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Case Report
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Invisible Orthodontic Technology to Assist Long Distance Movement of Maxillary Molars Through the Maxillary Sinus, A Case Report

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Abstract

A 26-year-old previously healthy adult female had a chronically missing left maxillary first molar with a poor bite and associated maxillary sinus collapse. The molar was successfully moved anteriorly by more than 5 millimeters through the maxillary sinus by means of the Invisalign technique without any assistive tools. The gap was finally closed and the patient's occlusal and esthetic function was significantly improved. This case demonstrates the light force application characteristics and flexible design of the Invisalign technology for complex cases [1,2].

Diagnosis and Etiology

A 26-year-old girl came with a chief complaint of uneven teeth and poor occlusion. The patient was physically healthy without significant family history or systemic disease. Pre-treatment facial photographs showed a symmetrical face and normal vertical facial height, when she smiled, the maxillary dental midline deviates 1mm to the left relative to facial midline, and the exposure of maxillary incisors is normal. Lateral appearance observation showed thick lips and convex profile. The intraoral examination indicated a permanent dentition with unseen maxillary right second premolar, maxillary left lateral incisor, first molar and large fillings were seen in the maxillary central incisor and left maxillary first premolar Figure 1. The cast analysis Figure 2 demonstrated a 24.36 mm space in the upper dentition and 6mm crowding in the lower dentition. Arch widths of the maxillary and mandibular intercuspids were 33.5 mm and 26.1 mm, respectively, and the mandibular intermolar width was 41.7 mm, a mild curve of Spee (2.0 mm), normal overjet and overbite, and neutral molar relationship.

Panoramic radiographs and cone-beam computed tomography (CBCT) revealed essentially symmetrical condylar morphology bilaterally with continuous bone cortex and normal height alveolar bone. Maxillary right wisdom tooth present Figure 3A. CBCT showed an alveolar bone defect in the left maxillary first molar after tooth extraction. The distances from the proximal mesial root and crown of the left maxillary second molar to the anterior wall of the maxillary sinus were 16.8 mm and 9.9 mm, respectively. Meanwhile, the distances from the apical root and proximal mesial crown of the left maxillary third molar to the anterior wall of the maxillary sinus were 22.5 mm and 19.8 mm, respectively Figure 4.

Combined with cephalometric analysis, the patient was diagnosed with skeletal class II, Angle Class I malocclusion with dental defects (Figure 3B and Table 1).

Treatment Options

Two treatment options were provided:

1. The first option was to extract 25, 34, 44, restore 22, 26 with implants and 14, 11, 21 with fixed restorations at the end of orthodontic treatment. With this option, the patient would have a shortened course of treatment. However, it requires patients to undergo additional implant surgery and faces long-term gaps in missing teeth (aesthetics) and an increased risk of alveolar bone loss.

2. The second option was the extraction of 34 and 44 to regain space with subsequent orthodontic traction. This option could preserve the patient's natural teeth, which is beneficial to improving the appearance and oral function. However, it is associated with many potential complications,

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Figure 1: Facial and intraoral photos before treatment.

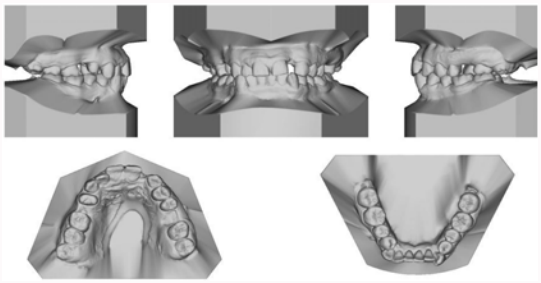

Figure 2: Tooth model before treatment.

Figure 3: X-ray examination A, panoramic film B, lateral skull film before treatment.

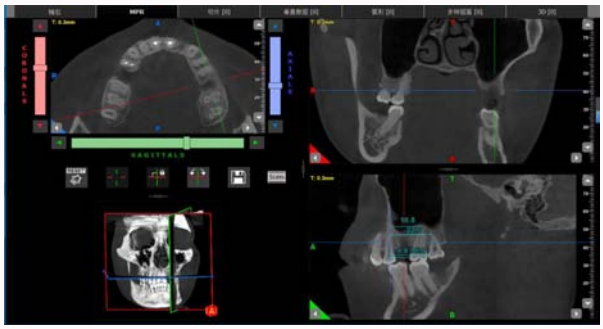

Figure 4: CBCT images before treatment.

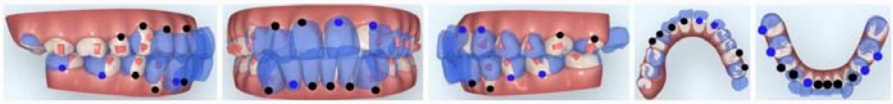

Figure 5: Design of orthodontic attachment in the first stage

including the asymmetry of the arch and the compromise of the occlusal relationship associated with asymmetric extractions, as well as a risk of traction failure.

The patient considered and chose option 2 eventually.

Treatment Objectives

Align the upper and lower teeth and close the gap. Coordinate the occlusal relationship and align the midline of the front teeth.

Figure 6: Oral image at step 28.

Figure 7: Intraoral and extraoral images at the end of the first stage.

Figure 8: X-ray examination at the end of the first stage (panoramic film A, lateral skull film B).

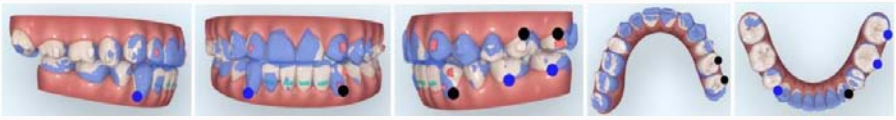

Figure 9: Design of orthodontic attachment in the second stage.

