Skeletal Anchorage Facilitates the Treatment of Jaw Deformities with Vertical Discrepancy: Its Application and Limitations

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Abstract: The treatment of severe skeletal vertical discrepancy in patients with jaw deformity consists mainly of surgically repositioning the maxilla and/or mandible, because tooth extrusion has been generally regarded as an unstable movement and absolute tooth intrusion has been impossible with traditional orthodontic mechanics. However, the emergence of temporary anchorage devices (TADs) has significantly changed the treatment strategy.

Le Fort I osteotomy or anterior alveolar segmental osteotomy has been used in cases of excessive overbite with a gummy smile. Meanwhile, TADs make it reasonably possible to intrude the incisors without any undesirable counteractions, and also helps to increase the application of camouflage treatment in cases of severe deep overbite. Molar intrusion using TADs has now become a new strategy for treating open bite patients. In cases with a skeletal Class I or II jaw relationship, absolute molar intrusions and the subsequent counterclockwise rotation of the mandible are quite effective to increase the reduced overbite. These methods have several advantages compared with orthognathic surgery, including less surgical stress, less psychological stress, lower cost, and less postoperative discomfort with better treatment results.

On the other hand, some clinicians are still concerned about the biological safety of tooth intrusion. Several clinical studies have revealed that neither remarkable root resorption nor disruption of the periodontal tissue was induced. Moreover, our recent histological study demonstrated that mechanical stress induced new bone formation on the surface of the maxillary sinus. These evaluations suggest that absolute tooth intrusion might be a safe procedure and have no limitation on its movement. However, further studies are required to assess its long-term alteration.

Introduction

The treatment of severe skeletal vertical discrepancy in patients with jaw deformity consists mainly of surgically repositioning the maxilla and/or mandible, because it is impossible to change the size or shape of deformed jaw bones without orthognathic surgery. As for jaw deformities with vertical discrepancy, they are closely related to several specific malocclusions. Maxillary vertical excess often causes a deep overbite with a gummy smile, while patients with a long-face tendency occasionally also have an anterior open bite.

Treatment of these vertical discrepancies is often difficult, because absolute tooth intrusion has been impossible in conventional orthodontic mechanics and tooth extrusion has been generally regarded as one of the most unstable tooth movements.

On the other hand, the emergence of temporary anchorage devices (TADs) has greatly expanded the possibility of orthodontic camouflage treatment in mild to moderate jaw deformity patients. Even without patient cooperation, these materials can provide stationary anchorages for various tooth movements and even make it possible to move the tooth in directions...
which have been impossible with traditional orthodontic mechanics. In this article, we describe the clinical application of TADs in jaw deformity patients with vertical discrepancies and discuss its limitations.

**Application of TADs in deep overbite cases**

Patients with a mild to moderate deep overbite have been treated without orthognathic surgery since their facial profile is generally included in the acceptable range. On the other hand, Le Fort I osteotomy or anterior alveolar segmental osteotomy has been used in excessive overbite cases with a gummy smile because it was difficult to achieve sufficient incisor intrusion without orthognathic surgery. Meanwhile, the recent development of TADs makes it reasonably possible to intrude the incisors, and helps to increase the application of camouflage treatment in deep overbite cases. Typically, TADs are placed in the intraradicular areas of incisors and intrusion force is directly applied from the TADs to arch wires. Incisor intrusion of approximately 1 mm per month is possible. As a result of the procedure, both the deep overbite and gummy smile are improved without any undesirable counteraction, i.e. apical root resorption, pulp necrosis, and extrusion of the posterior teeth. In comparison with traditional intrusion mechanics such as a high-pull J-hook headgear on the maxilla, the method does not require patient cooperation and provides better treatment results.

**Application of TADs in anterior open bite cases**

Treatment of anterior open bite was dramatically improved by the application of TADs as an absolute anchorage. In cases with a skeletal Class I or II jaw relationship, absolute molar intrusions and the subsequent counterclockwise rotation of the mandible are quite effective for increasing the reduced overbite. As a result, we can now treat such patients without orthognathic surgery even though they have a negative overbite of less than −5 mm.

The method has several advantages compared with surgical maxillary and mandibular repositioning, including less surgical stress, less psychological stress, lower cost, and less postoperative discomfort. Additionally, our cephalometric comparative study in severe anterior open bite patients indicated that the incisors were significantly elongated in surgically treated subjects and there were no significant differences in the treatment results between TADs and surgery groups, with reduced facial heights of 4.0 mm and 3.8 mm, and increased overbites of 6.8 mm and 7.0 mm, respectively. These results reveal that the new method also provides better treatment results than two-
Fig. 3 Schematic illustration of molar intrusion treatment in patients with anterior open bite. Before intrusion (A); after intrusion (B). Reduced overbite was improved by the mandibular forward rotation resulting from molar intrusions.
Jaw surgery in cephalometrics. Molar intrusion using TADs has thus become a strategy for treating anterior open bite patients.

