fortune Journals

Case Report

JOURNAL OF SURGERY AND RESEARCH

ISSN: 2640-1002

A 3D-Printed Extra-Oral Appliance for Orthodontic Traction of a Palatally Impacted Canine

Gianluigi Fiorillo[1], Lorenzo Garrisi[1*], Alice Mandelli[2], Fabio Arnò[3], Rosalia Leonardi[4], Gualtiero Mandelli[1], Giorgio Gastaldi[1]

Abstract

Background: The present case report shows the production and effective clinical use of a 3D-printed facemask tailored to the patient's anatomical characteristics for the orthodontic traction of a palatally impacted canine.

Methods: A 31-year-old female patient with an impacted upper right canine was treated using Invisalign in association with two palatal miniscrews and a customized facemask. The facemask was designed on the basis of a 3D CBCT and a face scan and it was produced with additive manufacturing techniques. 3D modeling of facemask components was performed using 3Shape Appliance Designer and 3D printed in biocompatible resin. The treatment plan involved the patient wearing Invisalign 22 h per day and the facemask 12 h per day. Combining Invisalign, skeletal anchorage and customized facemask, we were able to solve the case preventing unwanted movements caused by the use of any dental anchorage.

Keywords: Impacted canine; Cad-Cam; Facemask

Introduction

Maxillary canines are the most frequently impacted teeth, second only to maxillary third molars. Literature reports that canine impaction prevalence ranges from 0.92% to 1.7% [1] and that it occurs more frequently in girls than in males, and it is often unilateral. Canine impaction is 2-3 times more common in the palatal than in the buccal area [1-3]. The etiology of canine impaction is complex, involving both genetic and environmental variables, such as the presence of a pathological lesion or barrier that blocks the canine's path of eruption [4-5].

A variety of techniques, including surgical repositioning, extraction of the tooth and replacement with a dental implant, and the surgical-orthodontic approach, have been proposed as treatments for tooth impaction [6-8].

Several orthodontic methods, such as specific appliances and surgical techniques, have been suggested to guide an impacted canine into the arch. To encourage forced eruption in the crestal bone, most procedures include a variety of auxiliaries in addition to fixed appliances. In recent years there has been an increase in demand for orthodontic treatment using removable aesthetic appliances like aligners, particularly among adults. Orthognathic abnormalities and increasingly complex malocclusions can now be treated thanks to advancements in aligner technology [9]. Beyond the obvious benefits of improved hygiene and aesthetics, treating impacted canines with aligners is difficult and requires the use of auxiliary devices to provide proper traction force direction and sound, safe attachment.

Affiliation:

[1]Department of Dentistry, IRCCS San Raffaele Hospital, Dental School, Vita-Salute San Raffaele University, 20132 Milan, Italy

[2]Orthodontics, Dental School, Department of Medical and Surgical Specialities, Radiological Sciences and Public Health, University of Brescia, Italy

[3]Tecnort, Tricase, Italy

[4]Department of Medical-Surgical Specialties, School of Dentistry, University of Catania, Via Santa Sofia 78, 95123 Catania, Italy

***Corresponding author:**
Lorenzo Garrisi, Department of Dentistry, IRCCS San Raffaele Hospital, Dental School, Vita-Salute San Raffaele University, 20132 Milan, Italy

Citation: Gianluigi Fiorillo, Lorenzo Garrisi, Alice Mandelli, Fabio Arnò, Rosalia Leonardi, Gualtiero Mandelli, Giorgio Gastaldi. A 3D-Printed Extra-Oral Appliance for Orthodontic Traction of a Palatally Impacted Canine. Journal of Surgery and Research. 7 (2024): 178-183.

Received: April 01, 2024
Accepted: April 10, 2024
Published: May 06, 2024

Fiorillo G, et al., J Surg Res 2024
DOI:10.26502/jsr.10020357

In order to overcome these limitations and to apply an ideal biomechanical approach, TADs (temporary anchorage devices) and a customized facemask can be combined with aligners following a hybrid consecutive approach.

By matching facial scan (STL file) and dental scan (STL files) with a CBCT of the skull (DICOM file), it is possible to design an orthodontic facial mask and define the traction force direction reducing negative dental effects.

The present case report describes a versatile digital workflow applied to generate a customized facemask from facial scan as extra-dental anchorage for the treatment of an impacted canine.

Materials and Methods

Diagnosis

A 31-year-old female patient came for an orthodontic consultation to a private practice. From the frontal view, the patient showed a facial symmetry, a significant facial increment of the lower third, and no gingival exposure while smiling (Figure 1 A,B). From the lateral view, the facial profile was good with normal naso-labial angle and lip competence (Figure 1C).

