The Use of Clear Aligners in the Management of the Orthodontic Treatment before and after Class III Surgical Approach

Letizia Lugli[1]
Francesca Chiara De Razza[2]
Saveria Loberto[2]
Paola Cozza[2]

[1] Università degli Studi di Roma Tor Vergata
[2] UniCamillus International Medical University in Rome

Corresponding author: Letizia Lugli
e-mail: lugliletizia96@gmail.com

Abstract

The approach to skeletal dysmorphisms in the maxillofacial area usually requires an orthodontic treatment by means of fixed appliances, both before and after the surgical phase. Since its introduction, Invisalign system has become a popular treatment choice for the clinicians because of the aesthetics and comfort of the removable clear aligners compared with the traditional appliances. Therefore, the aim of the present report was to illustrate the management of a malocclusion by means of clear aligners associated with the traditional surgical technique. The present paper shows a case of a 18-year-old female patient characterized by a Class III malocclusion with lateral deviation of the mandible. Clear aligners were used during the pre- and postsurgical phases rather than fixed appliances. The posttreatment cephalometric analysis emphasized the stability of the dental and skeletal symmetry corrections, occlusion and functional balance, over a 4-year follow-up. The results achieved at the end of the treatment showed how clear aligners can be effective in the management of the orthodontic phases in orthognathic surgery. The follow-up after 4 years emphasizes the stability of the treatment over time.

Keywords: Clear aligners, Class III malocclusion, Orthodontic and surgical approach.

Introduction

Dentoskeletal Class III malocclusion is a structural deviation in the sagittal relationships of the maxillary and mandibular bony arches. It is characterized by maxillary retrusion, mandibular protrusion, or by their combination, molar and/or canine mesiocclusion, sometimes associated with anterior crossbite and increased or decreased divergency (1).
Class III malocclusion is considered one of the most complex and difficult orthodontic problems to diagnose and treat. The prevalence of this type of malocclusion in white populations is less than 5%, but it rises to as much as 12% in Chinese and Japanese populations, with a relatively high prevalence of Class III malocclusion observed also in Mediterranean and Middle Eastern populations (2).
Several studies were conducted both to determine significant differences between subjects with Class III and Class I malocclusions, and to assess the morphologic variability of craniofacial complex in patients with this disharmony (3-8).
These investigations showed that the term "Class III malocclusion" is not a single diagnostic entity, but it can result rather from numerous combinations of skeletal and dentoalveolar components (2).
The correction of Class III malocclusion by means of orthopedic/orthodontic treatment in growing subjects can be achieved in about 70% of the patients (9-12).
Prognostic evaluation of treatment outcomes based on pretreatment craniofacial features has been attempted in Class III malocclusion (13-15).
These researchs showed that one-fourth of Class III patients need surgery after the completion of active growth for the correction of the dentoskeletal disharmony, when they

Authors

Letizia Lugli - Università degli Studi di Roma Tor Vergata

Francesca Chiara De Razza - UniCamillus International Medical University in Rome

Saveria Loberto - UniCamillus International Medical University in Rome

Paola Cozza - UniCamillus International Medical University in Rome

How to Cite
Letizia Lugli, Francesca Chiara De Razza, Saveria Loberto, Paola Cozza.
The Use of Clear Aligners in the Management of the Orthodontic Treatment before and after Class III Surgical Approach
Annali Di Stomatologia, 15(3), 155-165.
https://doi.org/10.59987/ads/2024.3.155-165

did not respond satisfactorily to orthopedic therapy (16). Treatment alternatives of correction of a skeletal class III in adults are either Orthodontic camouflage or a combined orthodontic-orthognathic surgical therapy (17).

However, depending on the severity of the malocclusion, surgery is the only possible treatment option left. Traditionally, the orthognathic surgery is preceded by preoperative orthodontic therapy with conventional braces and these appliances facilitate intermaxillary fixation postoperatively (18-19).

Worms et al emphasized that the optimal surgical repositioning of the maxilla-mandibular complex is only possible following the presurgical removal of all dental compensation (20).

It was therefore proposed that comprehensive orthodontic treatment to align dental occlusion, incisor decompensation, tooth rotation, and arch coordination should be conducted before orthognathic surgery (21).

Worms et al. (20) reported 8 to 18 months to coordinate the arch before surgery while Luther et al. (22) have reported an average duration of 17 months for presurgical orthodontics, while Dowling et al. (23) and O'Brien et al. (24) have found the mean duration to be 15.4 months and 25 months, respectively.

