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Digital Tooth Alignment VTO-Assisted Treatment of an Adult with Class I Malocclusion: A Case Report

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Abstract

In orthodontic treatment, extraction-based correction has become a common approach. Since extraction is an irreversible procedure and different extraction plans lead to varied treatment outcomes, designing an appropriate extraction plan is crucial. However, different practitioners may propose distinct extraction plans for the same case, and even the same practitioner may design different plans for similar cases. Recently, VTO digital tooth arrangement has gradually been incorporated into orthodontic diagnostics as an auxiliary tool. This paper presents a case of adult Class I malocclusion correction using digital tooth arrangement to select an extraction plan, aiming to evaluate its effectiveness as an auxiliary method in orthodontic treatment. The findings show that, following the extraction plan determined by digital tooth arrangement, the patient achieved satisfactory occlusal and profile outcomes, indicating that digital tooth arrangement has potential reference value in orthodontic treatment.

Keywords

Visual Treatment Objectives, Digital Tooth Arrangement, Orthodontic Treatment, Three-Dimensional Digital Technology, Class I Malocclusion

1. Introduction

Digital technology is increasingly prevalent in the field of orthodontic treatment, particularly in digital tooth alignment and treatment outcome prediction. These technologies significantly enhance the visualization and predictability of treatment results, providing strong support for clinicians in making higher-quality decisions. Research indicates [1] that when different clinicians encounter the same case, the corrective treatment plans they devise often vary, making it difficult to reach a unified treatment consensus. Due to the irreversible nature of orthodontic treatment, practitioners cannot repeatedly experiment with multiple different plans on the same patient. Thus, the visualization and predictability of treatment outcomes become especially important.

Visual Treatment Objectives (VTO), first proposed by Holdaway [2] in 1971, aim to assist orthodontists in designing optimal plans by segmenting and aligning dental models and predicting the effects on both soft and hard tissues before treatment. This approach also facilitates effective communication between clinicians and patients by presenting the predicted results visually.

With continuous technological advancements, the methods for achieving VTO have evolved from two-dimensional to three-dimensional approaches, enabling digital tooth alignment to be performed from multiple angles and with greater efficiency. Furthermore, the scope of prediction has gradually expanded beyond mere tooth arrangement to include facial soft tissues, jawbones, and more, constructing a comprehensive oral simulation system that incorporates multiple tissues [3]. With the patient's informed consent for the entire treatment and reporting process, this article presents a case of adult Class I malocclusion correction assisted by digital VTO.

2. Case Report

A 22-year-old female presented with the chief complaint of "protruding teeth." The patient reported that after the transition from primary to permanent teeth, she noticed protrusion and misalignment of her teeth. She has no oral habits that may have contributed to the condition and denies any previous orthodontic treatment. The patient has a history of trauma to the upper anterior teeth but denies any systemic diseases or a family history of genetic disorders. Facial Examination: Frontal View: The face is generally symmetrical on both sides, with the upper, middle, and lower thirds of the face evenly proportioned. No lip incompetence or tooth exposure was observed. Lateral View: The profile is convex, with tension in the lip and mentalis muscles. Intraoral Examination: The patient has a permanent dentition. The molar relationship is neutral on both sides, with a distal canine relationship on the right side and a neutral canine relationship on the left side. The overbite is 5.8 mm, and the overjet is 3 mm. The upper midline is nearly aligned with the facial midline, while the lower midline is deviated 1.5 mm to the right. The upper dental arch is ovoid in shape, and the lower arch is square-ovoid. Teeth #11 and #21 exhibit mesial rotation and tooth #43 is labially displaced. There is 3 mm of crowding in the upper arch and 2.5 mm of crowding in the lower arch. The curve of Spee in the lower arch is flat. The Bolton anterior ratio is 74%, and the overall Bolton ratio is 91% (**Figure 1**). Mandibular Function and Temporomandibular Joint (TMJ) Examination: The maximum mouth opening is approximate "three finger widths". The opening pattern is normal, and no abnormalities were detected during the TMJ examination.

Figure 1. Pretreatment facial and intraoral photographs.

