J Huazhong Univ Sci Technol [Med Sci]
DOI 10.1007/s11596-013-1197-5
33(5):780-785,2013

Intrusion of Overerupted Maxillary Molars with Miniscrew Implant Anchorage: A Radiographic Evaluation

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Summary: The aim of this retrospective study was to quantitatively evaluate the treatment effects of intrusion of overerupted maxillary molars using miniscrew implant anchorage and to investigate the apical root resorption after molar intrusion. The subjects included 30 patients whose average ages were 35.5±9.0 years. All patients had received intrusion treatments for overerupted maxillary molars with miniscrew anchorage. There were 38 maxillary first molars and 26 maxillary second molars to be intruded. Two miniscrews were inserted in the buccal and palatal alveolar bone mesial to the overerupted molar. Force of 100–150 g was applied by the elastic chains between screw head and attachment on each side. Lateral cephalograms and panoramic radiographs taken before and after intrusion were used to evaluate dental changes and root resorption of molars. Only 6 of the 128 miniscrews failed. The first and second molars were significantly intruded by averages of 3.4 mm and 3.1 mm respectively (P<0.001). The average intrusion time was more than 6 months. The crown of the molars mesially tilted by averages of 3.1 degrees and 3.3 degrees (P<0.001) for first and second molars. The amounts of root resorption were 0.2–0.4 mm on average. The intrusion treatment of overerupted molars with miniscrew anchorages could be used as an efficient and reliable method to recover lost restoration space for prosthesis. Radiographically speaking, root resorption of molars was not clinically significant after application of intrusive forces of 200 to 300 g.
Key words: overerupted molar; miniscrew implant anchorage; molar intrusion

The overeruption of maxillary molars is a common problem in adult patients, usually caused by early loss of antagonist teeth. These overerupted teeth often make prosthodontic treatment difficult or even impossible, and also may result in occlusal interferences, functional disturbances and compromised periodontal health[1–3].

Traditionally, the treatment methods for correcting the elongated molar include coronal reduction, surgical impaction, extraction of severely extruded tooth, and orthodontic therapy with removable appliance, extraoral headgear or full-arch fixed appliance[4–8]. Coronal reduction by grinding is the simplest and quickest way, but it often requires endodontic treatment, periodontal surgery and crown restoration. Most patients also refuse to accept the subapical osteotomy or extraction treatment.

Orthodontic intrusion is a more conservative approach. Conventional fixed orthodontic treatment requires a full-arch appliance to intrude on the molar because of inadequate anchorage[8–10], but many adults are wary of wearing visible braces[7]. High-pull headgear and removable appliances can also be used to intrude on the maxillary molar. However the treatment result of these methods depends greatly on patient compliance[7, 11].

Recently, skeletal orthodontic anchorage systems have been recognized as stationary anchorage for various tooth movements[1–3, 12–22]. Of all skeletal anchorage devices, miniscrew implants are presently the smallest, and have the advantage of minimal anatomic limitation on placement, simpler placement and removal procedures, the ability to load immediately, lower medical costs, and no need for patient compliance. Miniscrew implants are especially appropriate for teeth intrusion because they can provide stationary vertical anchorage[23]. Several reports have demonstrated that severe skeletal open bites could be corrected by an intrusion of posterior teeth with mini-implant anchorage[19–22]. Miniscrew implants also make it possible to apply continuous light forces while intruding teeth, which could decrease apical root resorption during active intrusion treatment[24, 25].

The intrusive mechanics of overerupted molars with miniscrew implant anchorage are still poorly investigated. The available literature mainly consists of some case reports[2, 3, 26–29], a few animal studies[25, 30, 31], and one retrospective study about three-dimensional digital models[1]. However, fewer studies have reported in detail the intrusive movement of overerupted maxillary molars. The aims of this study were to quantify the treatment effects of the intrusion of overerupted maxillary molars using miniscrew implants, and to investigate the apical root resorption after molar intrusion.

