Dental Research Journal

Original Article

# Periodontal changes following molar intrusion with miniscrews

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## ABSTRACT

**Background:** With the introduction of skeletal anchorage system, recently it is possible to successfully intrude molar teeth. On the other hand, there have been concerns about periodontal changes associated with intrusion and there are few studies on this topic, especially for posterior teeth.

**Materials and Methods:** Ten female patients were enrolled in this study. Maxillary molar intrusion was achieved by inserting two miniscrews and a 17 × 25 titanium molybdenum alloy spring. Crestal height changes were evaluated at three intervals including: Baseline (T0), end of active treatment (T1) and 6 months after retention (T2). Other variables including probing depth, gingival recession, attachment level and bleeding on probing were evaluated by clinical measurements in the three above mentioned intervals. One-sample Kolmogrov-Smirnov test ascertained the normality of the data. For all patients, the changes in tooth position and crestal height were evaluated using one-sample *t*-test. ($P < 0.05$)

**Results:** Supra-erupted molars were successfully intruded a mean of 2.1 ± 0.9 mm during active treatment (T0-T1). A mean bone resorption of 0.9 ± 0.9 mm in mesial crest and 1 ± 0.8 mm in distal crest had occurred in total treatment (T0-T2). A mean of 0.6 ± 1.4 mm bone was deposited on mesial crest during the retention period (T1-T2) following tooth relapse. On average, 0.8 ± 0.4 mm attachment gain was obtained. Gingival margin coronalized a mean of 0.8 ± 0.6 mm throughout the entire treatment. Probing depth showed no significant change during treatment.

**Conclusion:** Within the limitations of this study, these results suggest that not only periodontal status was not negatively affected by intrusion, but also there were signs of periodontal improvement including attachment gain and shortening of clinical crown height.

**Key Words:** Molar, periodontal changes, tooth intrusion

**Received:** April 2014
**Accepted:** September 2014

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## INTRODUCTION

Orthodontic intrusion of supra-erupted molars has been a challenging matter for a long time. Conventional treatment to correct over extruded molars include crown reduction, followed by full coverage restorations[1,2] or posterior subapical osteotomy to impact the elongated segment.[3] Extra-oral traction as an orthodontic approach for tooth intrusion depends heavily on patient cooperation. Conventional fixed appliances are claiming to induce posterior intrusion actually resulted in extrusion of other teeth.[4]

The possibility of posterior tooth intrusion is now clearly shown in several studies introducing skeletal anchorage using miniscrews and miniplates.[5-12] However, a complete evaluation of periodontal changes following posterior teeth intrusion seems necessary.

Some studies suggest that an orthodontic treatment, especially involving intrusive movement, does include the risk to the periodontium.[13-15] Melsen *et al.*,[16-18]

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Murakami *et al*.[19] and da Silva *et al*.[20] have reported that if gingival inflammation is kept to a minimum, intrusion may lead to favorable results.

However, most of the studies existing in the literature are related to post-intrusion periodontal status for anterior teeth[15-18,21-23] and many of them are animal studies.[15,16,18,23] There have been few animal studies regarding periodontal changes following the posterior intrusion[20,24] and there are many unknown aspects of the biology of intrusion. Lee and Shuman[25] used a palatal technique in an animal study for molar intrusion that has been conducted as a case report. Xun *et al*.[26] used a radiographic technique for assessing molar intrusion on 56 human molars which lacks the measurements of periodontal status during intrusion.

The purpose of this study was to evaluate the clinical and radiographic periodontal variables after molar intrusion utilizing miniscrews with a standardized approach for measurements of crestal changes.

## MATERIALS AND METHODS

### Subjects

The present experimental study was conducted on 10 female patients, all of whom had at least one supra-erupted maxillary first molar with an edentolous space opposite their over-extruded tooth. The samples' average age was 43.6 (25-57). They neither had previous orthodontic treatment nor active periodontal disease at the beginning of the treatment. Since the treatment only involved one tooth, it was considered to be an adjunctive treatment. Informed consent was obtained from each patient before beginning of treatment. The Ethical Committee approved this proposal with the number of 1388234/12 in Mashhad University of Medical Sciences, Mashhad, Iran.

### Miniscrew insertion and force delivery

Two bracket type Absoanchor miniscrews (Dentos, Daegu, Korea) with 1.3 mm diameter and 7 mm length were used for each patient in this study. One of them was inserted in mesiobuccal, and another in mesiopalatal of maxillary first molar. After 2-week interval of soft tissue healing, bands with welded brackets were cemented on the teeth. Intrusion was accomplished with a new approach using a 17 × 25 titanium molybdenum alloy spring fitted on a miniscrew head in one end and ligated to the bracket on the other end [Figure 1]. The amount of force was adjustable depending on the displacement amount of the spring and measured with a force gauge. The spring was adjusted so a force of 50 g was exerted at each side of the tooth with a total of 100 g on the tooth. By engaging the wire inside the slot, tipping of the tooth can be corrected if needed. Oral hygiene instructions were given to patients. The patients were revisited every 4 weeks for springs' adjustment and oral examination until required intrusion judged by the prosthodontist was obtained.