Recently, instead of routinely orthodontics, the Invisalign system (IS) was introduced in the management of orthodontic treatment (25-26).

It first appeared in 1997, Invisalign (Align Technology, Inc., San Jose`, CA) is an increasingly popular technique for aligning teeth and correcting malocclusions orthodontically (27).

It consists in a series of transparent aligners that can obtain orthodontic movements without compromising the smile aesthetic. Invisalign system could represent a suitable solution to solve such problematic (27).

Through its software, ClinCheck, it is possible to realize the entire treatment planning with a very high predicibility index in movements' realization, with the possibility to plan each single movement and to dose the orthodontic strengths respecting the periodontal situation. At the beginning, this approach was used for the simple cases in which alignment is the only goal. Now, with the improvement of the technological software and with the use of increasingly high-performance materials, is possible to use this approach in all ages and in all cases, even in the harder ones.

The improvement in technological instruments and software, especially in imaging and in the digital management of the surgical and orthodontic approach, give the possibility to obtain a complete virtual planning. Many papers underline the reliability of a virtual planning in aesthetic and function goal (28-30). The new clinical approach is not very invasive and is therefore able to replace the "real" patient with a "virtual" one (31).

To our best knowledge, only few studies evaluating the use of clear aligners in the Management of the Orthodontic Treatment before and after Class III Surgical Approach.

This case report shows the possibility to use an alternative device instead of the traditional fixed appliance before and after orthognathic surgery.

Material And Methods

Case Report

An 18-year-old Caucasian female presented, reported to the Department of Orthodontics at the University of Rome "Tor Vergata" with a chief complaint of forwardly placed lower jaw and chin with mandibular lateral deviation.

Frontal extraoral examination (Fig. 1) revealed an increased lower anterior facial height, asymmetry of the lower third of the face associated with chin deviation to the right side and lip incompetence. On smiling, a midline deviation to the right side and limited exposure of lower incisors were detected. Lateral extraoral examination (Fig 1.) showed a concave profile, characterized by a mandibular prognathism and a flat nasolabial angle.

Frontal intraoral examination (Fig. 2) revealed a permanent dentition with anterior cross-bite, a midline discrepancy with a shift of the lower midline to the right, a negative overbite, slight dental crowding in the upper arch, diffuses diastemas in lower arch and negative lingual inclination of the upper molars and premolars.

Lateral intraoral examination (Fig. 2) revealed molar and canine class III relationships, more severe on the

Figure 1. Pre-treatment Frontal and lateral extraoral views

10.59987/ads/2024.3. 155-165

Figure 2. Pre-treatment Frontal and lateral intraoral views

left side, an anterior crossbite, a reverse Overjet and a flat curve of Spee.
The panoramic radiograph (Fig. 3) showed a permanent dentition, including developing third molars. The overall bone level was within normal limits. Pre-treatment lateral cephalogram is shown in figure 4.

Figure 3. Pre-treatment orthopantomography

Figure 4. Pre-treatment lateral cephalogram

The lateral cephalogram analysis (Table 1) revealed a skeletal Class III malocclusion (Wits appraisal -10mm; ANB -2°), characterized by a normal position of the mandible (SNB = 82°) and of the maxilla (SNA=80°) in a dolicofacial patient. In the vertical plane, FMA and the mandibular plane-SN angles were increased (30° and 42°, respectively) to relative normal, with a obtuse gonial angle (140°).
The maxillary incisors proclination and lower incisors retroclination (U1 to FH 120°, IMPA 80°) confirmed the typical dentoalveolar compensation of the dentition in the presence of a class III skeletal malocclusion.
The soft tissue profile had a retrusion of the upper lip and protrusion of the lower lip.
Considering all diagnostic elements, the patient was diagnosed as having a severe skeletal Class III, with a mandibular deviation to the right and a bilateral molar and canine Class III relationship.
The primary treatment objectives were to correct the Class III canine relationship, overjet, and overbite, to enhance the smile aesthetics and to improve facial esthetics. The complementary treatment goal was to establish good functional and stable occlusion. The patient was informed of the necessity of a long-term retention phase at the end of the active treatment to maintain stable aesthetic outcomes over time.

Treatment Plan

Considering the extent of the skeletal discrepancy and the patient's aesthetic compromise, a treatment plan was developed to correct the class III skeletal malocclusion by performing orthodontic treatment initially, followed by surgical correction. Instead of using the traditional multi-bracket system, in this case report, innovative digitally customized appliances were employed throughout the entire treatment. Below, the treatment phases are explained in detail: pre-surgical orthodontics, surgical phase, and post-surgical orthodontics.