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1 MATERIALS AND METHODS

1.1 Subjects

The subjects of this study included 30 patients (5 males and 25 females) from our department. Their ages ranged from 19 to 50 (mean 35.5±9.0 years). All patients had received orthodontic treatment of intrusion of overerupted maxillary molars with miniscrew anchorage before their prosthetic reconstruction for the missing mandibular molars. They refused full-arch fixed appliances for aesthetic reasons. Only partial appliances were adopted for these patients because of the application of skeletal anchorage. There were 38 maxillary first molars and 26 maxillary second molars to be intruded in these 30 patients. All participants underwent periodontal examinations prior to orthodontic treatment and no advanced periodontal diseases were detected.

1.2 Miniscrew Implant Procedure

To provide stationary skeletal anchorage, two self-drilling orthodontic miniscrews, 1.6 mm in diameter and 11 mm in length, were implanted into the buccal and palatal alveolar bone mesial to the overerupted molar respectively. Under infiltrative local anesthesia the miniscrews could be drilled directly into the cortical bone manually with a screwdriver. No mucoperiosteal flap and pilot drilling were necessary. The buccal miniscrew was inserted at the level of the mucogingival junction. The palatal miniscrew was inserted in the palatal slope. One hundred and twenty-eight miniscrews were implanted in this study to intrude 64 overerupted molars.

1.3 Orthodontic Treatment

After one week of miniscrew implantation, intrusion treatment was initiated. Orthodontic attachments were bonded to the buccal and lingual surfaces of the molar. Force of 100–150 g was applied by the elastic chains between screw head and attachment on each side. The power chains changed every visit at one-month intervals. Once it had been intruded into the optimal position, the molar was maintained by orthodontic ligature wires from miniscrews to attachments until the prosthetic reconstruction of the missing lower molar was finished (fig. 1).

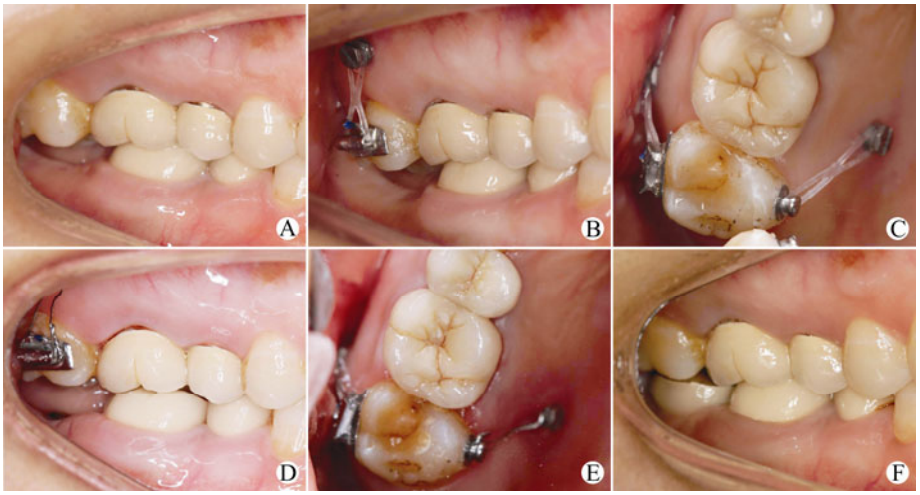

Fig. 1 Miniscrew implant procedures

A: Before treatment: B and C: Beginning of molar intrusion; D and E: Finishing of molar intrusion, and molar maintained by ligature wires; F: Achievement of prosthetic reconstruction

1.4 Cephalometric Analysis and Panoramic Radiograph Evaluation

Lateral cephalograms were taken before and after the intrusion treatment. Measurements (two linear and one angular) were used to evaluate dental changes in overerupted molars (fig. 2). Pretreatment and posttreatment panoramic radiographs were used to evaluate root resorption of molars during intrusion treatment.

All lateral cephalograms and panoramic films were retraced and remeasured by the same operator one month later. The reliability of the measurements was evaluated by statistical analysis of the difference between double measurements. Paired *t*-tests showed no significant difference between the first and second measurements ($P>0.05$).

