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Lower incisor extraction treatment with the Invisalign[®] technique: three case reports

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The extraction of a lower incisor can lead to satisfactory orthodontic results for patients with moderate to severe lower incisor crowding. Invisalign[®] is a treatment modality for such treatments, moving teeth with precision and reducing inconvenience for the patient. Three case reports are presented in this article supporting the above statements.

Key words: Extraction treatment, incisor extraction, Invisalign technique

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Introduction

Extraction of teeth to alleviate dental crowding is a therapy that is almost universally accepted and has been used for decades. However, while planning orthodontic cases that include extractions, the crucial decision is determining which teeth should be extracted. Several aspects must be considered, such as periodontal health, orthodontic biomechanics, functional and aesthetic alterations and treatment stability. Premolars are often the teeth of choice for orthodontic extractions, but there are situations in which extraction of other teeth can facilitate mechanics, preserve periodontal health and retain the original facial profile. Extraction of one lower incisor can be one such choice (Grob, 1995).

The following diagnostic characteristics are usually recommended for single lower incisor extractions:

- Class I or Class III molar relationship;
- moderately/severely crowded lower incisors;
- mild or no crowding in the upper arch;
- acceptable soft-tissue profile;
- non-surgical treatment for Class III malocclusion (Faerovig and Zachrisson, 1999; Canut, 1996);
- malocclusions with a lower incisor with poor long term prognosis (Canut, 1996; Brandt *et al.*, 1975; Riedel *et al.*, 1992; Telles *et al.*, 1995);
- reduced or normal overbite and overjet;
- residual growth potential;
- tooth-size discrepancy, such as small or shaped lateral incisors, which can be used to resolve the inevitable tooth-size discrepancy without inter-proximal stripping (Owen *et al.*, 1993; Raju *et al.*, 2012).

Invisalign[®] is an orthodontic technique to align teeth with a series of invisible, removable and comfortable aligners. Align Technology, Inc. developed the Invisalign appliance for orthodontic tooth movement in the USA in 1998. This appliance was the first orthodontic treatment method based on CAD-CAM technology.

It was initially developed to correct mild-to-moderate crowding, to close naturally occurring spaces, and to produce dental tipping (Vlaskalic and Boyd, 2001; Boyd, 2008). After years of experience with the system, orthodontists have reported its successful use in more complex cases, such as those involving extractions, open bites, and Class II malocclusions (Norris *et al.*, 2002; Honn and Goz, 2006; Womack, 2006; Boyd, 2007; Womack and Day, 2008; Giancotti *et al.*, 2008; Giancotti and Di Girolamo, 2009; Giancotti and Mampieri, 2012).

Moreover, the use of the Invisalign[®] technique in lower incisor extraction treatments has been previously shown by Miller in an adult patient case (Miller *et al.*, 2002). However, over the past 12 years a number of new features and protocols concerning Invisalign[®] were developed.

Therefore, the objective of this article is to illustrate the current application of the Invisalign[®] technique in lower incisor extraction treatments.

Clinical report

Case 1

Diagnosis. A 40-year-old male patient presented with a Class I dental malocclusion and a normal skeletal



Figure 1 Pre-treatment records

pattern. He was particularly concerned about his lower incisors as he noticed a worsening of the gingival recession on 32 and could not maintain a good level of oral hygiene due to the crowding of the anterior teeth.

Intraoral examination showed light crowding in the upper arch combined with severe crowding in the lower arch. The upper midline was centred in the face while the lower midline was shifted 2 mm to the left (Figure 1). The most challenging problems were to solve lower crowding, and to improve oral hygiene and periodontal health. Pre-treatment X-ray images were analyzed (Figure 1) (Table 1). Moreover, the patient was seeking a treatment with low aesthetic impact.

Treatment plan. Given the amount of lower crowding, the gingival recession on 32 and its position out of the dental alveolar ridge so as not to allow sufficient periodontal health in the mid and long term, we decided to extract 32 and to align the other teeth using the Invisalign® technique.

A tool as accurate as Invisalign® has enabled not only the alignment of lower incisors but also the alignment of upper teeth without expanding the upper intercanine width so as not to worsen the overjet. In fact, alignment in the lower anterior area by extraction of an incisor often leads to a good alignment, but it can create an increase in lateral overjet and worsening of the posterior occlusion.

The treatment plan featured the movement of only the upper and lower front teeth from canine to canine, while the posterior dental elements that had a good occlusal relationship were planned to remain where they were.

