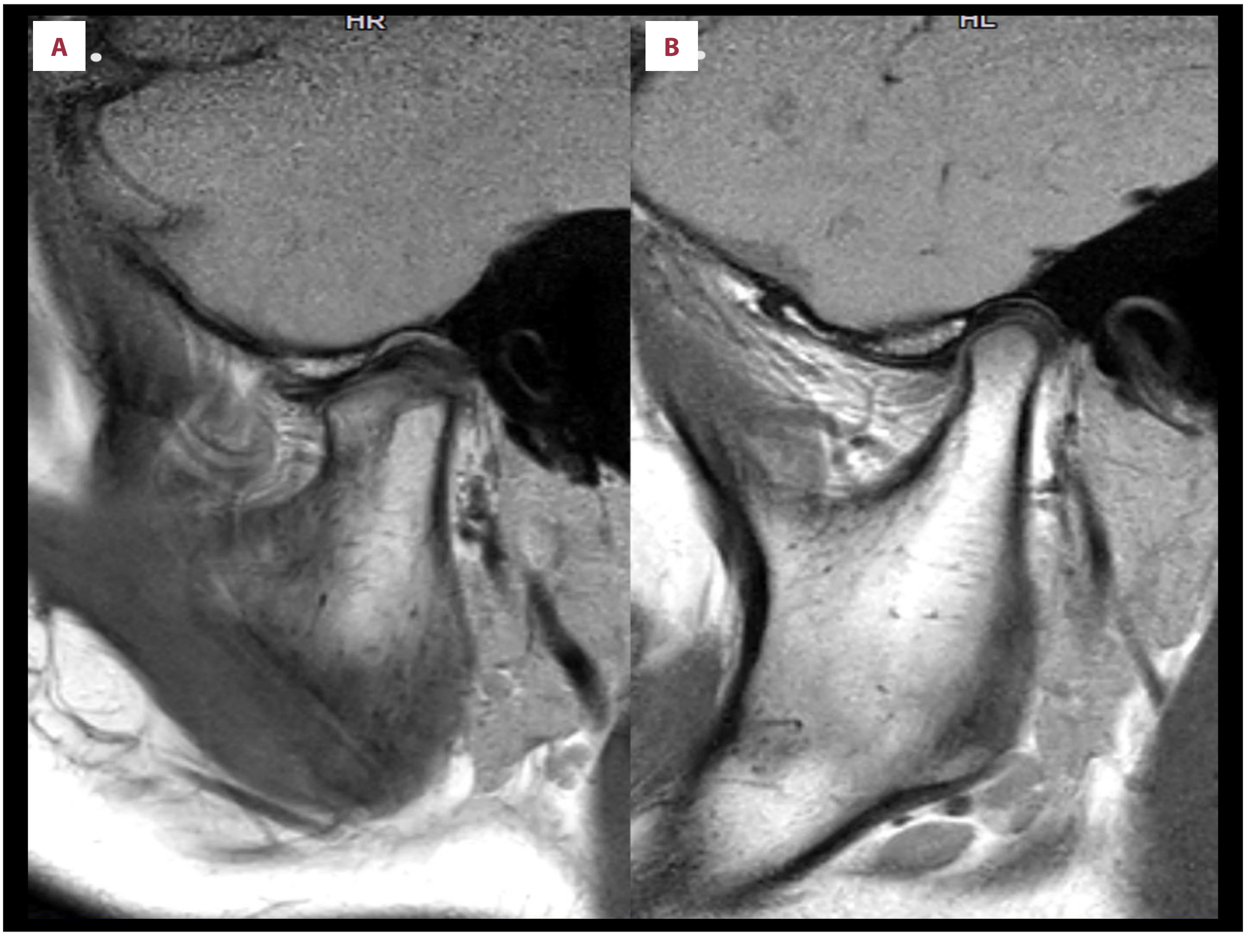

Figure 4. Magnetic resonance imaging (MRI): (**A**) right high-neck condylar fracture, and (**B**) normal left condyle.

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Figure 5. Pre-treatment lateral X-ray.