Intra-oral examination revealed the presence of the upper right deciduous canine, a mild molar and canine Class II relationship on the left side with moderate upper and lower crowding (Figure 2A-E).

Figure 1: Pre-treatment extra-oral examination: (**A**) Frontal view, (**B**) frontal view of the smile, (**C**) lateral view.

Figure 2: Pre-treatment intra-oral examination. (**A**–**C**) Point of view (POV) of occlusion, (**D**) upper arch, (**E**) lower arch.

In order to to confirm the diagnostic hypothesis of maxillary canine impaction a panoramic X-ray (figure 3) is performed. Figure 3. shows an overlap between lateral incisors and canines. From Lindauer's analysis, the impaction is evaluated as belonging to sector IV, with an alpha angle of 38° and a beta angle of 41° which favor a prescription for a second-level diagnostic investigation (CBCT 3D).

CBCT is strongly recommended to assess the proximity and adjacency with the anatomical and dental structures around to the impacted tooth, as it provides detailed images of the position, inclination, and angle of these teeth. In the specific case, the crown of the upper right canine (UR 3) was positioned in strict adjacency with the root of the upper right lateral and central incisors (UR 1 and UR 2) without visible resorption of the latter (figure 4).

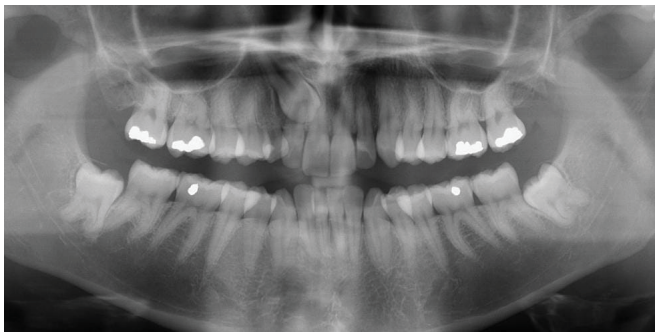

Figure 3: Panoramic radiograph.

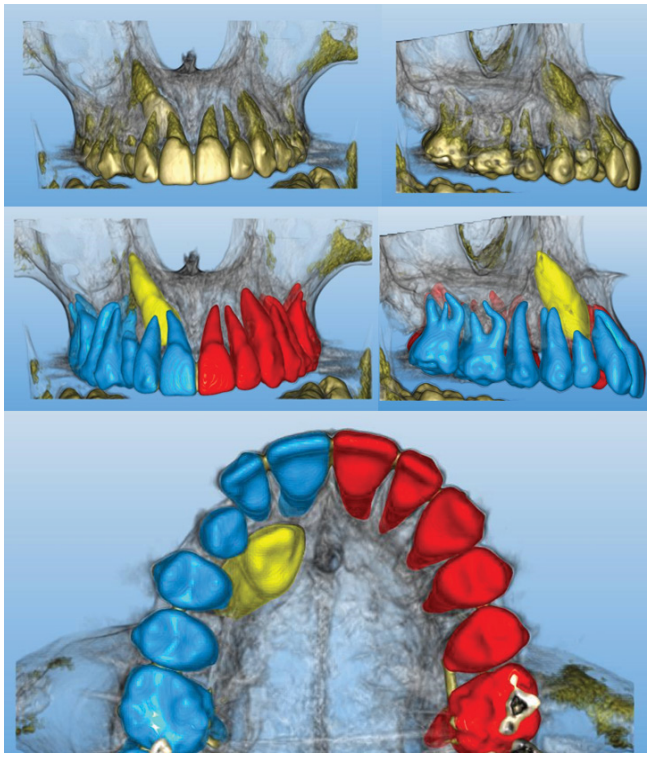

Figure 4: Cbct

Citation: Gianluigi Fiorillo, Lorenzo Garrisi, Alice Mandelli, Fabio Arnò, Rosalia Leonardi, Gualtiero Mandelli, Giorgio Gastaldi. A 3D-Printed Extra-Oral Appliance for Orthodontic Traction of a Palatally Impacted Canine. Journal of Surgery and Research. 7 (2024): 178-183.

Fiorillo G, et al., J Surg Res 2024
DOI:10.26502/jsr.10020357

Treatment Plan

The treatment plan involved the use of aligners, a TADs supported palatal device and a customized facemask with the aim of improving the anchorage for the orthodontic traction of the impacted upper right canine. A detailed description of the treatment phases with particular emphasis on the workflow used to generate the customized facemask is presented below.