Moreover, to control root movement of the lower anterior teeth, it was decided to apply rectangular vertical attachments designed to allow the three-dimensional control of tooth movement on the lower incisors, which had to be moved in the extraction space. Additionally, two horizontal rectangular attachments on the lower first premolars were planned for vertical anchorage together with one rotation attachment on the lower right canine (Figure 2).

Treatment objectives:

- to align the upper and lower arches;
- to improve periodontal health in the area of the lower incisors area;
- to minimize the increase in the anterior overjet;
- to maintain the posterior occlusion;
- to minimize the aesthetic impact.

The ClinCheck® pre-post superimpositions show how the space resulting from the extraction of 32 has been employed for the displacement of 31, 41 and 42, while the lower canines remained stationary as scheduled in the treatment plan (Figure 3). Also, the posterior teeth were kept in place to maintain a proper occlusion.

The first phase of therapy consisted of 10 aligners for the upper arch and 24 for the lower one. During the refinement stage, seven aligners were used for the upper arch and nine for the lower one for five months of treatment time.

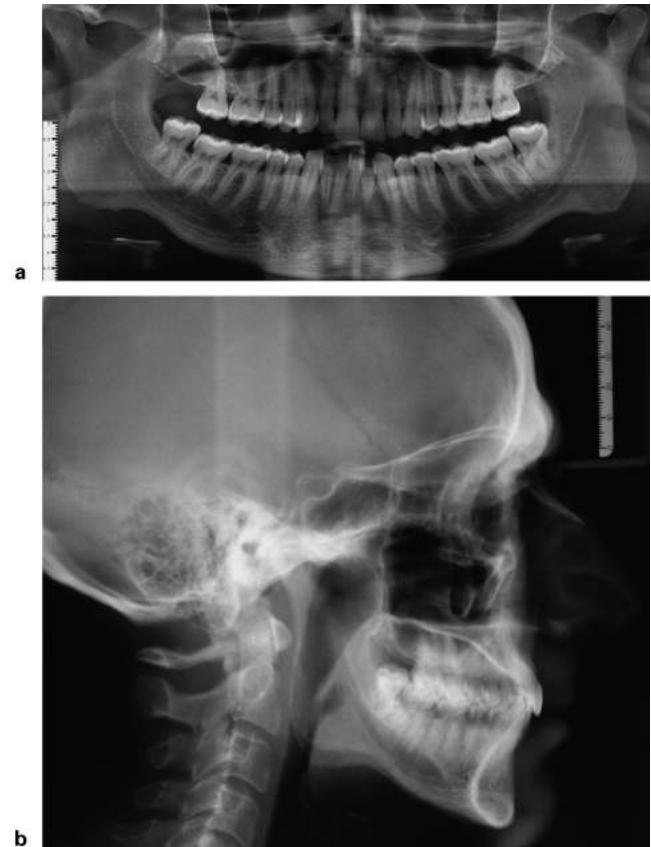


Figure 2 Optimized attachments in the lower arch for three-dimensional control of tooth movement

Treatment results. The patient was seen every 6 weeks to check the aligner fit, attachment stability, and patient compliance. The final result showed a good alignment

Table 1 Summary of cephalometric changes

CEPHALOMETRIC MORPHOLOGICAL ASSESSMENT	MEAN SD	PRE-TREATMENT	POST TREATMENT
SAGITTAL SKELETAL RELATIONS			
MAXILLARY POSITION S-N-A	82° ± 3.5	83°	83°
MANDIBULAR POSITION S-N-PG	80° ± 3.5	80°	80°
SAGITTAL JAW RELATION A-N-PG	2° ± 2.5	3°	3°
VERTICAL SKELETAL RELATIONS			
MAXILLARY INCLINATION S-N/ANS-PNS	8° ± 3.0	10°	11°
MANDIBULAR INCLINATION S-N/GO-GN	33° ± 2.5	28°	32°
VERTICAL JAW RELATION ANS-PNS/GO-GN	25° ± 6.0	18°	20°
DENTO-BASAL RELATIONS			
MAXILLARY INCISOR INCLINATION <u>1</u> /ANS-PNS	110° ± 6.0	119°	120°
MANDIBULAR INCISOR INCLINATION <u>1</u> /GO-GN	94 ± 7.0	96°	92°
MANDIBULAR INCISOR COMPENSATION ₁ /A-PG (MM)	2 ± 2.0	4	2
DENTAL RELATIONS			
OVERJET (MM)	3.5 ± 2.5	3	3
OVERBITE (MM)	2 ± 2.5	5.5	3
INTERINCISAL ANGLE <u>1</u> /1	132° ± 6.0	127°	128°