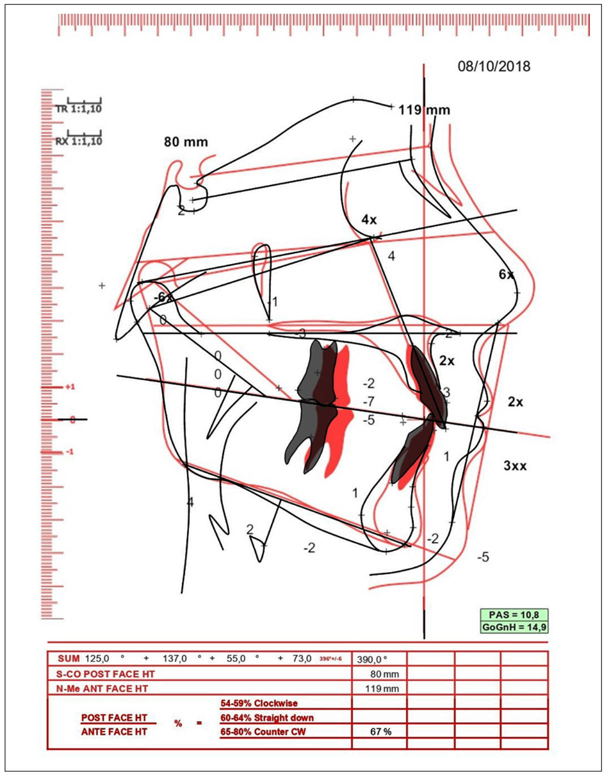

Figure 6. Cephalometry.

Table 1. Cephalometric analysis: the patient's pre-treatment cephalometric (cranial structure) data.

	Norm	Pre-treatment data	Difference from the norm
SpP^GoGn	20°±5°	20°	0
SpP^F	5°±3°	11°	+6°
SpP^Oc	8°±3°	8°	0
A: Po	2±3 mm	6 mm	+4 mm
SNA	82°±2°	86°	+4°
SNB	80°±2°	80°	0
ANB	2°±2°	6°	+4°
Wits	-1±2 mm	0 mm	+1 mm

Measurement was performed by a skilled operator with more than 10 years' experience in the field, who was blinded to the purpose of the study. Cephalograms were traced and values measured using custom-made software. SpP^GoGn – angle between the superior maxilla (SpP) and the body of the mandible (GoGn) to evaluate maxillary divergency, according to Schudy [25]. SpP^F – angle between superior maxilla (SpP) and condyle-or- bital plane (CoOr) [26]. SpP^Oc – angle between superior maxilla (SpP) and occlusal functional plane (Oc), measured to evaluate the orientation of the occlusal plane [26]. SNA – sagittal cranial relationship of the maxilla (the relationship in the sagittal plane of the upper maxilla with respect to the cranial base as reference), according to Steiner [27]. SNB – sagittal cranial relationship of the mandible (the relationship in the sagittal plane of the mandible with respect to the cranial base as reference), according to Steiner [27]. ANB – sagittal cranial relationship (the relationship in the sagittal plane between the upper maxilla and the mandible with respect to the cranial base as reference), according to Steiner [27]. A: Po – sagittal maxillary relationship (the relationship in the sagittal plane between the upper maxilla and the mandible, using the upper maxilla as reference bone), according to Schudy [25]. Wits – Wits appraisal.

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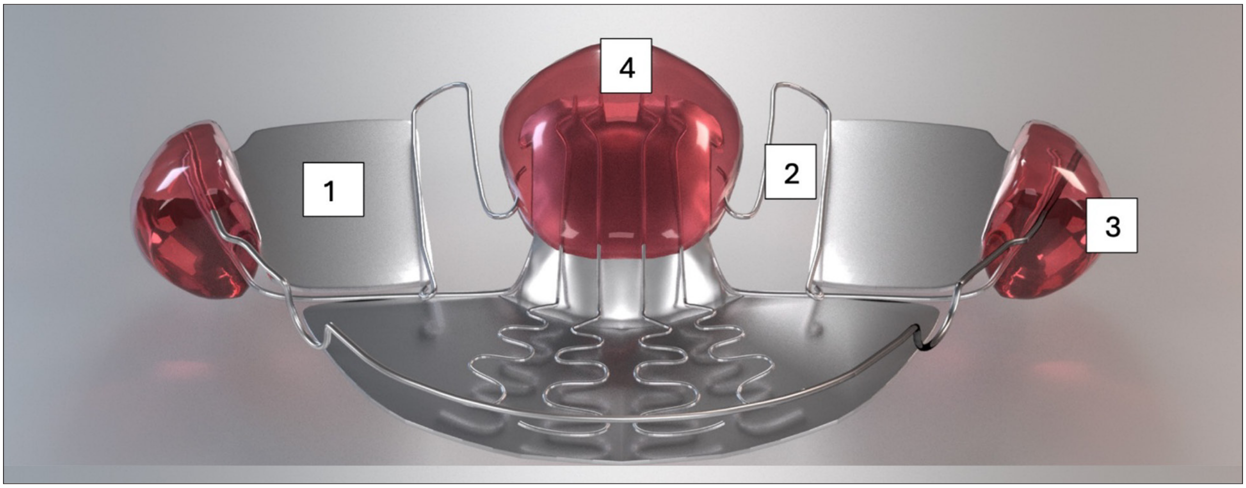