Panoramic radiograph shows the absence of tooth #38, vertical impaction of teeth #18 and #28, and horizontal impaction of tooth #48. The root morphology of the remaining teeth is normal (Figure 2). Cephalometric analysis of the lateral cephalogram reveals excessive protrusion of the upper anterior teeth, skeletal Class I, and a high-angle pattern (Table 1). This patient was diagnosed with: Angle Class I malocclusion; Skeletal Class I; High-angle pattern; Protrusion of the upper anterior teeth; Mild dental crowding; Moderate deep overbite; Horizontal impaction of the right mandibular third molar.

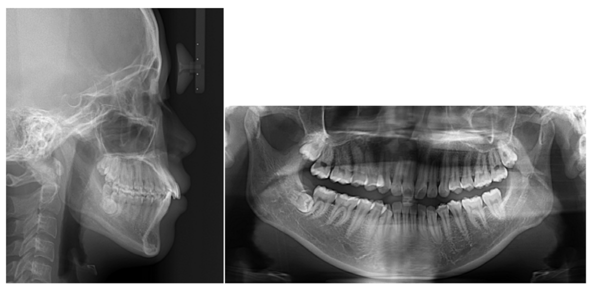

Figure 2. Pretreatment lateral cephalogram and panoramic radiograph.

Table 1. Cephalometric data before and after orthodontic treatment.

Measurement	Pretreatment	Chinese norm	Posttreatment
SNA (˚)	82.3	82.8 ± 4.0	79.47
SNB (˚)	78.18	80.0 ± 3.0	75.57
ANB (˚)	4.12	2.70 ± 2.0	3.90
FH-MP (˚)	35.49	28.0 ± 4.0	36.62
MP-SN (˚)	41.92	33.0 ± 4.0	42.33
U1-NA (˚)	23.23	21.0 ± 6.0	21.04
U1-NA (mm)	7.16	4.0 ± 2.0	2.07

Continued

L1-NB (˚)	24.3	28.0 ± 6.0	22.87
L1-NB (mm)	6.88	6.0 ± 2.0	3.56
U1-L1 (˚)	137.36	127.0 ± 9.0	137.4
U1-PP (mm)	29.72	28.0 ± 2.0	28.83
L1-MP (mm)	43.2	40.0 ± 2.0	41.45
ZAngle (˚)	68.36	71.0 ± 5.0	72.57
UL-EP (mm)	2.17	−1.4 ± 0.9	−0.77
LL-EP (mm)	3.41	0.6 ± 0.9	−0.69

3. Treatment Objectives

To correct bimaxillary protrusion, retract the anterior teeth, achieve alignment and leveling of both dental arches, establish optimal occlusal relationships, and enhance the patient's facial profile.

4. Treatment Alternatives

1) Inform the patient that the treatment will involve tooth extraction and, if necessary, the placement of temporary anchorage devices, and explain the potential risks associated with the treatment. 2) Collect comprehensive pre-treatment data, including panoramic radiographs, lateral cephalograms, cone-beam CT scans, facial and intraoral photographs, and intraoral scanning data. 3) Before the extraction procedure, utilize oral scanning data and the 3Shape orthodontic module, in conjunction with conventional diagnostic records, to conduct a digital tooth alignment trial (VTO) to determine the final extraction plan. 4) After extractions, initiate full-arch fixed orthodontic treatment, align and level the dental arches, and retract the upper and lower anterior teeth.

5. Treatment Progress

Import the patient's pre-treatment intraoral scanning data into the 3Shape OrthoSystem for digital tooth alignment (**Figure 3**).

Propose two different extraction plans: Plan 1 involves extracting the first premolars bilaterally in both the upper and lower arches; Plan 2 involves extracting the second premolars bilaterally in both arches. Use digital tooth alignment simulations to model the final treatment outcomes for each plan (**Figures 4-5**). By comparing the alignment results of the two plans through model superimposition (**Figure 6**). Compared to Plan 2, Plan 1 achieves an additional 1.17 mm of anterior retraction, with a more pronounced upright effect on both upper and lower anterior teeth. Based on the patient's cephalometric measurements, excessive retraction of the upper lip should be avoided, and the FH-MP angle of 35.49˚ suggests a high-angle tendency. Additionally, the patient reported a prior trauma to the upper anterior teeth about a year ago, which increases the risk of root resorption during orthodontic treatment. Therefore, it is recommended to limit the movement of the upper anterior teeth to achieve aesthetic goals while minimizing the risk of root resorption, making the extraction of the second more appropriate. Plan 2, which involves extracting the second premolars bilaterally, was selected for the final treatment.