A detailed analysis of the treatment process in nine open bite patients showed that one millimeter molar intrusion by TADs resulted in approximately 1 degree counterclockwise rotation of the mandible (Fig. 4A). As a result, the overbite was increased by 1.7 mm per 1 mm molar intrusion on average (Fig. 4B). A recent report also demonstrated similar correlations between the cephalometric parameters. These parameters might be useful for predicting the prognosis of absolute molar intrusion in severe anterior open bite cases. On the other hand, the change of SNB angle was not correlated with the amount of molar intrusion \((r = 0.1659)\). Individual prediction of profile improvement is recommended since the change is strongly affected by each skeletal feature.

The strategy is not considered appropriate for patients with a skeletal Class III jaw relationship, since the mandibular forward rotation emphasizes the protruded chin which might not be acceptable in terms of facial esthetics (Fig. 5). Even in such cases, the molar intrusion with TADs can also facilitate the surgical procedure to avoid maxillary surgery and to increase the stability of the mandibular repositioning.

Several recent studies evaluated relapse rates of molar intrusion using TADs. Sugawara, et al. evaluated relapse rates of molar intrusion using TADs.
reported that the average relapse rates of mandibular molar intrusion were 27% at the first molars and 30% at the second molars. Heravi, et al.\textsuperscript{24} subjected 10 overerupted maxillary first molars which were intruded by two miniscrews to a force of 100 g and concluded that the amount of intrusion was 2.1 mm and the relapse during a 6-month retention period was 0.4 mm, giving a relapse rate of 19%. Baek, et al.\textsuperscript{25} analyzed the nine anterior open bite cases treated with maxillary molar intrusion using miniscrews, and reported that the first molars were intruded by 2.4 mm and relapsed by 0.5 mm at the 3-year follow-up on average, for a relapse rate of 23%. Incisal overbite increased by a mean of 5.6 mm during treatment and decreased by a mean of 1.2 mm by the end of the retention period, giving a relapse rate of 17%. These results demonstrate the clinical stability of molar absolute intrusion, although 20 to 30% overcorrection is recommended. Although most open bite patients treated by TADs show stable treatment outcomes in our clinical experience, long-term stability is still unknown and future studies are required.

**Biological limitations of absolute tooth intrusion**

We now know much about the usefulness of absolute tooth intrusion for the treatment of jaw deformity patients. However, some clinicians are still concerned about its biological safety. Wehrbein, et al.\textsuperscript{25} showed that root resorption and a loss of osseous supporting tissue may occur in the basal cortical bone of the nasal sinus after translatory tooth movements in dogs. In addition, they also reported on their histological findings in human beings that tooth movement in the maxillary sinus region was accompanied by rival resorptive processes from the periodontal ligament side and from the sinus side and it might cause root resorption\textsuperscript{26}.

In contrast, several clinical studies explored the dentoalveolar changes after tooth intrusion with TADs and revealed that neither remarkable root resorption nor disruption of the periodontal tissue was induced\textsuperscript{14-17}. Further, several animal studies revealed the histology of molar intrusion with TADs\textsuperscript{27, 28}. Konno, et al.\textsuperscript{27} reported on the morphologic and hemodynamic changes of dental pulp and periodontal ligament during and after absolute molar intrusion in dogs. In their report, after 4-month intrusion with skeletal anchorages, both blood flow in pulp and the number of capillary vessels around the root apex were significantly decreased and vacuolization in the odontoblast layer was increased. However, these recovered after the 4-month retention phase. Moreover, nervous continuity in pulp remained normal during the tooth intrusion.

Daimaruya, et al.\textsuperscript{28} showed bone formation around the root apex which penetrated the bony floor of the nasal cavity after the orthodontic molar intrusion using mini-plates as a skeletal anchorage in their animal experiments. In their study, the nasal mucosa was initially lifted and a thin epithelial layer covered the root apex, but the bone formation was observed abundantly around the apex after the 7-month intrusion. Our recent histological study also revealed that bone formation on the surface of the maxillary sinus was evoked by mechanotransduction of mechanical stress applied to a tooth, and was induced ahead of bone resorption on the periodontal ligament side.\textsuperscript{29} The results suggest that teeth can be moved into the sinus without losing bone or causing root damage. This osteogenic ability has been exploited for sinus floor augmentation\textsuperscript{30}. Following elevation of the sinus wall membrane, bone formation around implants inserted into the maxillary sinus was significantly enhanced without any bone grafting\textsuperscript{31, 32}. Carrillo, et al.\textsuperscript{33} reported that constant intrusive forces for mandibular molars with TADs from 50 to 200 g produced clinically significant amounts of intrusion with little or no root resorption, suggesting that immediately loaded TADs hold great promise as fixed anchorage devices for intruding multi-radicular teeth.

Overall, these evaluations suggest that absolute tooth intrusion might be a safe procedure and have no limitations of its movement. However, further studies are required to assess its long-term alteration.

**References**