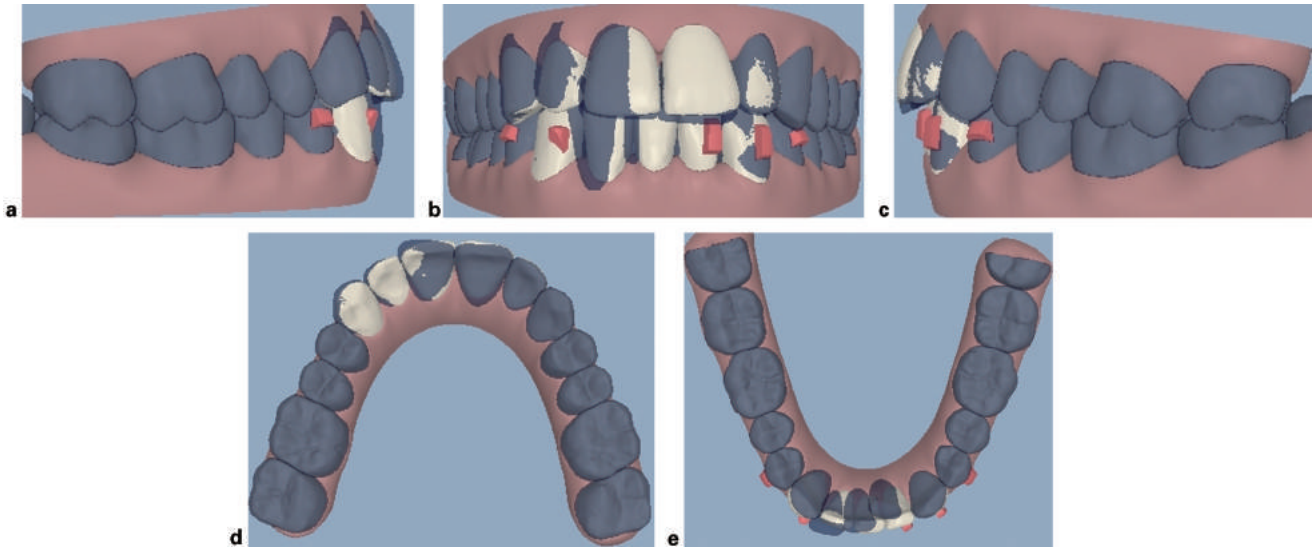


Figure 3 ClinCheck® pre-post superimpositions

and occlusion, thanks to the good compliance in wearing each aligner for 2 weeks as planned (Figure 4). The upper and lower anterior teeth were aligned; the periodontal status in the anterior lower arch had improved and oral hygiene had improved greatly. The post-treatment panoramic X-ray image showed that the roots of all teeth were in an acceptable position, particularly the lower incisors (Figure 4); there was no sign of root resorption; interproximal bone was regularly spaced favouring periodontal health maintenance. The cephalometric measurements indicate that at the end of treatment the skeletal values were in the normal range. However, the dental values show an improvement regarding the overbite correction from 5.5 to 3 mm. The value of the overjet was left unchanged despite the lower incisor extraction (Table 1).

Case 2

Diagnosis. A 24-year-old male patient presenting a Class I dental malocclusion and a normal skeletal pattern was particularly concerned about crowding in both arches with poor aesthetics. The posterior occlusion was acceptable apart from an edge-to-edge contact on the right side in the premolar area. Intraoral examination showed crowding in the upper arch and more severe crowding in the lower one. The overbite had increased slightly. The upper midline was centred in the face while the lower midline was shifted 4 mm to the right (Figure 5). Solving lower crowding was crucial to improve oral hygiene and periodontal health. Pre-treatment radiographs were analyzed (Figure 5). The patient was possibly seeking a treatment with removable appliances having minimal aesthetic impact. For these

reasons, both conventional and lingual fixed appliances were not considered.

Treatment plan. The severe localized discrepancy in the lower arch and reasonably good posterior occlusion drove the decision to extract one lower incisor. Moreover, the tooth to be extracted was chosen after closely examining the periodontal status of all four incisors. Thus, the most vestibular incisor 41 was removed before taking a polyvinyl siloxane impression to start the Invisalign® treatment. In the upper arch, the planned correction was to expand bilaterally about 3 mm to solve the edge-to-edge contact on the right side and to reach a good transversal coordination between the arches. Moreover, the space gained allowed a good correction of the crowding, particularly of the anterior teeth. The optimized attachments in the lower arch were selected to correct the rotation of the lower bicuspids and left canine. To obtain a good root parallelism of the upper central incisors in the upper arch, a root control attachment was applied on 11 and 21. No attachments were applied on the lower incisors, as the initial apex position was reasonably good (Figure 6).