Figure 7. FGB appliance: 1) stainless steel resilient bite planes, 2) expansion springs, 3) buccal shields, and 4) palatal plate. FGB – function-generating bite.

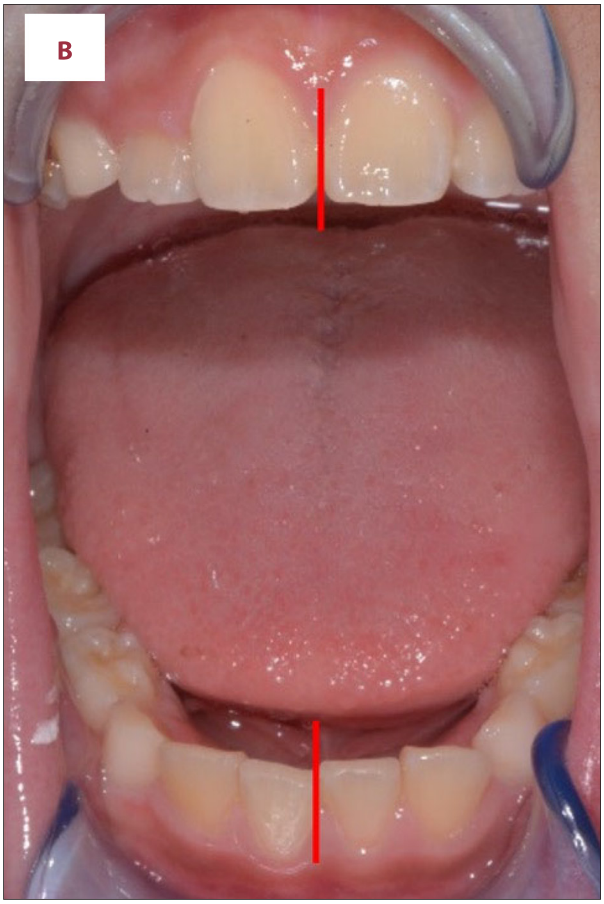

Figure 8. Comparison between the beginning images before the treatment and after 6 months. (**A**) Limitation of mouth opening and severe right lateral deviation during opening. (**B**) At 6 months after treatment, the midline is centered during mouth opening and there is clear improvement of the maximal opening.

steel, with metallic occlusal bite planes designed to prevent intercuspal contact, align the occlusal plane, and allow the mandible to naturally reposition in all 3 spatial planes. The expansion springs were placed 2 mm below the equator of the posterior maxillary teeth at rest, making contact during swallowing to utilize the force generated by the activated masseter muscles. During the active treatment phase, the patient was advised to wear the appliance for as long as possible throughout the day and night, removing it only during meals (**Figure 7**). The patient demonstrated excellent compliance with the treatment.