Pre-surgical orthodontics

The III molar extraction was performed 6 months before surgery to allow a perfect bone consolidation. No premolar extraction was performed (as normally usual in orthodontic treatment) nor logopedic rehabilitation (because of the absence of an atypical swallowing).
The orthodontic presurgical phase was performed by an expert Invisalign Provider orthodontist (PC) using the Invisalign® System to achieve decompensation of the malocclusion (Fig. 5).
The ClinCheck® plan forecasted dental alignment, decompensation of proclined upper incisors and retroclined lower incisors and to correct angulations of every tooth on their respective bases (Fig. 6).

Figure 5. Frontal and lateral intraoral views with clear aligners

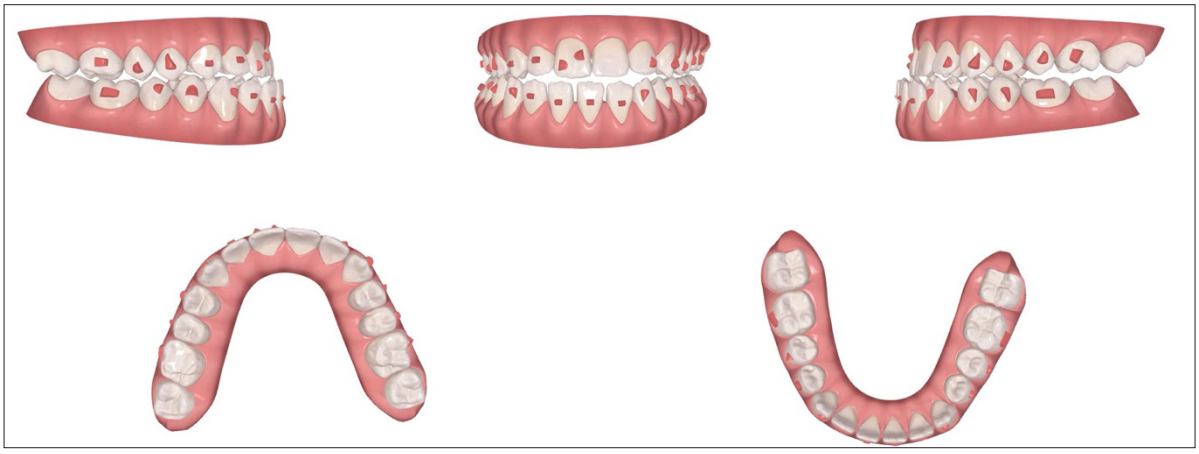

Figure 6. The ClinCheck® plan forecasted at the end of Pre-surgical orthodontics

10.59987/ads/2024.3. 155-165

Direct-bonded attachments from the third phase were planned to improve patient compliance. Retentive attachments were placed on posterior teeth to maintain the best fitting of aligners.
The patient was instructed to wear aligners 22 hours per day and to change aligners once a week. Every 6 stages the clinician checked the good aligner fitting and the position of the attachments.

At the end of treatment, intraoral and extraoral examinations highlighted:
- a bilateral Class III molar and canine relationship
- achievement of positive overbite
- increased negative overjet by decompensation of proclined upper incisors and retroclined lower incisors
- a significant worsening in the soft-tissue profile with a more anterior position of the chin.

The overall treatment lasted 1 year, has requested two refinements set, and it was well tolerated by the patient. No adverse events were noticed during any stage of the treatment.
At the end of the pre-surgical phase, attachments have been removed and a digital impression was taken using an iTero scanner, and the resulting STL file was sent to the orthodontic laboratory to fabricate an intermediate digitally designed custom appliance.
This individual pre-surgical wire, made of cobalt-chromium alloy (Remanium Star CL), was designed digitally, and consisted of two arches bonded to the vestibular surface of the dental elements the day before surgery. Each splint was equipped with the hooks necessary to achieve intermaxillary fixation. (Fig. 7).
This type of device was designed and previously published by Dr L. Huanca Ghislanzoni.

Surgical phase
Le Fort I and bilateral sagittal split osteotomies and surgical stabilization with internal rigid fixation using titanium mini bone plates and monocortical screws were carried out. Intermaxillary guiding elastics were engaged on the hooks for fourteen days in the immediate postoperative phase (Fig. 8). Strict follow up was observed after the procedure.