Treatment objectives:

- to align the upper and lower arches;
- to coordinate the arches transversally;
- to solve the unilateral cross-bite on the right side;
- to maintain the posterior occlusion;
- to maintain the upper incisor position and profile.

The ClinCheck® projection indicated an excellent solution to the crowding in both arches, as well as effectively



Figure 4 Post-treatment records



Figure 5 Pre-treatment records

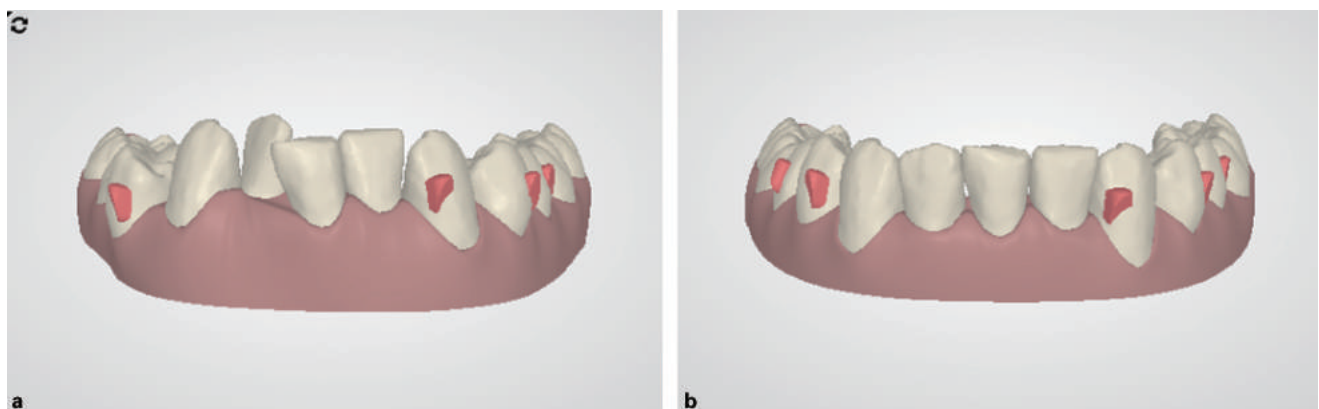


Figure 6 Optimized attachments for rotation in the lower arch

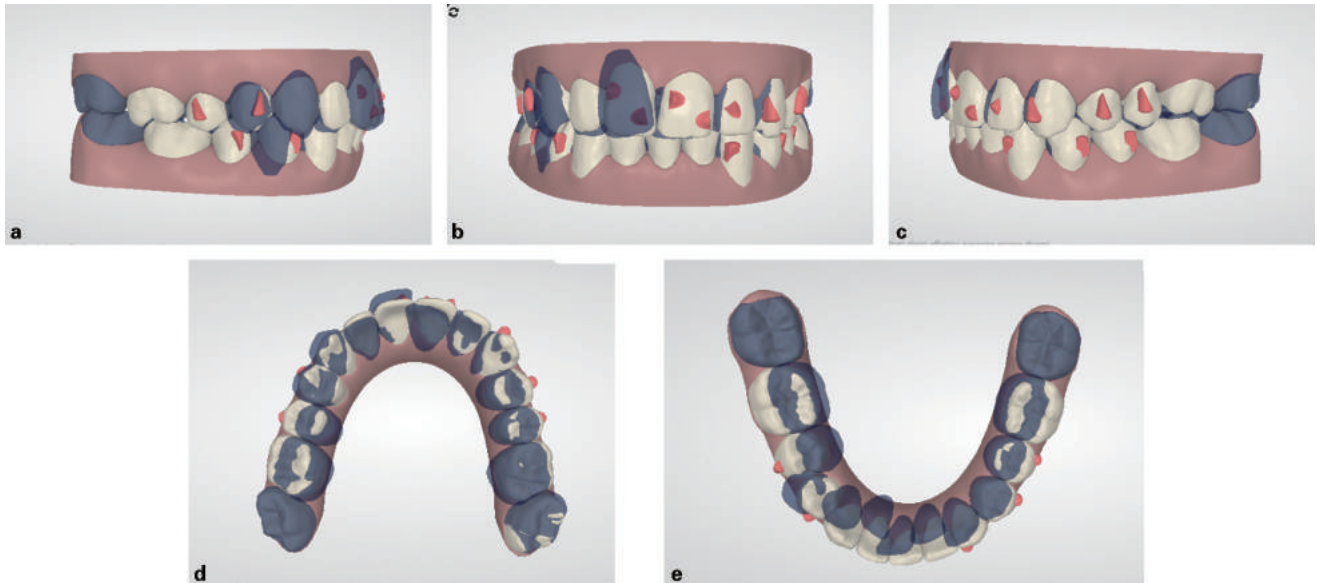


Figure 7 ClinCheck pre-post superimpositions

maintaining the posterior relationship and the axial inclination of the incisors (Figure 7).

The first phase of therapy consisted of 25 aligners for the upper arch and 23 for the lower one. During the refinement stage, eight aligners were used for the upper arch and six for the lower one.

Treatment results. The final outcome showed a good alignment of both arches and correction of the transverse discrepancy (Figure 8). The upper and lower anterior teeth were aligned, and the periodontal condition in the anterior area was maintained. The patient's cooperation in wearing each aligner was satisfactory and oral hygiene had improved. Clearly, one important concern in all these cases is to attain a good root parallelism at the end of treatment, so as not to create a future negative condition in bone support. The evaluation of the post-treatment panoramic X-ray showed a satisfactory position for the roots of all teeth particularly for the lower incisors, where inter-radicular bone levels were acceptable (Figure 8). The patient decided not to have post-treatment cephalogram taken, as not relevant for the final treatment outcome. We accepted his decision for ethical reasons. The overall final display of the smile improved thanks to widening of the arches, making smiling more radiant.

Moreover, the extraction of both tipped lower third molars was planned, in order to treat the decayed lower left second molar as well. The retention protocol of the post-treatment phase for the patient was to use a thermoformed retention appliance for 14–16 h daily for

1yr, and then only at nighttime. The Vivera[®] retainers were preferred and delivered to the patient at the end of the active refinement phase.