1.5 Statistical Analysis

The statistical analysis was performed with SPSS 13.0 for windows. Treatment changes and root lengths before and after molar intrusion were evaluated by paired students' *t*-tests. A probability of $P<0.05$ was considered to be statistically significant.

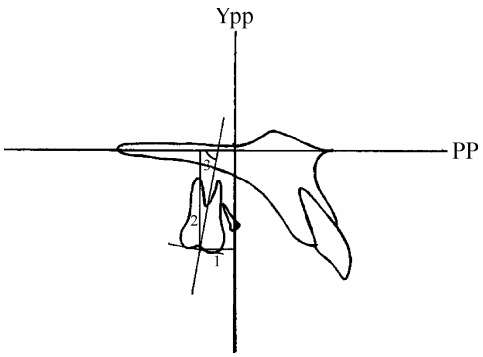

Fig. 2 Angular and linear measurements

1: Upper molar cusp to Ypp, vertical plane from landmark images of screw head to palatal plane (Umolar /Ypp); 2: Upper molar cusp to palatal plane (Umolar/PP); 3: Axis of upper molar to palatal plane (Umolar-PP). Ypp: vertical plane from landmark image of screw head to palatal plane; PP: palalal plane.

2 RESULTS

The intrusion treatment worked fairly well and all the patients achieved satisfactory outcomes. The average intrusion time was 6.2±2.1 months for maxillary first molars, and 6.5±1.9 months for maxillary second molars.

In this study 6 miniscrew implants were loosened, 4 on the buccal side and 2 on the palatal side, after 2–3 months of loading. Miniscrews were re-implanted and remained stable until the completion of treatments.

The data obtained from cephalometric measurements demonstrated remarkable changes in the molar position. The quantitative assessments for intrusion of 38 maxillary first molars and 26 maxillary second molars are presented in tables 1 and 2.

Table 1 Comparison of preintrusion and postintrusion measurements of maxillary first molars in cephalometric analysis

Variables	Preintrusion T1		Postintrusion T2		T1–T2		*P* values
	Mean	SD	Mean	SD	Mean	SD	
U6/PP (mm)	29.9	3.1	26.5	2.4	3.4	1.2	0.000**
U6/Ypp (mm)	7.3	1.7	7.1	1.8	0.2	0.6	0.047*
U6-PP (°)	86.4	5.4	89.5	5.3	–3.1	3.4	0.000**

SD: standard deviation; T1: before treatment; T2: after treatment. *P<0.05, **P<0.001

Table 2 Comparison of preintrusion and postintrusion measurements of maxillary second molars in cephalometric analysis

Variables	Preintrusion T1		Postintrusion T2		T1–T2		*P* values
	Mean	SD	Mean	SD	Mean	SD	
U7/PP (mm)	28.6	3.7	25.5	2.9	3.1	1.1	0.000**
U7/Ypp (mm)	7.2	1.7	7.0	1.8	0.2	0.4	0.015*
U7-PP (°)	84.2	5.6	87.5	5.7	–3.3	2.5	0.000**

SD: standard deviation; T1: before treatment; T2: after treatment. *P<0.05, **P<0.001

The results showed that the overerupted maxillary first molars and second molars were intruded greatly relative to the palatal plane by averages of 3.4 mm and 3.1 mm respectively (P<0.001). Meanwhile, the crown of the molars moved forward an average of 0.2 mm (P<0.05) with mesially tipping by averages of 3.1 degrees and 3.3 degrees (P<0.001) for first and second molars respectively. The intrusion of molars ranged from 1.5 to 6.5 mm which could result from the natural variation in initial position of extruded teeth.

There were significant reductions in lengths of buccal mesial and distal roots of overerupted molars. The amounts of root resorption were 0.2–0.4 mm on average (table 3).