Post-surgical orthodontics
After one month, the splints were removed and new dental impressions were taken, in order to start the postsurgical orthodontic phase with the following series of aligners.
This consisted in a total of 32 aligners' stages for both the upper and the lower dental arches.
The overall treatment lasted 24 months and it was well tolerated by the patient. No adverse events were noticed during any stage of the treatment. The treatment objectives were achieved. The profile of the patient has improved after the treatment.
At the end of treatment, intraoral and extraoral examinations (Fig. 9-10) highlighted a bilateral Class I molar and canine relationship, a significant improvement in the soft-tissue profile.
Post-treatment rx, orthopantomography lateral cephalogram are illustrated in figures 11 and 12.

Figure 7. Individual Pre-surgical spints

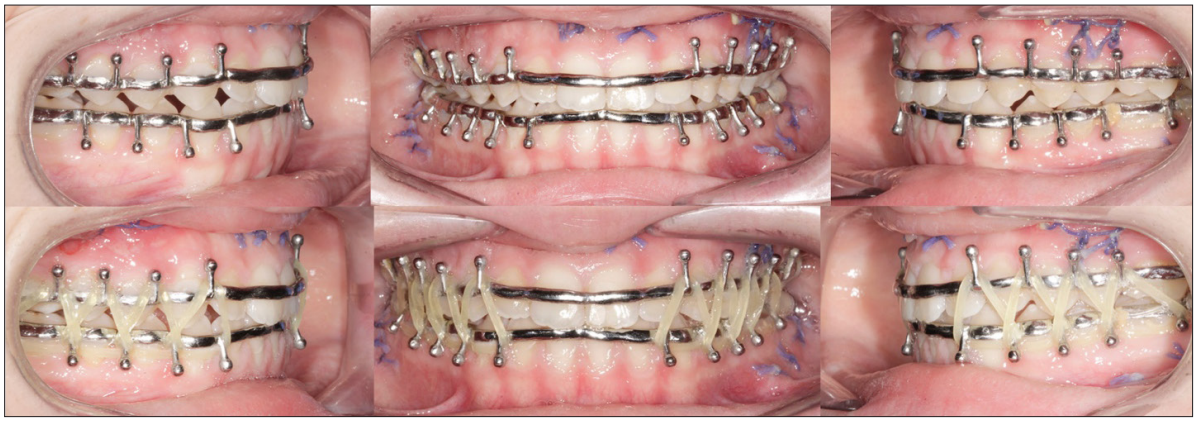

Figure 8. Frontal and lateral intraoral views after Surgical phase with and without intermaxillary elastics