The orthodontic forces generated by the FGB are intermittent and self-regulating, as they result from the patient's own neuromuscular activity during swallowing. So, the device being custom-made is proper for the growing child. The fact that FGB allows the spontaneous repositioning of the mandible in a centric position with intermittent and self-regulating forces, is a very important aspect of this treatment method in cases of high fracture of the condyle. Especially, the self-repositioning of the mandible and condyle is important to allow the

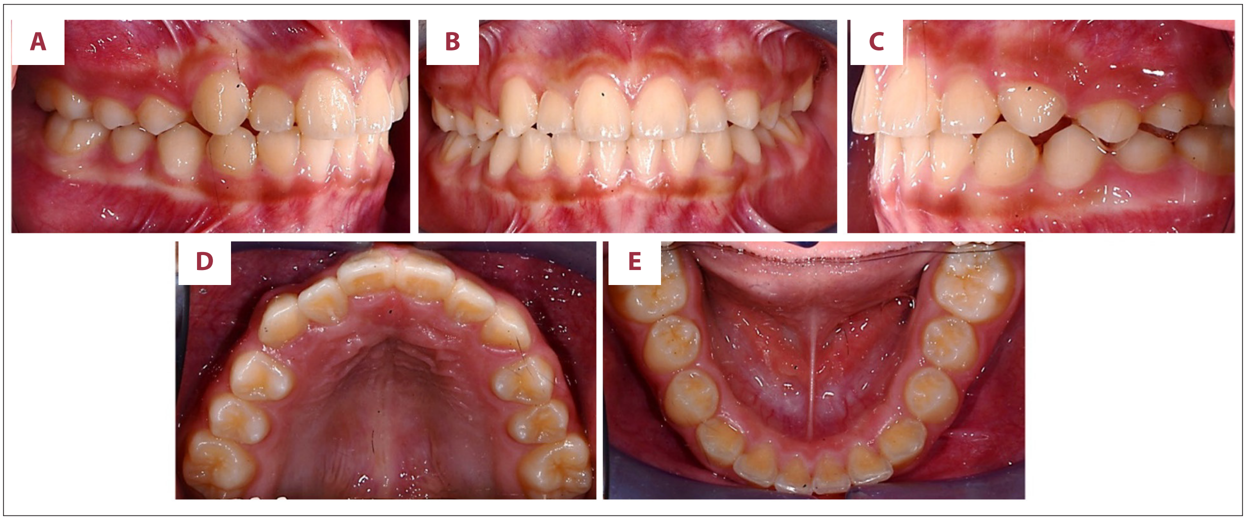

Figure 9. Post-treatment images showing correction of the anterior crossbite: (**A**) right lateral occlusion, (**B**) frontal view of both arches in occlusion, (**C**) left lateral occlusion, (**D**) maxillary arch, and (**E**) mandibular arch. The alignment of the lateral incisor could have been further improved using the FGB, but the patient moved from Italy to another country. FGB – function-generating bite.