Table 3 Comparison of preintrusion and postintrusion measurements in root length

Variables	Preintrusion T1		Postintrusion T2		T1–T2		*P* values
	Mean	SD	Mean	SD	Mean	SD	
U6M (mm)	22.3	1.2	22.0	1.3	0.3	0.4	0.000**
U6D (mm)	21.1	1.2	20.9	1.1	0.2	0.5	0.016*
U7M (mm)	21.7	1.5	21.3	1.4	0.4	0.5	0.001**
U7D (mm)	20.5	1.1	20.3	1.1	0.2	0.4	0.042*

SD: standard deviation; T1: before treatment; T2: after treatment; M: buccal mesial root; D: buccal distal root. *P<0.05, **P<0.01

3 DISCUSSION

Because of the lack of appropriate methods for vertical anchorage control, it is difficult to achieve molar intrusion in correcting overerupted molars for prosthetic rehabilitation until recently, when mini-implant anchorage systems are introduced to serve as orthodontic anchorage[1–3, 23, 26–29, 32–34]. Molar intrusion with mini-implant anchorage can avoid the extrusion of anchorage teeth and also make a patient's compliance and full-arch appliances unnecessary[1–3].

Some investigators used zygomatic skeletal anchorage (titanium miniplates) to intrude molars or posterior teeth for treatment of skeletal open bite or overerupted molars[1, 14–18, 32–35]. Although miniplates have been successfully used for molar intrusion, they require flap surgery and often need oral surgeons to finish the implantation operation. In contrast, miniscrews have a simpler and less invasive surgical procedure.

In the present study treatment effects of molar intrusion using miniscrew implants were quantified by cephalometric evaluation after the validity of this clinical method was confirmed. Remarkable clinical outcomes were achieved. Overerupted molars were intruded by an average of 3.1–3.4 mm with treatment duration of over 6 months. Yao *et al*[1] investigated maxillary molar intrusion with fixed appliances and mini-implant anchorage through 3D digital model analysis and achieved similar results. To facilitate teeth movement, it was suggested that miniplate anchorage combined with corticotomy could reduce root resorption and treatment time during molar intrusion. With corticotomy assistance, Moon *et al*[32] reported a 3.5 mm intrusion of overerupted molars in 2 months, and Tuncer *et al*[35] achieved 4.0 mm molar impaction in 2.5 months for treatment of a severe open bite case. Corticotomy requires more extensive surgical procedures which often limit the acceptance for many

patients. In contrast with conventional methods or corticotomy surgery, overerupted teeth intrusion with miniscrew anchorage seemed more acceptable to the patients.

In our study, almost all the miniscrews remained stable except for 6 miniscrews for the reason of periimplant inflammation. The success rate was close to 95%, which was higher than that in previous reports. In an experimental study Carrillo *et al*[25] reported that only 1 of the 96 miniscrews used as anchorage to intrude multiradicular teeth were failed after 98 days of force application. He pointed out that immediately loaded miniscrew implants were highly stable anchorage devices while receiving constant forces of 25 to 100 g.

The most critical factor in molar intrusion is the point of force application. Some investigators[16, 18–21] have introduced the application of transpalatal arch or overlay round archwire to control the crown tipping while only using skeletal anchorage in one side for correction of open bite. To avoid transverse displacement during overerupted molar intrusion, force should be simultaneously applied from buccal and palatal aspects. Yao *et al*[1] confirmed that the palatal cusp was easier to be intruded than buccal cusp because of the fact that the interradicular septum is between the buccal roots. So, he suggested that levels of buccal and palatal force are needed to be closely monitored.

There are adequate interradicular bone and attached gingiva mesial to the maxillary molars to allow for implantation of a buccal miniscrew. The midline suture and the paramedian region have sufficient bone for miniscrew placement. However the force from the miniscrew implanted in the midline suture is not parallel to the long axis of the molar and an extension arm or hook is needed to reach the palatal slope. In our study the miniscrews were implanted in the palatal slope and only 2 miniscrews failed.