Figure 9. Post-treatment frontal and lateral extraoral views

Figure 10. Post-treatment frontal and lateral intraoral views

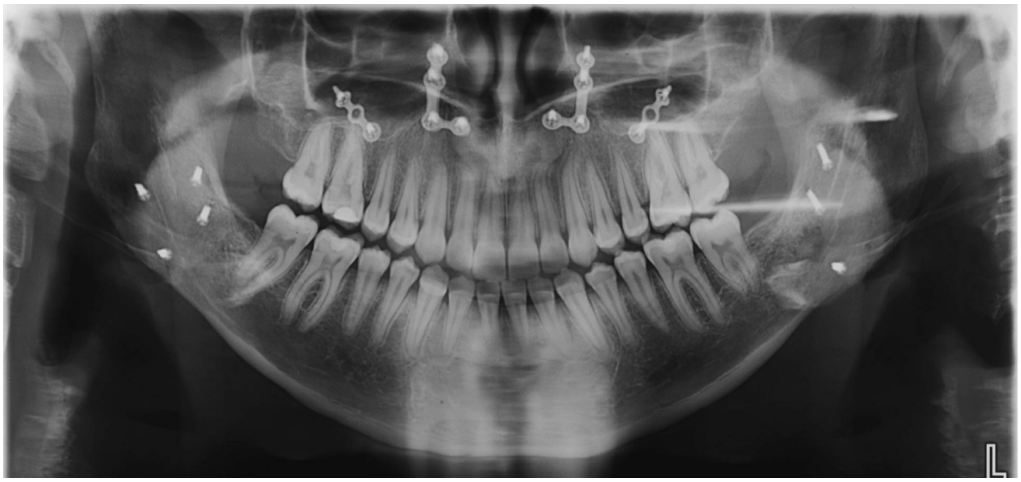

Figure 11. Post-treatment orthopantomography

10.59987/ads/2024.3. 155-165

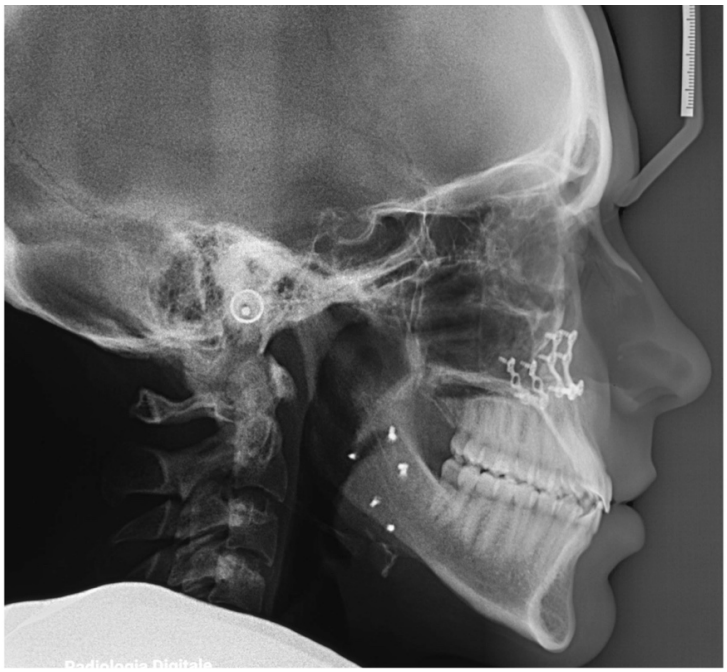

Figure 12. Post-treatment lateral cephalogram

Results

The effects of the combination of orthodontic-surgical treatment were evaluated cephalometrically at the end of treatment (Table 1). An improvement of 3° in ANB was achieved, mainly by a back displacement of the mandible (SNB 80°). Upper proclination and lower retroclination was reduced (IMPA 91°, U1 to FH 116°). Also, normal overjet and overbite were obtained (OVJ 2.5 mm, OVB 2 mm).

At 1 year of post-orthodontic follow up, the patient presents an Angle class I occlusal relationship, no deep bite, no scissor or cross- bite and no open bite. The patient did not refer TMJ discomfort nor severe post-surgical complications and no surgical-orthodontic relapse occurred.

At 4 years of post-orthodontic follow up the surgical and occlusal results are stable in terms of stability. Long-term effects of the combination of orthodontic-surgical treatment were evaluated cephalometrically (Table 1) and in intraoral and extraoral examinations (Fig. 13-14). Post-orthodontic follow up rx are illustrated in figures 15 and 16.

Figure 13. Frontal and lateral extraoral views at 4-year post-orthodontic follow-up

Figure 14. Frontal and lateral intraoral views at 4-year post-orthodontic follow-up

Figure 15. Orthopantomography at 4-year post-orthodontic follow-up

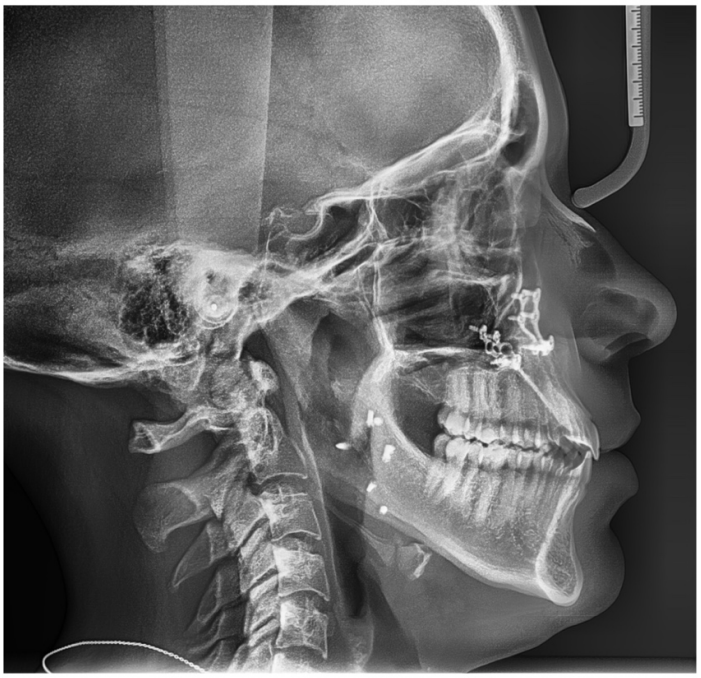

Figure 16. Lateral cephalogram at 4-year post-orthodontic follow-up

10.59987/ads/2024.3. 155-165

Table 1. Cephalometric parameters at pre-treatment, post-treatment and 4-year post-orthodontic follow-up.