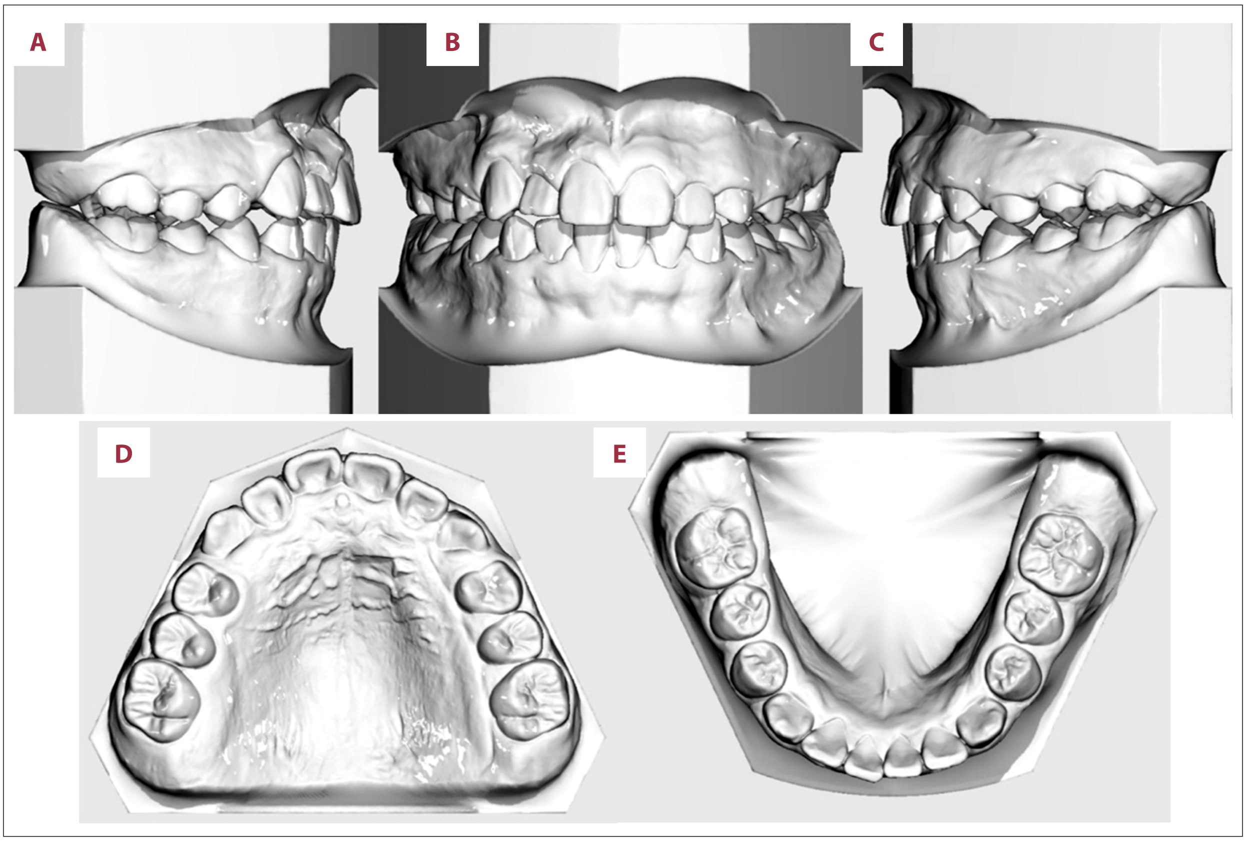

Figure 10. Post-treatment virtual casts/e-models showing correction of the anterior crossbite: (**A**) right lateral occlusion, (**B**) frontal view of both arches in occlusion, (**C**) left lateral occlusion, (**D**) maxillary arch, and (**E**) mandibular arch.