**Figure 1:** 17 × 25 titanium molybdenum alloy spring fitted on a miniscrew head in one end and ligated to the bracket on the other end for molar intrusion.

### Variable measurements

All the variables were measured at three time intervals including baseline (T0), end of treatment (T1) and 6 months after retention (T2) and changes during active treatment (T0-T1), the retention period (T1-T2) and total treatment (T0-T2) were recorded. In order to evaluate periodontal status, clinical and radiographical variables were studied as follows.

### Clinical variables

Clinical variables included the probing depth, gingival recession (cementoenamel junction [CEJ] to gingival margin distance), attachment level (probing depth plus CEJ to gingival margin distance), and bleeding on probing.[27] A periodontal probe (Hu-Friedy, Chicago, IL, USA) with Williams marking was used at six aspects of tooth (mesiobuccal, buccal, distobuccal, mesiopalatal, palatal and distopalatal) and the average was recorded as probing depth, gingival recession and attachment level (as ordinal data) for each interval. Bleeding on probing was assessed according to Ainamo Index, which is performed through gentle probing of the orifice of the gingival crevice. If bleeding occurs within 10 s a positive finding is recorded, and the number of positive sites is recorded and then expressed as a percentage of the number of sites examined.

Gingival margin position was measured as a distance in mms between CEJ and the most coronal part of the margin at the six mentioned sites around the tooth. By subtracting the scores of gingival margin position in three phases of treatment, the amount of coronalization of gingiva was assessed. Clinical crown height-which means the amount of tooth that can be seen in mouth-was not measured directly, but the general trend of the changes of this variable toward decreasing or increasing was considered. According to the fact that CEJ was visible in all cases, by assessing distance from the gingival margin to CEJ in each phase and subtracting it from the same factor in the previous phase, the amount of changes in clinical crown height in millimeters could be assessed. Positive findings indicate increasing in the distance between the gingival margin and CEJ and thus increasing in clinical crown height, and the reverse is correct for negative findings.

According to the fact that all the teeth were over-extruded, attachment level was measured as the distance between CEJ and gingival margin plus probing depth in the six mentioned sites around the tooth. By subtracting the three, attachment levels pertained to the three intervals, the amount of attachment gain or loss was obtained.

### Radiographic evaluation

Parallel periapical radiographs with bite blocks were used with an X-ray device (Planmeca, Helsinki, Finland) for measuring the amount of intrusion and mesial and distal crest heights in three intervals including baseline (T0), treatment completion (T1) and 6 months after retention (T2). Film-holder-tube position remained the same in these three intervals by having patients bite on poly-vinylsiloxane material (Dentsply, NY, USA).

In order to have a precise assessment of tooth movement and crestal height changes, a computer software named, Planmeca Dimaxis Classic was applied, which measured the variables by pixel units and then converted them to millimeters.

Two obvious and distinguishable landmarks in adjacent teeth (like restoration edge or cusp tip) were determined, and a line connecting them was used as a reference line for further measurements. In order to measure mesial and distal crest changes during treatment, a perpendicular line was drawn from this line to the most apical point in each crest near the tooth. The program automatically calculated the distances in pixel units [Figure 2]. Intrusion for each root was calculated in the same manner.

To measure root resorption, a line passing the furcation point of the tooth was drawn parallel to the reference axis, and the perpendicular distance of each root apex to this line was computed in pixel units in three time intervals. By comparing perpendicular distances from root apices to these lines in the three-time intervals, it is possible to measure intrusion amount and apical root resorption. The numbers in pixels denote these distances, which are transformed later to millimeters.

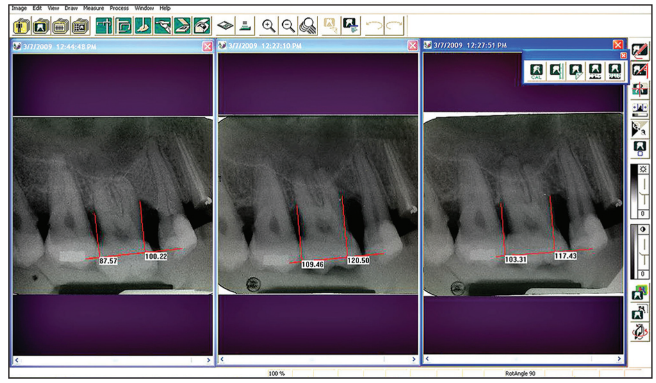


**Figure 2:** Assessment of crestal changes by Planmeca Dimaxis Classic program. A reference line connecting two distinguishable landmarks in adjacent teeth (restoration edge here) has been drawn. By comparing perpendicular distance from the most apical point in each crest near the tooth to this line in the three time intervals it is possible to measure crestal resorption or apposition. The numbers in pixel denote these distances which are transformed later to millimeter.