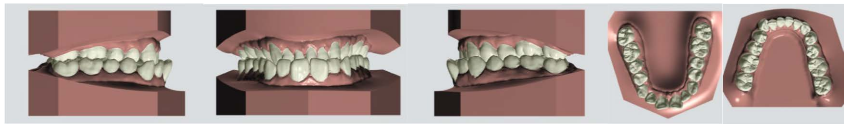

Figure 3. Pre-treatment data displayed in the 3Shape OrthoSystem software.

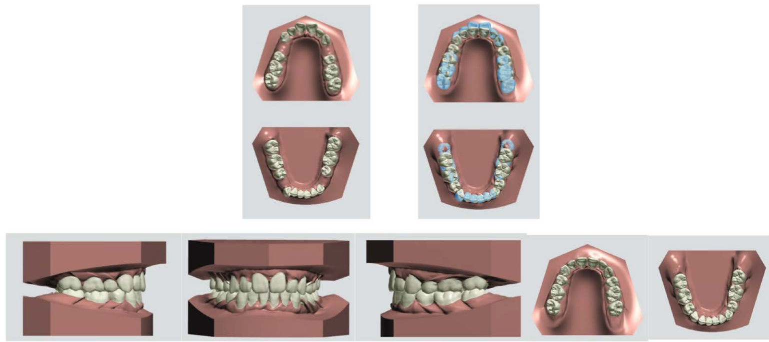

Figure 4. Digital tooth alignment results based on extraction Plan 1.

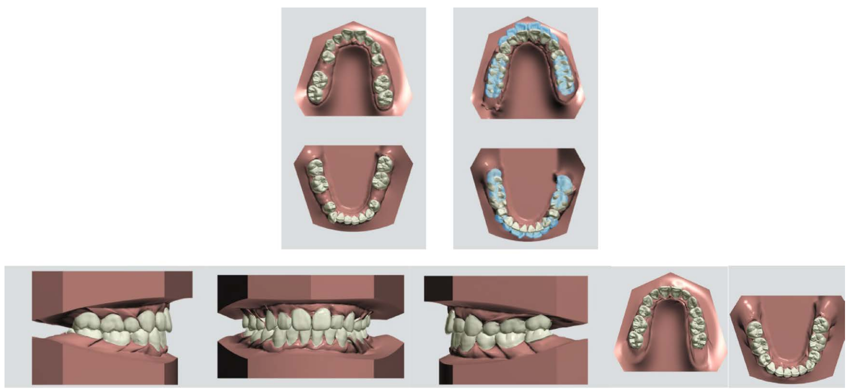

Figure 5. Digital tooth alignment results based on extraction Plan 2.

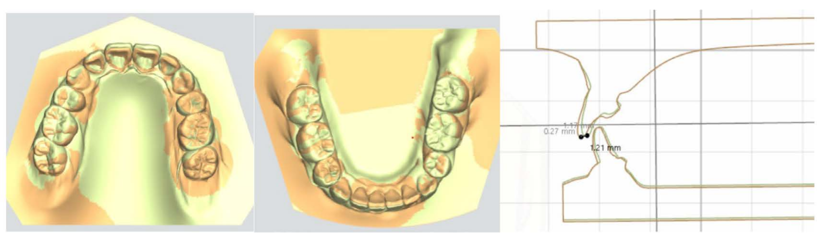

Figure 6. Model superimposition of the two extraction plans.

After extracting teeth #15, #25, #35, #45, #18, #28, and #48, brackets were bonded to both the upper and lower arches. Sequential nickel-titanium round wires of 0.014", 0.016", and 0.018" were used to align the teeth, followed by nickel-titanium rectangular wires of 0.016 × 0.022", 0.017 × 0.025", and 0.018 × 0.025", and finally stainless steel rectangular wires of 0.017 × 0.025" and 0.018 × 0.025". To close extraction spaces using stainless steel rectangular wires, distal tip-backs are applied to posterior teeth to prevent mesial tipping of molars, particularly in the maxillary arch. In the final stages, any remaining minor gaps are closed more efficiently with vertical closure loops bent on stainless steel round wires. After switching to stainless steel rectangular wires, continuous use of 1/4-inch elastics for Class II intermaxillary traction is employed to adjust both the canine and molar relationships (Figure 7).