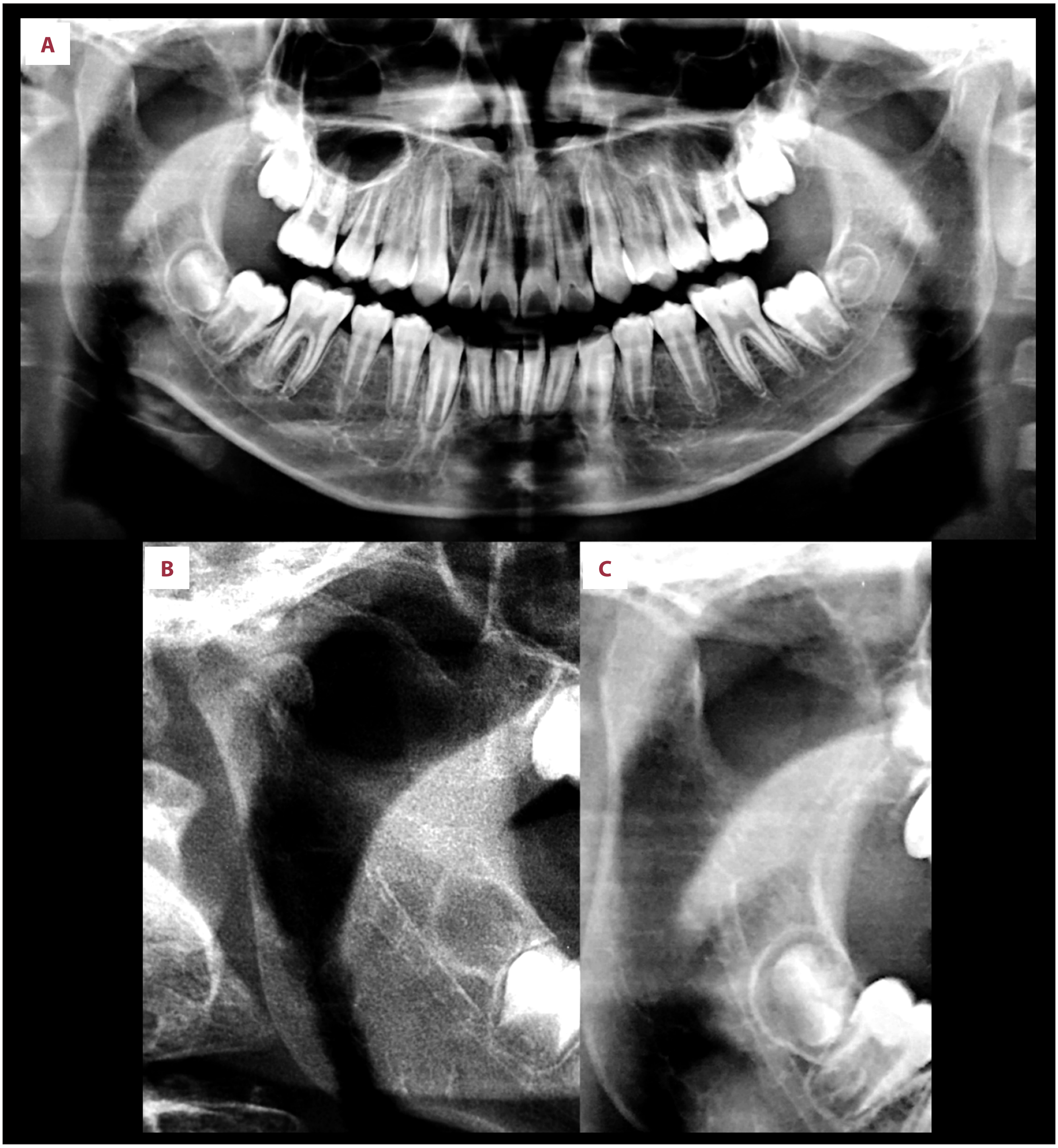

Figure 11. (**A**) Post-treatment orthopantomography showing recovery of the right high condylar fracture. (**B**) Pre-treatment condyle. (**C**) Post-treatment condyle.

restoration of function of the temporomandibular joint in a balanced position of the mandible. Due to the fact that the appliance does not have any dental anchorage, it is able to adapt to the therapeutic changes occurring in a developing individual.

Moreover, the patient presented with an anterior crossbite which needed to be corrected during the treatment of the condylar fracture. For this purpose, an anterior spring was added and activated to solve the anterior crossbite. Treatment for children's condylar fractures is often necessary at the same time as orthodontic therapy is needed. Since both therapies aim at bone remodeling and functional adaptation of the TMJ, they should be performed simultaneously [9].

In our case, functional therapy resulted in the recovery of the symptomatology without pain and in the correction of the right