	Norm	Pretreatment	Post-treatment	Follow-up
Sagittal skeletal				
SNA	82 ± 2°	80°	81°	81°
SNB	80 ± 2°	82°	80°	80°
ANB	2 ± 2 °	-2°	1°	1°
WITS	0±2 mm	-10 mm	2 mm	2mm
Vertical skeletal				
FMA	25 ± 3 °	30°	28°	28°
SN/ANS-PNS	7 ± 3 °	13°	12°	12°
SN/Go-Me	33 ± 5 °	42°	42°	42°
ArGoMe	130 ± 7 °	140°	134°	135°
Dentobasal				
U1 to FH	105-110°	120°	116°	113°
IMPA	94 ± 5 °	80°	91°	89°
Dental				
Overjet	2.5 ± 2.5 mm	-2 mm	2,5 mm	2 mm
Overbite	2.5 ± 2.5 mm	-1 mm	2 mm	2 mm

Discussion

The present case report shows how new technologies can be integrated with acquired knowledge and skills of orthodontic clinicians to enhance the diagnosis and treatment plan of a skeletal Class III Malocclusion in adult patient (28,33-34).

The conventional orthognathic approach, or an orthodontics-first approach, involves orthodontic decompensation before surgery. During pre-*surgical orthodontics* skeletal deformities become more evident or even severely aggravated and this is a major complaint among patients, especially those with class III dentofacial deformities. For this reason, an aesthetic treatment at this stage could be more accepted by the patient.

Recently we have seen an increase in demand for aesthetic and more comfortable approaches. Among the latest innovations, Align Technology (Santa Clara, CA, USA) introduced the Invisalign System® consisting of clear aligners to treat any type of malocclusion.

The precision of surgical and orthodontic planning is essential for the success of complex treatments, particularly those involving the movement of dental structures and bone bases.

The effectiveness of the treatment lies in the perfect calibration of the 3D dental movements simulation on Clincheck software.

To our best knowledge, only few studies evaluating the use of The Use of clear aligners in the Management of the Orthodontic Treatment before and after Class III Surgical Approach (28-34).

The main issue related to the use of clear aligners in surgical cases is due to the inability to use this device during the surgical phase. In fact, Traditional orthodontic therapy, commonly used, with orthodontic wires, provides opportunity for application of surgical lugs or Kobayashi style ligature wires and facilitate intraoperative maxillomandibular fixation into occlusion with opposing arch. These difficulties can be effectively overcome by carefully planning the surgery and implementing alternative methods for maxillomandibular fixation.

In this case report, a new device, designed by Dr Luis Huanca Ghislanzoni, was digitally developed and applied a few days before the surgical procedure. This appliance introduced an alternative possibility for inter-arch fixation between the upper and lower jaws during clear aligners therapy, which can be employed during maxillary and/or mandibular osteotomies.

The present paper shows the possibility to use an alternative device instead of the traditional fixed appliance before and after orthognathic surgery.

Clear aligners provided accurate and precise results guaranteeing a better aesthetic, the maintenance of oral hygiene, and a comfortable management of the removable appliance. Furthermore, patient satisfaction

was recorded as very high due to the invisible orthodontic treatment, and, above all, his occlusion was functionally rehabilitated.

Conclusion

Clear aligners can be considered an efficient approach for the combined orthodontic and surgical treatment of skeletal Class III patient.
This case report offered a better aesthetic and comfortable treatment alternative expanding the repertoire of treatment options to surgical patients.