Phase 1: a set of 14 Invisalign aligners to increase the space for the upper right canine position (Figure 5)

Phase 2: first Invisalign refinement with 14 Invisalign aligners; after aligner 5, we performed a guided insertion of two palatal TADs (Figure 6). The choice of the miniscrews placement site was based on a careful evaluation of bone tissue thickness and quality, assessed through CBCT analysis, and the biomechanical efficiency of the selected site as an anchorage platform.

Then we located the cusp of the impacted tooth and surgically exposed it. At the same time, an orthodontic button was placed. The ligation of the bonded button on the palatal surface of the upper right canine (UR 3) was then immediately engaged in a spring mechanism using a 0.017x0.025 molybdenum titanium alloy cantilever inserted in the palatal appliance anchored to the miniscrews (figure 7). At the same time, we extracted 53.

To guide the canine to the desired position, the traction was conducted in two steps, each in its own direction. In the first step the impacted canine was moved away from the root of the lateral incisor and put in an ideal position to come down into the arch directly. This is usually possible for palatal canine impactions by applying a movement with a vertical and slightly distal vector. After 7 weeks post-surgery, the canine erupted and became visible in the oral cavity. The tooth could then be buccally transitioned with a translatory movement.

Phase 3: After the canine fully erupted in the oral cavity, a new scan was performed in order to plan a second Invisalign refinement with 11 aligners; at this stage we added the use of a customized facemask in order to change the force vector of the traction force.

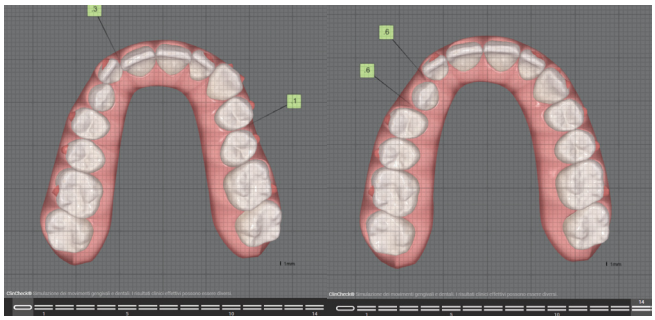

Figure 5: Clincheck of the first phase: (A) initial position, (B) final position.

Figure 6: Guided insertion of the two palatal miniscrews

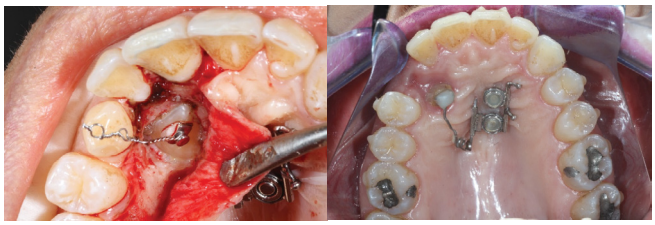

Figure 7: (A) canine exposure and bonding of the button, (B) TMA cantilever applied