Figure 10: Intraoral and extraoral at the end of the third stage of treatment.

The first stage of designing tooth movement method is shown in Figure 5.

1. After tooth extraction, design weak anchorage on the left side and strong anchorage on the right side of the maxillary posterior teeth, and design weak anchorage on the lower jaw. Use the tooth extraction gap to align and level the lower dental arch, and adjust the occlusal relationship.

2. Design a distal inclination of the upper and lower molars, add lingual torque to the upper and lower front teeth roots, then lower the upper and lower front teeth to prevent the occurrence of "bone opening", "bone cracking", and "pendulum effect" during the adduction process.

3. Add appropriate root-lingual torque to the maxillary canines, while coordinating the arch shape and the width between the canines.

Figure 11: X-ray examination after orthodontic treatment (A panoramic film, B lateral skull film).

Figure 12: CBCT examination at the end of orthodontic treatment.

Orthodontic process: the patient was instructed to change the aligners at a frequency of 10 days/step and to wear them for more than 22 hours/day. Step 28 shows that the patient's tooth extraction gap has narrowed, the crowding of the lower front teeth has been relieved, while the left posterior tooth shows an open bite (Figure 6). At step 47, the maxillary anterior teeth were internally retracted, and only a small gap remained between the upper and lower dentition. The upper and lower midlines were aligned, and the anterior teeth achieved normal overjet and overbite. The right posterior teeth largely achieved cusp-fossa interlocking, the left posterior teeth had an increased open bite, and the anterior protruding facial shape improved (Figure 7). A restart was initiated and imaging is shown in Figure 8. In the second stage, 13 tooth roots are designed for proximal movement and 12 tooth roots are designed for distal movement; 25, 27, and 28 extend and move closer as a whole; Tight mandibular dentition see in Figure 9.

Treatment Results

Post-treatment facial photographs show an improved lateral appearance. Intraoral examination showed complete closure of the arch gap at the end of orthodontic treatment, and Class I canine and molar relationships were established with proper overbite and overjet (Figure 10). The panoramic X-ray and CBCT images after treatment showed that 27 and 28 were moved forward to close the gap after tooth extraction, and 27 entered the maxillary sinus. The roots of the upper and lower teeth were arranged parallel, and no obvious absorption was observed Figure 11A. The distances from the crown and mesial root of tooth 27 to the anterior wall of the maxillary sinus were 6.0mm and 11.4 mm, respectively, while the distances from the crown and mesial root of tooth 28 to the anterior wall of the maxillary sinus were 15.9 mm and 20.4 mm, respectively Figure 12.

Cephalometric analysis revealed an improvement of sagittal skeletal discrepancy between the maxilla and mandible, with a significant reduction in the ANB angle (ANB from 5.29 to 3.28). The anterior teeth were restored to normal inclination (U1-SN from 99.81 to 93.25; L1-MP from 96.61 to 90.78) (Figure 11B and Table 1).

Table 1: Cephalometric analysis.

Measurement item	Normal value	pre-treatment	post-treatment
SNA (°)	82.0±4.0	80.5	79.55
SNB (°)	80.0±4.0	75.21	76.27
ANB (°)	3.0±2.0	5.29	3.28
U1-SN (°)	105.0±6.0	99.81	93.25
IMPA (°)	92.5±7.0	96.61	90.78
U1-L1(°)	82±4	127.36	141.34
GoGn-SN (°)	82±4	35.98	34.13

Discussion

The adult maxillary sinus varies in morphology, is adjacent to the posterior maxillary teeth, and is prone to collapse. Early scholars questioned the movement of tooth roots through the maxillary sinus, believing that when the roots of maxillary molars pass through the thin layer of cortical bone on the bottom wall of the maxillary sinus and undergo orthodontic movement, it is easy to form "cortical bone anchorage", resulting in incomplete closure of the molar space and even hard tissue damage [3,4]. Later scholars found through further clinical research that under light force conditions, mesenchymal stem cells present on the maxillary sinus membrane can differentiate into osteoblasts, undergo osteogenic activity, and achieve "bone penetration movement" [5].

Traditional molar advancement techniques, including the use of straight wire arch orthodontic techniques and partial molar relocators, are not only complex but also discomfort. Invisalign has the advantage of assisting the movement of teeth through the maxillary sinus by personalizing the design of the support and step, providing a continuous light force for molar movement and torque control during the orthodontic process [6,7].

The design of anchorage is the key to successful treatment, and step-by-step design is the guarantee of treatment effectiveness. In routine cases that require long-distance movement of molars,

implantation screws are generally used to achieve this. In this case, the designed molars are weakly anchored, and it is advisable to avoid simultaneous movement of both molars when the molars move towards the mesial direction. At the same time, using the reaction force of 27 close movement to enhance the anchoring of 28, the close movement of 28 only begins after ensuring sufficient wrapping of the invisible aligner appliance to 27 and 28 at half the distance of 27 close movement. This not only saves steps, but also prevents the molars from tilting forward during the process of proximal movement. Ultimately achieving gap closure and achieving good therapeutic effects.

Conclusion

A successful case of maxillary sinus movement requires sufficient evaluation of the difficulty of the case before treatment, sufficient understanding of the advantages and disadvantages of orthodontic tools, and sustained positive axis in the posterior tooth area during orthodontic treatment. Finally, it is of great significance to increase the retention period after orthodontic treatment to ensure the effectiveness of the treatment.

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