It is nearly impossible to produce a parallel force because the miniscrews are commonly placed between roots. To achieve the bodily intrusion movement of the molars, Kravitz *et al*[2] inserted the buccal and palatal miniscrews in diagonal distribution, and Moon *et al*[32] attached a specially designed hook to palatal miniscrews with light-curing resin to attain a parallel intrusive force. Carrillo *et al*[30] also emphasized force distribution, which plays an important role in determining how the segmental teeth are intruded. In the present study, buccal and palatal miniscrews were implanted mesial to the overerupted molar, and the intrusive force didn't pass through the centre of resistance. The angle of molar axis to palatal plane was significantly increased by averages of 3.1 degrees and 3.4 degrees for first and second molars respectively. The molars were slightly tilted mesially. Sometimes this could cause mild crowding in premolar areas. If necessary we used partial appliances with sectional arch wire to solve the potential problems of molar tipping and premolar crowding after molar intrusion (fig. 3).

Until recently, the optimal force value for molar intrusion had not been established. The intrusive force of molars varied from 90 to 1000 g in some reports about the treatment of skeletal open-bite[17–19, 36, 37]. Kravitz *et al*[2] applied 150 g of force to achieve the intrusion of overerupted upper first molar with miniscrew anchorage. Heavier forces of 200 to 300 g were recommended in the corticotomy case combined with mini-implant anchorages[32, 33, 35]. In an experimental study Carrillo *et al*[25] confirmed that constant forces differing from 50 to 200 g had no significant effect on the amounts of premolar intrusion. Another study by van Steenbergen *et al*[38] also showed that there was no significant difference between the 40 and 80 g force groups after intrusion of the maxillary anterior teeth. Their studies indicated that teeth intrusion was time-dependant and force value did not affect the rate of intrusion.

Fig. 3 Application of partial appliances to solve the potential problems of molar tipping and premolar crowding after molar intrusion if necessary

The optimal amount of force to intrude anterior teeth is approximate 20–50 g. With the consideration of different root quantity and periodontal ligament area between molars and anterior teeth, we used intrusive force of 200–300 g to accomplish the molar intrusion, which agreed with Park's viewpoint about intrusive force in aged patients[27].

It is necessary to evaluate the apical root resorption after intrusion treatment of overerupted molars using miniscrew anchorage because intrusion movement may be the most detrimental to the roots involved. Fewer reports[39, 40] have investigated root resorption of the posterior teeth. Hendrix *et al*[40] assessed the root resorption of posterior teeth in orthodontic patients using panoramic films. The identification of the apical point on the palatal root of the first maxillary molar proved to be very difficult and unreliable. Although panoramic radiographs had their limitations in diagnosing apical root form and resorption, it was suggested this method could be sufficiently reliable for vertical measurements on mesial and distal roots of molars, provided head posture during exposure was standardized.

In our study, root resorption of buccal-mesial and buccal-distal roots showed statistically significant difference in measurements of panoramic radiographs. However, the average amount of root resorption was minor, less than 0.5 mm, so resorption could be undetected radiographically. So we can conclude that root resorption of the overerupted maxillary molars was clinically insignificant after intrusion with miniscrew anchorage. A few clinical and experimental reports supported the viewpoints of our study[18, 25, 30–32, 39, 41, 42].

In this study, passive retention for overerupted molars was performed after the active intrusive treatment. We also recommended that, once the prosthesis was placed immediately after the molar was intruded to the appropriate position, no retainer was required.

With the limitations of this retrospective study, we cannot evaluate the changes of crestal bone height and periodontal tissue alterations. The long-term stability of overerupted molar intrusion is also needed to be investigated in further studies.

To sum up, intrusion of overerupted maxillary molars can be successfully and reliably achieved with miniscrew anchorage. Amounts of intrusion were more than 3 mm during 6 months. Root resorption of the mesial and distal roots of molars had no clinically significant difference after application of intrusive forces of 200 to 300 g.

Conflict of Interest Statement

The authors declare that there is no conflict of interest with any financial organization or corporation or individual that can inappropriately influence this work.

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(Received Apr. 22, 2013; revised Aug. 14, 2013)