Case 3

Diagnosis. A 27-year-old male patient presented with a Class I dental malocclusion and a normal skeletal pattern. He was referred to us by a medical–legal dentist, who was also a periodontist, because the patient had undergone an unsuccessful orthodontic treatment with fixed appliances and required further orthodontic treatment.

Intraoral examination showed severe gingival recessions in the lower arch, mainly in the incisor and canine regions, and 41 had a negative prognosis. The upper midline was centred in the face while the lower midline was shifted 1 mm to the left (Figure 9). The most challenging issue was to solve the lower crowding, also providing orthodontic movements which should not worsen the periodontal conditions. Pre-treatment X-rays were evaluated (Figure 9). Moreover, in this case, a partial cone beam computed tomographic scan was required in the lower incisor area to evaluate bone conditions. The information from this exam was important in driving part of the treatment plan, allowing proper evaluation of the bone structure in the lower incisor area, as well as further confirming whether 41 needed to be extracted. The patient was not only looking for a treatment without visible braces, but one that would enable aesthetic recovery of the upper incisors, where the orthodontic appliance should have properly



Figure 8 Post-treatment records

aligned upper incisors, followed by restoration of upper incisors before retention. Such a condition was the result of a poor Inter Proximal Reduction performed during the earlier orthodontic treatment.

Treatment plan. Since 41 had to be extracted to correct the severe gingival recession and bone loss, the goals of the treatment plan were not ideal. We had to consider obtaining a proper alignment in the upper arch and uprighting the upper central incisors to be our main aims, while maintaining a proper Class I canine and

molar relationship on both sides without increasing the overjet (Figure 10).

Treatment objectives:

- To align the upper and lower arches;
- To minimize the increase in the anterior overjet;
- To maintain a good posterior occlusion;
- To minimize the aesthetic impact of the orthodontic appliance.