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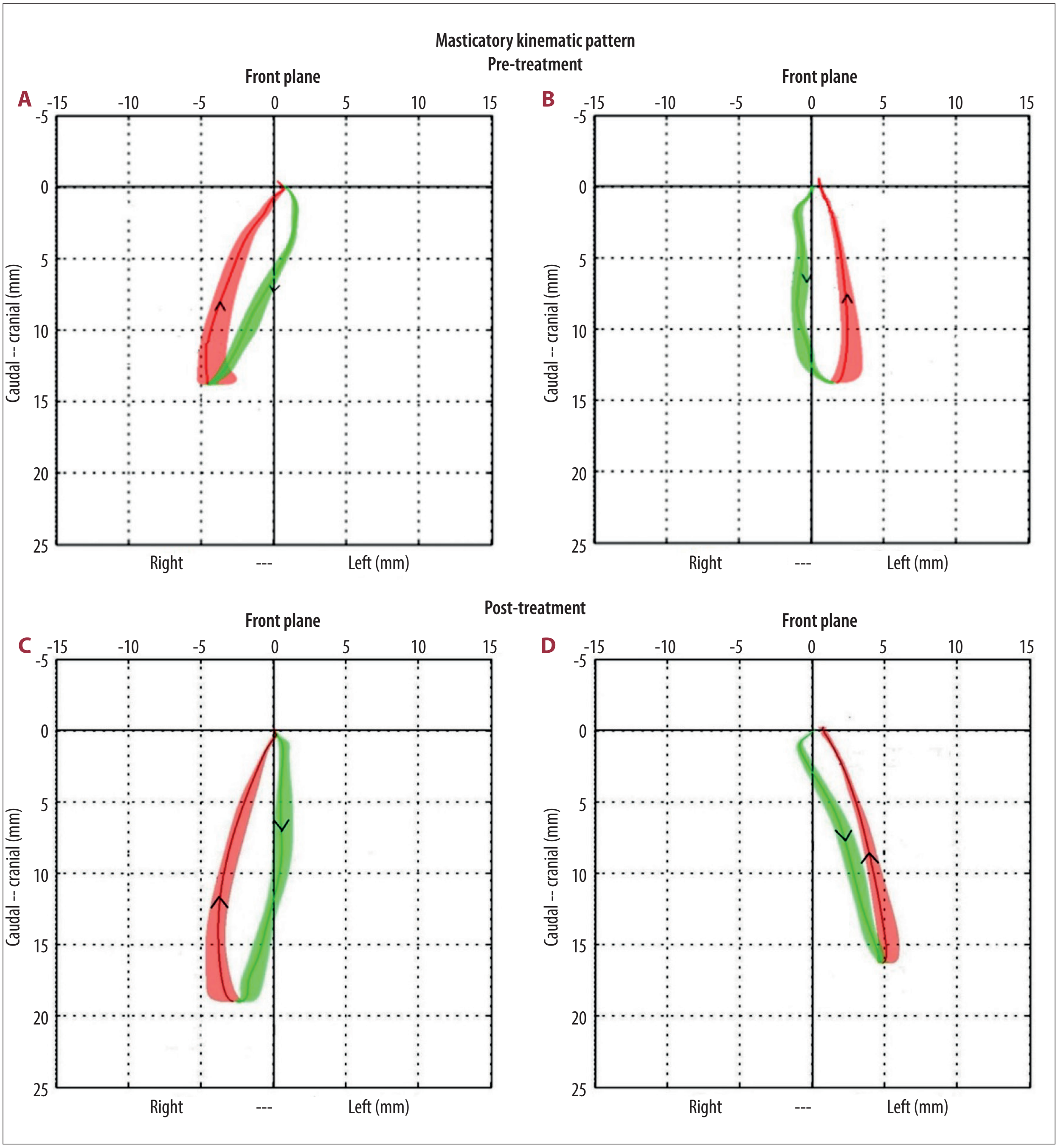

Figure 12. Masticatory kinematic patterns in the frontal plane before (**up**) and after (**down**) treatment of the patient during chewing a hard bolus. The solid green line shows the opening and the solid red line shows the closing pattern. They represent the average chewing cycle of 3 trials lasting 10 s each; the green and red areas represent the standard deviation over the average cycle. (**A**) Deliberate chewing on the right side, (**B**) deliberate chewing on the left side. During chewing on the left side, the mandible is not able to move on the left side. Deliberate chewing after therapy on the right (**C**) and left (**D**) sides shows that the displacement on the left side improved.

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lateral deviation of the mandible during opening, which was centered in maxima intercuspation and opening. Concurrently, the anterior crossbite was corrected and the midline aligned (**Figures 8-10**).

The total duration of the active therapy was 8 months. The retention period, during which the appliance was used at home and during the night only, was important to stabilize the occlusion and the recovery of the fracture. From the joint point of view, the orthopantomography after 18 months of therapy showed reconstruction of the condyle and demonstrated that a remodeling occurred following the functional therapy. Realignment of the displaced condyle segment did not occur and the fragment was reabsorbed (**Figure 11**).

For this treatment's success, it is clinically important to address both the repositioning of the teeth within the arches and the impact of therapy on oral function. After therapy, recovery of the left lateral displacement was observed, with good functional symmetry (**Figure 12**).

Discussion

This case allows us to understand how a conservative functional approach can positively stimulate the healing process of a high condylar fracture, eliminating pain during chewing and deviation of mandibular opening, and also correct crossbite malocclusion with the same appliance, the FGB, at the same time.

A 9-year-and-7-month-old male patient was referred to the Dental School at the University of Turin. He presented with a right high-neck condylar fracture resulting from a bicycle fall, showing significant right lateral deviation during mouth opening, with pain primarily when opening the mouth and chewing hard foods. Concurrently, the patient showed an anterior crossbite between the right upper lateral incisor and the lower right lateral incisor which displaced the lower mandible (**Figure 1**). The present case report describes a conservative treatment approach, for growing patients, to concurrently treat condylar fractures and malocclusions. The patient was treated with a functional appliance, the FGB. The results showed that the fractured condyle was restored, the pain and the right-side deviation during opening disappeared, and the anterior crossbite was corrected, all with the same appliance, the FGB (**Figures 9-11**).