References

1. Ellis E, McNamara JA Jr. Components of adult Class III malocclusion. J Oral Maxillofac Surg. 1984; 42:295–305. DOI: 10.1016/0278-2391(84)90109-5
2. Mouakeh M. Cephalometric evaluation of craniofacial pattern of Syrian children with Class III malocclusion. Am J Orthod Dentofacial Orthop. 2001; 119:640–649. DOI: 10.1067/mod.2001.112671
3. Zentner A, Doll GM, Peylo SM. Morphological parameters as predictors of successful correction of Class III malocclusion. Eur J Orthod. 2001;23:383–392. DOI: 10.1093/ejo/23.4.383
4. Franchi L, Baccetti T, Tollaro I. Predictive variables for the outcome of early functional treatment of Class III malocclusion. Am J Orthod Dentofacial Orthop. 1997; 112:80–86. DOI: 10.1016/s0889-5406(97)70277-4
5. Jacobson A, Evans WG, Preston CB, Sadowsky PL. Mandibular prognathism. Am J Orthod. 1974;66:140–171 DOI: 10.1016/0002-9416(74)90233-4
6. Williams S, Andersen CE. The morphology of potential Class III skeletal pattern in the growing child. Am J Orthod. 1986; 89:302–311. DOI: 10.1016/0002-9416(86)90052-7
7. Pavoni C, Paoloni V, Ghislanzoni LTH, Laganà G, Cozza P. Geometric morphometric analysis of the palatal morphology in children with impacted incisors: a three-dimensional evaluation. Angle Orthod 2017; 87(3):404-408 DOI 10.2319/071716-557.1
8. Laganà G, Di Fazio V, Paoloni V, Franchi L, Cozza P, Lione R. Geometric morphometric analysis of the palatal morphology in growing subjects with skeletal open bite. Eur J Orthod 2019; 41(3) DOI 10.1093/ejo/cjy055
9. Pavoni C, Masucci C, Cerroni S, Franchi L, Cozza P. Short-term effects produced by rapid maxillary expansion and facemask therapy in Class III patients with different vertical skeletal relationships. Angle Orthod. 2015 Nov;85(6):927-33. DOI: 10.2319/052414-366.1.
8. Franchi L, Pavoni C, Cerroni S, Cozza P. Thin-Plate spline analysis of mandibular morphological changes induced by early class III treatment: A long term evaluation. Eur J Orthod. 2014 36(4):425-430. DOI: 10.1093/ejo/cjt067
9. Pavoni C, Mucedero M, Baccetti T, & Cozza P. The effects of facial mask/bite block therapy with or without rapid palatal expansion. Prog in Orthod. 2009 10(1):20-28. ISSN 17237785
10. Hagg U, Tse A, Bendeus M, Rabie AB. Long-term follow-up of early treatment with reverse headgear. Eur J Orthod. 2003;25:95–102. DOI: 10.1093/ejo/25.1.95
11. Westwood PV, McNamara JA Jr, Baccetti T, Franchi L, Sarver DM. Long-term effects of Class III treatment with rapid maxillary expansion and facemask therapy followed by fixed appliances. Am J Orthod Dentofacial Orthop. 2003; 123:306–320. DOI: 10.1067/mod.2003.44
12. Mucedero M, Fusaroli D, Franchi L, & Lione R. Long-Term evaluation of rapid maxillary expansion and bite-block therapy in open bite growing subjects: A controlled clinical study. Angle Orthod. 2018 88(5):523-529. DOI 10.2319/102717-728.1
13. Baccetti T, Franchi L, McNamara JA Jr. Cephalometric variables predicting the long-term success or failure of combined rapid maxillary expansion and facial mask therapy. Am J Orthod Dentofacial Orthop. 2004; 126:16–22. DOI: 10.1016/j.ajodo.2003.06.010
14. Souki BQ, Nieri M, Pavoni C, Pavan Barros HM, Junqueira Pereira T, Giuntini V & Franchi L. Development and validation of a prediction model for long-term unsuccess of early treatment of Class III malocclusion. European Journal of Orthodontics. 2020; 42(2), 200-205. DOI: 10.1093/ejo/cjz031
15. Cong A, de Oliveira Ruellas AC, Tai SK, Loh CT, Barkley M, Yatabe M, & Cevidanes L. Presurgical orthodontic decompensation with clear aligners. American Journal of Orthodontics and Dentofacial Orthopedics. 2022: 162(4), 538-553. DOI: 10.1016/j.ajodo.2021.12.019
16. Dastgir R, Bemudez PF, Valiathan M, Baur DA, Quereshy FA. The use of clear aligners in orthognathic surgeries: a case series. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology. 2024: 137(3), e22-e40. DOI: 10.1016/j.oooo.2023.07.016