The ClinCheck[®] pre-post superimpositions show how the space resulting from the extraction of 41 was used to

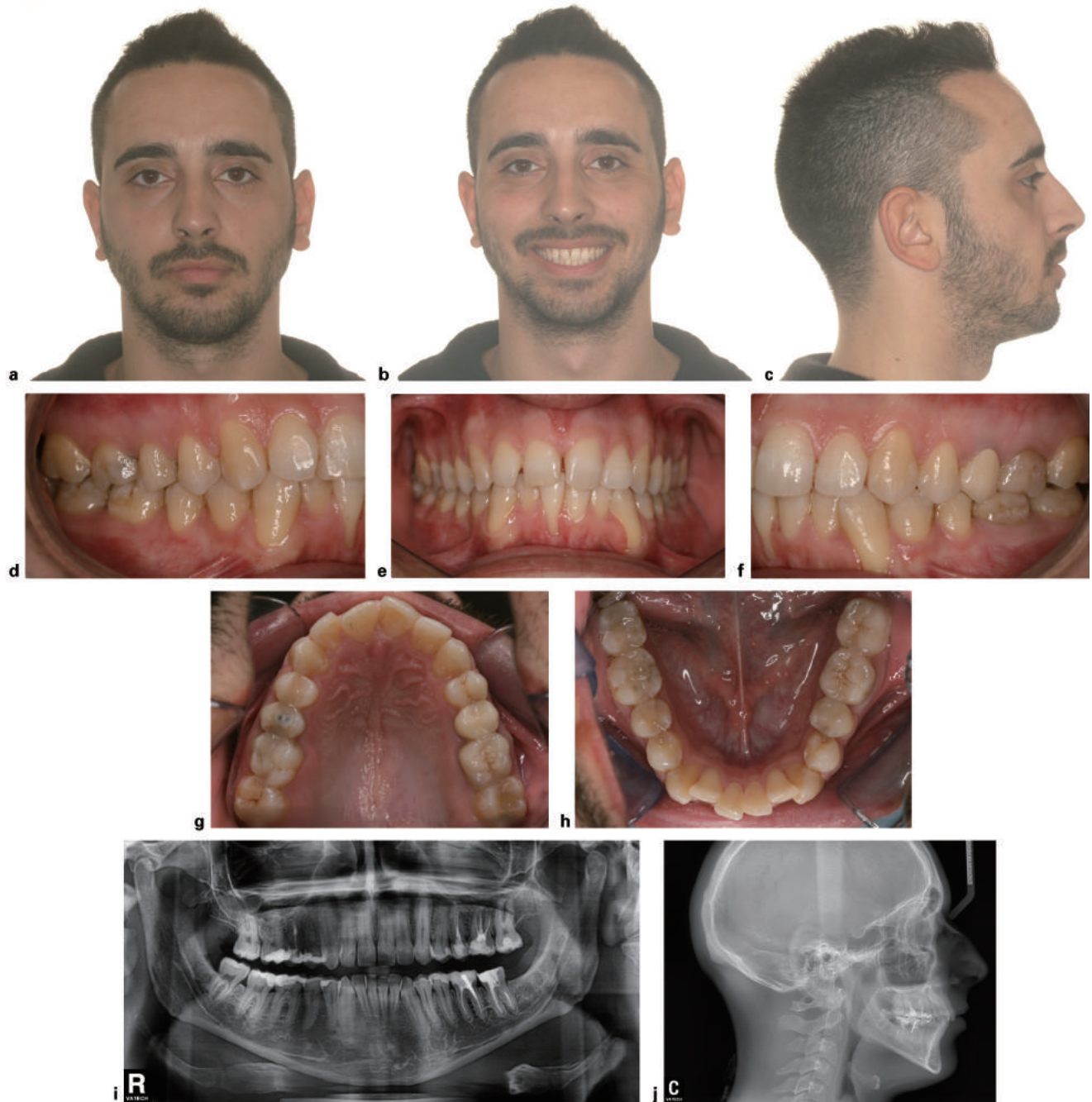


Figure 9 Pre-treatment records

correct the crowding of 31, 32 and 42, and correct the rotation of the lower canines as decided in the treatment plan (Figure 11).

In the lower arch, after the extraction of 41, the correction of lower crowding was planned through a progressive closure of the extraction space by mesially moving the incisors adjacent to the extraction space. For this reason, in the virtual treatment plan, the technician

placed a vertical rectangular attachment on the two incisors adjacent to 41, to allow for bodily movement and to avoid tipping movement.

Due to the calibrated tooth movement forecasted in every aligner (max. 0.25 mm of linear movement per stage), no tipping was detected during the treatment.