The fixed orthodontic treatment lasted for 30 months, followed by the use of a clear retainer for retention after treatment (Figures 8-9).

Figure 7. Intraoral image of the patient during treatment (13th month).

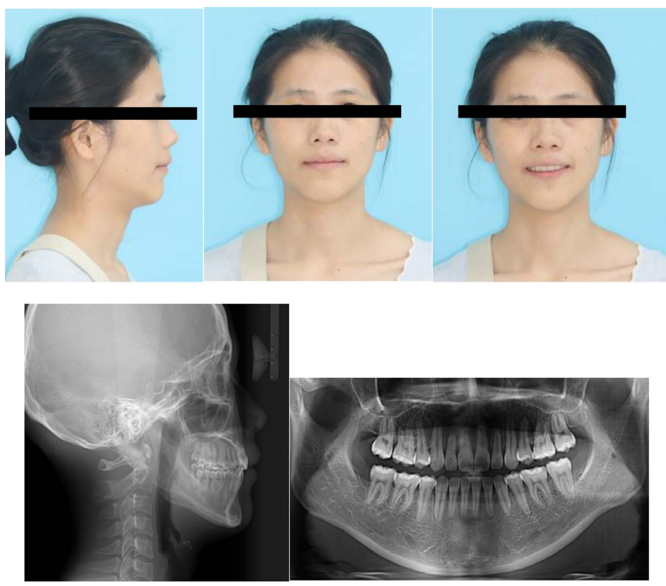

Figure 8. Posttreatment facial and radiographic images.

Figure 9. Posttreatment intraoral photograph.

6. Treatment Results

At the conclusion of treatment, the upper and lower incisors were retracted with a shallow overbite and overjet. Bilateral molars exhibited a neutral (Class I) relationship. The temporomandibular joint area showed no signs of tenderness or clicking, and mandibular movements, including opening, closing, and lateral excursions, were normal, without premature contacts or occlusal interferences. The changes in cephalometric measurements before and after treatment are presented in Table 1. Superimposition of pre- and post-treatment cephalometric tracings (Figure 10) demonstrates significant retraction of the upper incisors and a reduction in facial convexity.

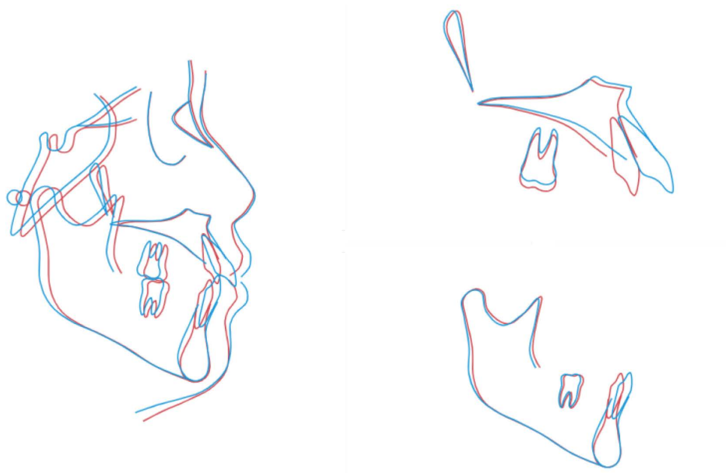

Figure 10. Overall superimposed tracings. (Blue, pretreatment; Red, posttreatment).

7. Discussion

A convex facial profile is a common malocclusion, particularly prevalent in southern regions of China. This case primarily presented as an Angle Class I malocclusion with maxillary protrusion. For Class I malocclusions with a dental protrusion, the primary treatment approach involves extraction to create space for retraction of the upper and lower incisors, with the aim of reducing facial convexity. Many researchers believe that differences exist between the treatment outcomes, duration, and anchorage considerations when extracting first premolars versus second premolars. Therefore, selecting the appropriate extraction plan is a critical step in the treatment process. However, different clinicians may propose varying extraction plans for the same case, and even the same clinician may recommend different plans for similar cases. Achieving a high-quality extraction plan requires careful decision-making, as extractions are irreversible procedures that cannot be repeatedly tested on the same patient. As a result, visual treatment objectives (VTO) are particularly important in orthodontic treatment planning.