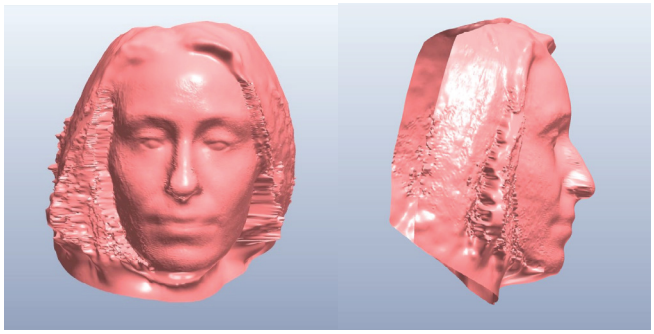

Figure 8: Facial scan: (A) frontal view, (B) lateral view

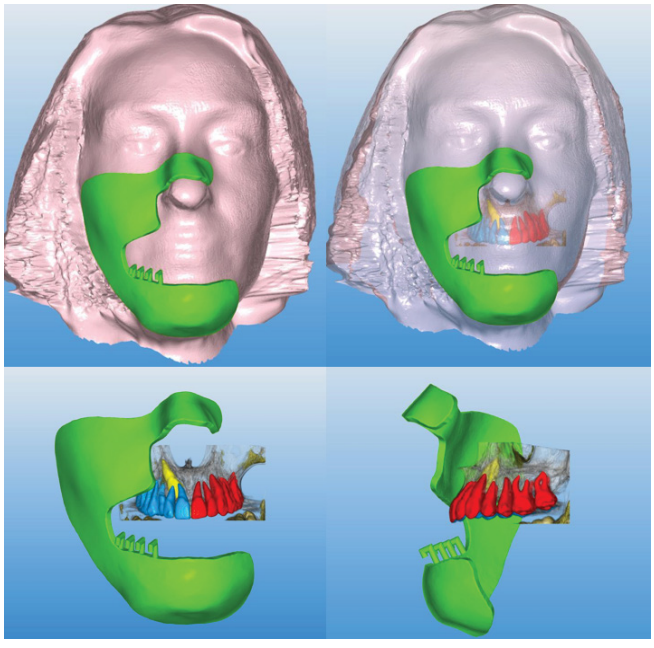

Figure 9: Customized face mask design

Fiorillo G, et al., J Surg Res 2024
DOI:10.26502/jsr.10020357

Figure 10: Customized face mask delivery

Figure 11: Daytime elastics: (A) occlusal view, (B) lateral view

Customized facemask

The facemask used in this clinical case for 1.3 traction is a particular type of Diprom, which is an extraoral protraction facemask made from the patient's facial scan, modeled in computer graphics and prototyped in biocompatible resins [10]. The facemask described below was produced in order to apply the necessary force and obtain a controlled movement of the palatal canine in the buccal-lingual direction.

Design and production

1) The clinician creates a model of the patient's face acquired by a 3D scanning camera or 3D scanner app (Figure 8) [11].

2) The technician matches the STL file of the facial scan with the initial CBCT (DICOM file). Then he graphically develops the mask using the Aplliance Designer 3Shape software. He creates a shell mask with a pre-set 4 mm thickness (this value can be modified according to specific requests by the clinician). Then he designs the pins for elastic traction(Figure 9).

3) The mask is then prototyped by stereolitography (SLA) using biocompatible resins (Dental SG Resin Formlabs) with a Form 3B printer, optimized for biocompatible materials. This kind of resin is autoclavable and biocompatible class 1 meeting the main quality standards (EN ISO 10993-5: 2009/ISO10993-10:2010/(R)2014)

   The inner part of the mask is covered with a soft, antibacterical and washable lining, certified to be in contact with the skin.

4) The mask is then customized with a graphic pattern chosen by the patient, which will cover the outer surface (Figure 10).

The patient is instructed to wear elastics with the force vector towards the aligner during daytime and towards the facemask during night time (Figure 11-12).

- Phase 4: At the end of previous phase, which lasted approximately 12 weeks, the canine had a normal orientation and was ready to be translated into the arch using the elastics. A third Invisalign refinement was performed in order to improve the upper right canine position (Figure 13).

Results

The post-treatment records showed that the treatment goals were achieved.

Improvement in mini-aesthetics was evident in the restoration of arch integrity resulting from the disimpaction of the canine. The smile arc was consonant and symmetrical (Figure 14).

The intra-oral examination showed the eruption and repositioning of the upper right canine and the correction of molar and canine Class II relationships on the left side with a good aligning and leveling of the arches. (Figure 15 A-E).

Post-treatment ortopantomography confirmed the bodily movement of the teeth, with good root parallelism (Figure 16).

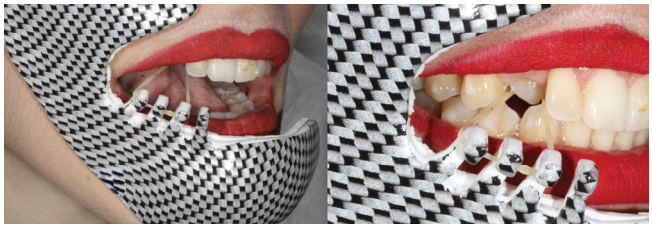

Figure 12: Nightime elastics

Figure 13: Finishing elastics: (A) frontal view, (B) lateral view

Fiorillo G, et al., J Surg Res 2024
DOI:10.26502/jsr.10020357

Figure 14: Post-treatment extra-oral examination. (**A**) Frontal view, (**B**) smiling frontal view, (**C**) lateral view.

Figure 15: Post-treatment intra-oral examination. (**A**–**C**) Point of view (POV) of occlusion, (**D**) upper arch, (**E**) lower arch.