To correct rotations, optimized attachments were placed on the lower cuspids and the final results

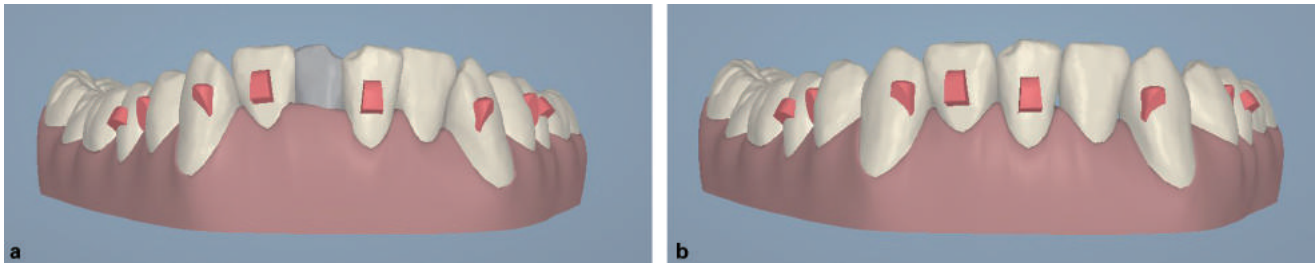


Figure 10 ClinCheck before and after treatment of the lower arch

highlight the proper action of such auxiliaries. To obtain a good root parallelism of the upper central incisors in the upper arch, a root control attachment was applied to 21 (Figure 10). In addition, the posterior teeth were kept stationary to maintain a proper occlusion.

The first phase of therapy consisted of 14 aligners for the upper arch and 21 for the lower one. During this phase, to minimize the aesthetic impact due to 41 extraction, a virtual pontic was created within ClinCheck[®] and a physical pontic was placed inside the lower aligner. The pontic was reduced over the course of treatment, and once the interdental space was less than 2 mm, it was no longer required (Figure 12) The patient then underwent two short refinement stages: the first with seven upper and eight lower aligners, the second with three upper and four lower aligners to optimize the final outcome. Specifically, the second refinement was only made because the anatomy of the upper incisors had slightly changed after minor restorations, so this minor refinement aimed at completing rotation of upper incisors.

Treatment results. The patient was seen every 4–6 weeks to check tooth tracking, mainly in the extraction area, attachment stability, and patient compliance.

Final results underscored a good coordination between dental arches and correction of the severe crowding (Figure 13). The upper and lower anterior teeth were aligned without increasing the overjet despite lower incisor extraction; the periodontal condition in the lower arch was not worsened; the periodontist will follow-up and evaluate the possibility of future gingival surgery. Patient compliance in wearing aligners was optimal during the overall treatment period, and oral hygiene was improved as well. Moreover, the root parallelism of the incisors adjacent to the extraction space and the root control of the upper incisors were carefully monitored during treatment (Figure 13).

Before the last refinement stage, the patient went visited to his general dentist to make for small minor restorations on upper incisors in order to better shape the upper incisors, following the previous Inter Proximal Reduction procedure.