17. Williams AC, Shah H, Sandy JR, Travess HC. Patients' motivations for treatment and their experiences of orthodontic preparation for orthognathic surgery. J Orthod. 2005; 32:191–202. DOI: 10.1179/146531205225021096
18. Kankam H K, Gupta H, Sawh-Martinez R, Steinbacher DM. Segmental multiple-jaw surgery without orthodontia: clear aligners alone. Plastic and Reconstructive Surgery. 2018; 142(1), 181-184. DOI: 10.1097/PRS.0000000000004491
19. Worms FW, Isaacson RJ, Speidel TM. Surgical orthodontic treatment planning: profile analysis and mandibular surgery. Angle Orthod. 1976; 46:1–25. DOI: 10.1043/0003-3219(1976)046<0001:SOTPPA>2.0.CO;2
20. Grubb J, Evans C. Orthodontic management of dentofacial skeletal deformities. Clin Plast Surg. 2007; 34:403–415. DOI: 10.1016/j.cps.2007.05.002
21. Luther F, Morris DO, Hart C. Orthodontic preparation for orthognathic surgery: how long does it take and why? A retrospective study. Br J Oral Maxillofac Surg. 2003;41:401–406. DOI: 10.1016/s0266-4356(03)00163-3
22. Dowling PA, Espeland L, Krogstad O, et al. Duration of orthodontic treatment involving orthognathic surgery. Int J Adult Orthodon Orthognath Surg. 1999;14:146–152. PMID: 10686838
23. O'Brien K, Wright J, Conboy F, et al. Prospective, multicenter study of the e ectiveness of orthodontic/orthognathic surgery care in the United Kingdom. Am J Orthod Dentofacial Orthop. 2009;135: 709–714. DOI: 10.1016/j.ajodo.2007.10.043
24. Lagravère MO, Flores-Mir C. The treatment effects of Invisalign orthodontic aligners: a systematic review. J Am Dent Assoc. 2005 Dec;136(12):1724-9. doi: 10.14219/jada.archive.2005.0117.
25. Zhang W, Yang H. Orthognatic Surgery in Invisalign Patients. J Craniofacial Surg. 2022 33(2):e112-e113. DOI: 10.1097/SCS.0000000000007968
26. Cervino G, et al. Dental restorative digital workflow: digital smile design from aesthetic to function. Dent J. 2019:7–30. DOI: 10.3390/dj7020030
27. Lavorgna L, Cervino G, Fiorillo L, et al. Reliability of a virtual prosthodontic project realized through a 2D and 3D photographic acquisition: an experimental study on the accuracy of different digital systems. Int J Environ Res Public Health. 2019; 16:5139. DOI: 10.3390/ijerph16245139
28. Ballanti F, Lione R, Fiaschetti V, Fanucci E, Cozza P. Low-dose CT protocol for orthodontic diagnosis. Eur J of paediatric dent 2008 9(2):65-70 ISSN 1591996X
29. Pagani, R., Signorino, F., Poli, P. P., Manzini, P., & Panisi, I. (2016). The use of Invisalign® system in the management of the orthodontic treatment before and after Class III surgical approach. Case reports in dentistry, 2016. DOI: 10.1155/2016/9231219
30. Kwon, T., Alshehri, A., Palo, L., Kuo, C. L., Mu, J., Blanck, N., ... & Uribe, F. (2023). Assessment of the occlusal outcomes in patients treated with orthognathic surgery and clear aligners. Orthodontics & Craniofacial Research, 26(3), 371-377. DOI: 10.1111/ocr.12617
31. Kendrick DE, Park CM, Fa JM, Barber JS, Indresano AT. Stryker SMARTLock hybrid maxillomandibular fixation system: clinical application, complications, and radiographic findings. Plastic and reconstructive surgery. 2016: 137(1),

10.59987/ads/2024.3. 155-165

142e-150e. DOI: 10.1097/PRS.0000000000001920
32. Kankam H, Madari S, Sawh-Martinez R, Bruckman KC, Steinbacher DM. Comparing outcomes in orthognathic surgery using clear aligners versus conventional fixed appliances. Journal of Craniofacial Surgery. 2019: 30(5), 1488-1491. DOI: 10.1097/SCS.0000000000005572
33. Zhou G, Yu F, Yu H, Xia L, Yuan L, Fang B. Treatment of skeletal class III malocclusion using a combined clear aligner and surgery-early approach: Assessment based on the American Board of Orthodontics Objective Grading System. J Orofac Orthop. 2023 Mar 3. DOI: 10.1007/s00056-023-00458-2
34. Amodeo G, Meuli S, Carboni A, Brugnami F, Marrocco S, Orsini R, Scopelliti Domenico. Surgery First and Invisalign System: Combined Digital Approach. Journal of Craniofacial Surgery. 2020; 31(6): 1681-1686. DOI: 10.1097/SCS.0000000000006392