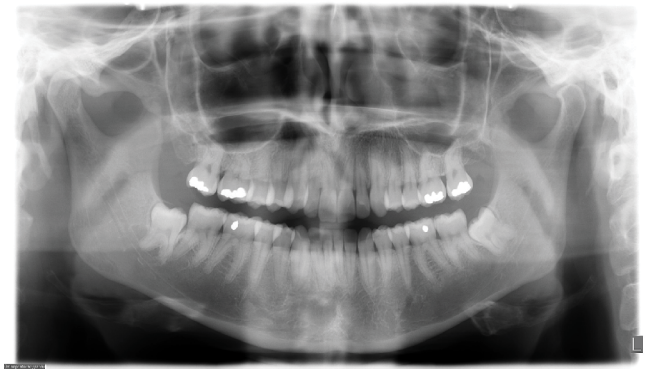

Figure 16: Post-treatment Ortopantomography

Discussion

One of the greatest challenges of orthodontic treatment is the traction of palatally impacted canines. There are many variables which can influence the outcome including apex position, angulation, vertical height, and incisor overlap. The conventional treatment approach uses the surgical "open exposure" or "closed exposure" method. Intraoperatively, an orthodontic button is bonded to attach a chain which is then connected to the archwire of the fixed appliance.

In the last few years, there has been a growing demand for orthodontic treatment with removable aesthetic appliances like aligners, particularly for adult patients. The treatment of impacted canines with aligner techniques has clear advantages such as aesthetics and easier hygiene, but it represents a challenge and requires auxiliary devices in order to obtain stable and safe anchorage.

In order to overcome the limitations related to the biomechanics of aligners, it is possible to set up an orthodontic treatment plan suitable for the recovery of an impacted canine, combining Invisalign aligners with temporary anchorage devices and a completely digitally customized face mask with the function of applying, by means of an elastic, a force vector capable of pulling the canine into the correct position in the arch, without dental anchorage. In this way the unwanted movements are prevented.

Matching the STL file of the patient's facial scan via an application downloaded onto an electronic device with the DICOM file of the pre-treatment CBCT makes it possible to design a totally digitally designed and customized face mask, which is then produced with 3D printers.

Conclusion

The combination of aligners, miniscrews and customized facemask allowed us to solve the case avoiding dental anchorage and using favorable force vectors.

The canine was moved immediately after disimpaction from the palatal site thanks to miniscrews and a TMA cantilever without anchorage on the posterior teeth.

The tooth was buccally translated thanks to elastics attached to the pin of the customized face mask which was designed matching face scan and CBCT, in order to define the most favourable force vector.

Finally, this aesthetic approach is better accepted and complied with by patients who are consistently supported throughout all the treatment phases.

References

1. Cooke J, Wang HL. Canine impactions: incidence and management. Int J Periodontics Restorative Dent 26 (2006): 483-491.
2. Kokich VG, Mathews DP. Surgical and orthodontic management of impacted teeth. Dent Clin North Am 37 (1993): 181-204.
3. Fournier A, Turcotte JY, Bernard C. Orthodontic considerations in the treatment of maxillary impacted canines. Am J Orthod 81 (1982): 236-239.
4. Becker A, Gillis I, Shpack N. The etiology of palatal displacement of maxillary canines. ClinOrthod Res 2 (1999): 62-66.
5. Kamak H, Kamak G. Incidence and effects of genetic factors on canine impaction. Am J Orthod Dentofacial Orthop 140 (2011): 286-287.

Fiorillo G, et al., J Surg Res 2024
DOI:10.26502/jsr.10020357

6. Pinho T. Impaction of both maxillary central incisors and a canine. Am J Orthod Dentofacial Orthop 142 (2012): 374-383.

7. Kuroda S, Yanagita T, Kyung HM, et al. Titanium screw anchorage for traction of many impacted teeth in a patient with cleidocranial dysplasia. Am J Orthod Dentofacial Orthop 131 (2007): 666-669.

8. Tausche E, Harzer W. Treatment of a patient with Class II malocclusion, impacted maxillary canine with a dilacerated root and peg-shaped lateral incisors. Am J Orthod Dentofacial Orthop 133 (2008): 762-770.

9. Rossini G, Parrini S, Castroflorio T, et al. Efficacy of clear aligners in controlling orthodontic tooth movement: A systematic review. Angle Orthod 85 (2015): 881-889.

10. Fiorillo G, Garrisi L, Mandelli A, et al. Design and Manufacturing of a Fully Digital Protraction Facemask (DIPROM). AJO DO Clin Companion (2024).

11. Ronsivalle V, Gastaldi G, Fiorillo G, et al. Customized Facial Orthopedics: Proof of Concept for Generating 3D-Printed Extra-Oral Appliance for Early Intervention in Class III Malocclusion. Prosthesis 6 (2024):135-145.