The final radiograph, taken after functional treatment with the FGB, demonstrated the remodeling of the condyle, which was hypothesized to be possible thanks to the growth potential. No realignment of the dislocated condylar segment was observed, but instead, resorption occurred (**Figure 11**). Treatment of high condylar fracture in children often requires the concurrent correction of malocclusion. The FGB treatment aims to promote bone remodeling, functional recovery of the temporo-mandibular joint, and correction of the malocclusion. For these reasons, all of these issues were addressed simultaneously (**Figures 9, 11**).

Looking at the literature, it is observed that remodeling of the condylar process occurs more frequently following early functional treatments than after immobilization. Remodeling rates can vary depending on the treatment method [20]. A positive outcome with conservative treatment depends on several factors, such as the patient's growth until puberty, the presence of a fragment confined within the joint space with minimal dislocation, and intact dentition [4,7]. Although the conservative approach has the disadvantages of prolonged treatment duration and reliance on patient compliance, the 1- to 2-year treatment period is necessary to obtain the stability of the correction, both condylar and occlusal. Therefore, combining functional fracture therapy with malocclusion treatment is convenient. This approach also makes sense from a biological standpoint, as bone fractures trigger a significant muscular reaction and increase in bone formation [21,22]. Osteogenesis is greatly enhanced following bone fractures, in addition to the remodeling of the condyle, and for this reason it requires a balanced occlusion to obtain a symmetrical restoration of the TMJ.

Given these factors, the treatment of high condylar fractures remains a controversial topic. The options available for managing this condition include maxillo-mandibular fixation, surgical repositioning, and conservative functional therapy with a functional appliance [1,7]. However, there is insufficient evidence to suggest that the surgical approach reduces the risk of adverse effects and long-term sequelae, and it entails a risk of additional pathologies, such as necrosis of the condylar head and abnormal growth due to constrictive scar tissue. Surgical repositioning of the condyle is more complex and has not demonstrated superior results [4,7]. Some longitudinal retrospective studies have shown surgical adverse effects, such as morphological asymmetries between the fractured and healthy condyle, become more likely with increasing age [23]. Given that the pediatric condyle is a major growth center of the mandible, conservative treatment with a functional orthodontic appliance is generally recommended for children.

In contrast to the conservative functional approach used in the present case, Kawai et al [8] reported the management of a high-neck condylar fracture in an adult patient using a custom-made titanium mesh combined with a miniplate fixation, achieving anatomical stabilization through open reduction and internal fixation. This highlights the differences in treatment plan between growing patients, in whom functional remodeling is possible, and adults, in whom rigid fixation is often required.

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Notably, in a similar case involving a 10-year-old patient with a 2.5-year follow-up, the malocclusion was not corrected concurrently using the same appliance. Nevertheless, therapy with non-rigid mandibular splint alone was sufficient to promote condylar remodeling and functional adaptation to the glenoid fossa [24].

Moreover in pediatric cases with malocclusion, simultaneous gnathological and orthodontic therapy is necessary. An FGB is an orthognathic appliance that is able to move the teeth together with gnathological effects. The resilient stainless steel bite planes allow for self-repositioning of the mandible in the 3 planes of the space and lets the condyle position into a centric position, promoting its functional balance. Additionally, optional springs can be activated to move the teeth and correct the malocclusions. The orthodontic movement is released simultaneously with the self-repositioning of the mandible and the condyles in the spontaneous balance position. This functional appliance is a useful tool in orthognathic treatment (**Figure 7**) [9].

In the present case, the fractured condyle was restored, the pain and the right-side deviation during opening disappeared, and the anterior crossbite was corrected, all with the same appliance, the FGB (**Figures 9-11**).

Conclusions

High fractures of the mandibular condyle are complex conditions that require a targeted and personalized therapeutic approach. Conservative functional therapy with an FGB appears to be an effective option for the treatment of condylar fractures concurrently with correction of malocclusions.

Department and Institution Where Work Was Done

The patient was treated in the Orthodontic Department of C.I.R. Dental School University of Turin, Turin, Italy.

Patient Consent

Informed consent for the processing of personal data for research and scientific publication purposes has been provided by the patient's parents in written form.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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