In this case, a digital setup was used to achieve the visual treatment objectives (VTO) through the 3Shape OrthoSystem software, which predicted the treatment outcomes of different extraction plans and calculated key data such as the amount of incisor retraction and molar mesial movement [4]. This approach helped avoid issues like insufficient or excessive incisor retraction, loss or overuse of anchorage, and midline deviation caused by improper extraction plan design or inadequate anchorage control [5]. Before initiating extraction-based treatment, two extraction plans were simulated. The results showed that extracting four first premolars resulted in greater incisor retraction, more upright incisors, less mesial movement of the maxillary first molars, and a slightly wider maxillary arch width at the first molar segment compared to extracting four second premolars [6] [7]. Based on the patient's cephalometric data, the patient was diagnosed with high-angle skeletal Class I malocclusion with maxillary incisor protrusion, and mandibular incisors were relatively upright. Intraorally, the crowding was mild (Class I), with a deep overbite (Class II). Additionally, the patient had a history of trauma to the maxillary incisors. Taking all these factors, along with the VTO setup results, into consideration, it was determined that the maxillary incisors should be moderately retracted to reduce the risk of root resorption. Therefore, extraction plan two, which involved extracting four second premolars with moderate anchorage control of the maxillary molars, was chosen for treatment. In terms of anchorage selection, since the goal is to retract the protrusive upper anterior teeth while minimizing their movement, strict control of molar anchorage is essential. Extracting the first premolar, compared to the second premolar, generally allows for greater anterior retraction, as the first premolar extraction results in less molar movement, preserving more space for anterior retraction and providing stronger anchorage. In this case, where dental crowding is minimal, and to avoid excessive anterior movement that could lead to root resorption during orthodontic treatment, extraction of the second premolar is considered more appropriate. With a second premolar extraction, special attention must be given to prevent the extraction space from being excessively occupied by mesially shifting first molars, which would reduce the effectiveness of anterior retraction. Therefore, throughout the treatment, molar anchorage will be carefully monitored and adjusted using methods such as utility arches and tip-back bends to achieve moderate anchorage. This approach prevents excessive mesial movement or tipping of molars during anterior retraction, thus maintaining stable anchorage.

There is still room for improvement in the field of digital tooth arrangement research. Currently, the simulated tooth movements in three-dimensional digital tooth arrangement software follow a mechanical motion model and cannot fully replicate tooth movement under biomechanical responses [8]. Additionally, due to variations in software algorithms and the semi-automatic nature of some steps, operators still require manual adjustments. For instance, the segmentation process may lead to inaccurate tooth data, as accurate digital arrangement relies on precise three-dimensional tooth models. If the models are coarse or distorted, the system may fail to recognize data correctly, thereby increasing uncertainty in tooth arrangement outcomes. Studies indicate that, in comparisons between digital tooth arrangement simulations at this stage and actual orthodontic outcomes, there is no statistical deviation for parameters such as overbite, overjet, and IMPA angle. However, some indices, such as the nasolabial angle and nasofacial angle, show statistical differences [9] [10].

Based on the comparison of pre- and posttreatment facial and intraoral photographs, there was a significant improvement in facial convexity after treatment. Both the upper and lower lips were positioned behind the E-line, with the maxillary incisors aligned and retracted and the midlines of the upper and lower incisors nearly coinciding. Cephalometric data comparison showed that the ANB angle decreased from 4.12˚ to 3.90˚, and the U1-NA (mm) value reduced from 7.16 mm to 2.07 mm, indicating significant retraction of the maxillary incisors. The mandibular plane angle remained essentially unchanged throughout the treatment. The upper lip projection decreased from 2.17 mm to −0.77 mm, and the lower lip projection reduced from 3.41 mm to −0.69 mm, resulting in a transition from a convex to a straight profile. After treatment, the upper and lower incisors were upright within the alveolar bone, and the roots of the incisors exhibited a slightly rounded shape with no evident root resorption or tooth mobility, aligning with the principles of healthy orthodontic treatment. The patient expressed satisfaction with the treatment outcome.

8. Conclusion

Digital VTO offers advantages such as visual clarity, repeatability, and high precision. In managing borderline cases, such as determining whether to extract teeth or selecting an extraction plan, digital VTO can assist orthodontists in developing high-quality treatment strategies. With the integration of advanced technologies like artificial intelligence, the precision and biomimetic accuracy of digital tooth alignment are expected to improve further in the future [11] [12], supporting optimization and innovation in orthodontic treatment.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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