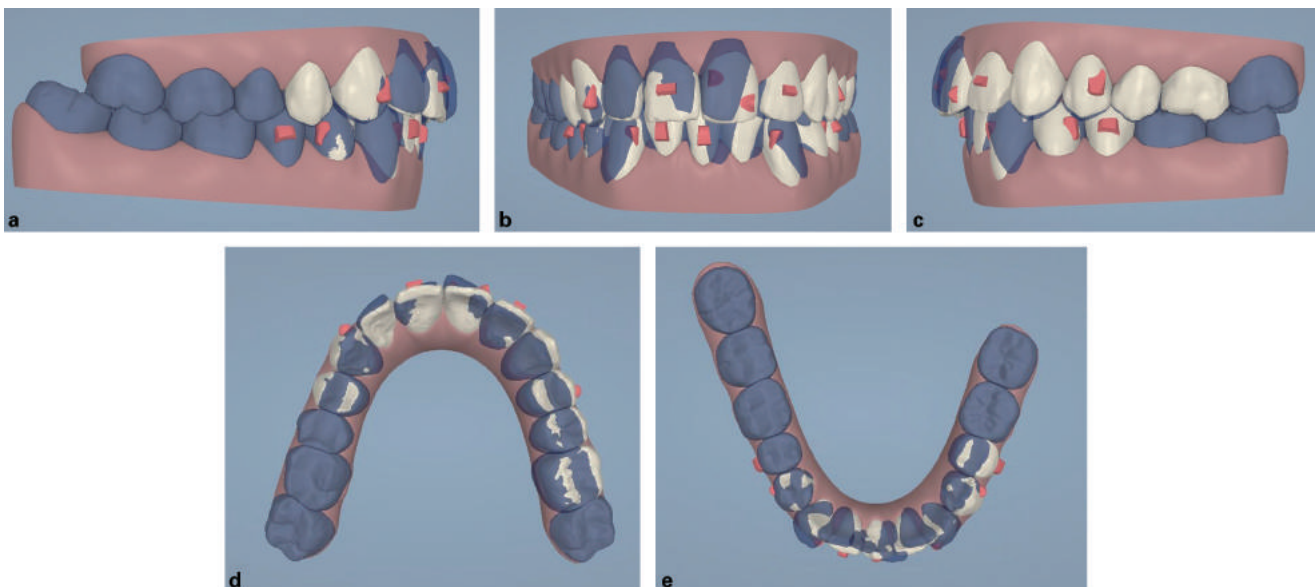


Figure 11 ClinCheck pre-post superimpositions

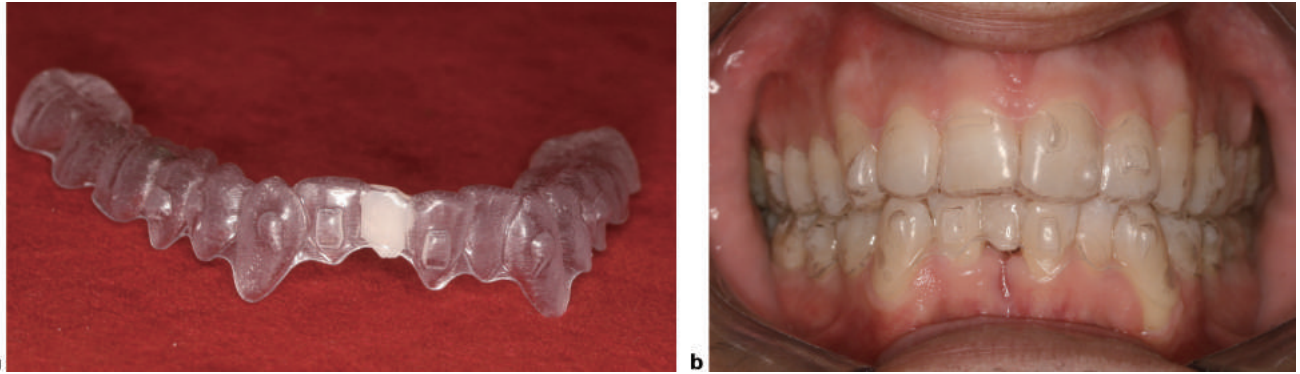


Figure 12 Pontic filled with resin placed in the aligner

The final panoramic X-ray was taken before removal of the attachments, and highlighted how nicely root parallelism had been achieved during closure of the extraction space. However, the patient chose not to

have post-treatment cephalogram taken, as this was considered not relevant for the purposes of final treatment results. We respected his decision for ethical reasons.



Figure 13 Post-treatment records

At the end of treatment, the patient's smile had improved due to the elimination of space between the upper incisors. Additionally, teeth uprighting and arch widening created a more pleasant aesthetic.

Discussion

Orthodontic treatment with the extraction of a lower incisor can be considered as an ideal indication to use the Invisalign® technique. The possibility to selectively move only some teeth while maintaining the position of the existing anchorage units enables an effective management of the extraction space, achieving both aesthetic and functional results. Specifically, if we compare this technique with conventional fixed appliances (buccal or lingual), we can highlight the former's higher possibility to plan any specific tooth movement with better predictability in terms of accuracy and sequential staging. Moreover, from a biomechanical point of view, the use of light and intermittent forces by means of aligners could be considered as being a safe and non-invasive procedure, in order to minimize root resorption risk.

Contrarily, such risk would not be highly predictable with conventional fixed appliances even upon using light forces. Thanks to the proper staging phase, we can trigger a positive outcome in terms of reduced trauma on teeth by cutting off any jiggling effect.

Additionally, the use of removable aligners can ease oral hygiene procedures.

This is a crucial factor because, as previously described, most of patients are young adults with potential for or latent incidence of periodontal disease.

Conclusion

In conclusion, we wish to underscore the notable advantages of using the Invisalign® technique in cases of lower incisor extraction. They can be summarized as follows:

1. Precise biomechanical control of tooth movements due to the fact that the force calibration of aligners can not be modified by the operator once approved the aligners' sequence.
2. Minimum trauma of the teeth during movement, due to the use of controlled and light forces.

3. Maintenance of appropriate oral hygiene throughout the orthodontic treatment.

Disclaimer statements

Contributors None.

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Conflicts of interest None.

Ethics approval None.

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