Instructions were given to each patient related to the oral hygiene and the cleaning of the miniscrews area. Inflammation was checked at each visit by examining the gingiva around miniscrews and bands by a periodontal probe searching for any bleeding or plaque accumulation. Instructions regarding cleansing the area were given to each patient if considered necessary according to the examination.

### Statistical analysis

One-sample Kolmogrov-Smirnov test ascertained the normality of the data. For all patients, the changes in tooth position and crestal height were evaluated by repeated measurement test. Positive changes during three mentioned periods represented crestal bone resorption, gingival recession, attachment loss and increase in probing depth, and negative changes indicated crestal bone apposition, root coverage, attachment gain, and decrease in probing depth ($P < 0.05$).

## RESULTS

The maxillary first molars were intruded in all patients to a limit to provide required vertical space for prosthetic rehabilitation of opposite edentulous arch [Figure 3].

Mean treatment duration was 7.7 months ranging between 4.3 and 11.5 months. Changes in tooth position and clinical periodontal variable changes during active treatment (T0-T1), the retention period (T1-T2) and total treatment (T0-T2) are shown in Table 1.

**Figure 3:** Radiograph and photographic pictures of a patient with a supra-erupted maxillary first molar before orthodontic treatment and after intrusion and prosthetic replacement. Note the significant root coverage achieved throughout treatment.

Mean intrusion value was 2.1 ± 0.9 mm (range 1.5-4.5 mm) during active treatment ($P$ < 0.001). A mean of 0.4 ± 0.2 mm relapse took place during retention period ($P$ < 0.001). The average amount of intrusion between T0 and T2 was 1.7 ± 0.6 mm ($P$ < 0.001). Root resorption in all the patients was <1 mm (0.7 mm of 10 mm mean root length), which was considered clinically insignificant. No resorption was seen in the furcation region following treatment.

Probing depth increased 0.2 ± 0.6 mm on average during active treatment ($P$ = 0.27), decreased 0.2 ± 0.6 mm during retention period ($P$ = 0.18) and showed no change in total treatment ($P$ = 0.9). We found a mean of 0.8 ± 1 mm coronalization of the gingival margin during active treatment ($P$ = 0.02). Gingival margin position remained stable during the retention period and displaced a mean of 0.8 ± 0.6 mm coronally ($P$ = 0.01). A mean of 0.4 ± 0.5 mm attachment gain was obtained during active treatment ($P$ = 0.03). Another 0.4 ± 0.9 mm attachment was gained during the retention period. On the whole, 0.8 ± 0.9 mm gain of attachment level was achieved ($P$ < 0.001). Bleeding on probing did not change significantly during treatment periods. The mesial crest resorbed 1.5 ± 1.3 mm on average during active treatment ($P$ = 0.008). A 0.6 ± 1.4 mm mean bone apposition occurred on mesial crest during the retention period and 0.9 ± 0.9 mm resorption remained in total treatment ($P$ = 0.013). The distal crest showed a mean of 0.9 ± 0.7 mm resorption during active treatment ($P$ = 0.003). No significant change occurred

**Table 1: Mean ± Standard Deviation (Min, Max) of intrusion amount and clinical periodontal variables' changes**

| Variables | Baseline (T0) | End of active treatment (T1) | 6 months after retention (T2) | Changes during active treatment (T0-T1) | Changes during retention period (T1-T2) | Total change (T0-T2) |
|---|---|---|---|---|---|---|
| Intrusion (mm) | — | — | — | 2.1±0.9<br>(1.5, 4,5)<br>$P$<0.001* | −0.4±0.2<br>(0.1, −0.7)<br>$P$<0.001* | 1.7±0.6<br>(1.1,2.9)<br>$P$<0.001* |
| Probing depth (mm) | 2.5±0.5<br>(2, 3.7) | 2.7±0.5<br>(1.8, 3.3) | 2.5±0.6<br>(1.8, 3.4) | 0.2±0.6<br>(−0.7, 1.3)<br>$P$=0.27 | −0.2±0.6<br>(0.4, −1.3)<br>$P$=0.18 | 0±0.7<br>(−0.7, 1.4)<br>$P$=0.9 |
| Gingival recession (mm) | 1.3±1.1<br>(0.1, 3.4) | 0.5±0.7<br>(0, 2) | 0.5±0.5<br>(0, 1.9) | −0.8±1<br>(0, −2.6)<br>$P$=0.02* | 0±0.3<br>(0.7, −1.5)<br>$P$=0.7 | −0.8±0.6<br>(0.3, −1.3)<br>$P$=0.01* |
| Attachment level (mm) | 3.9±1<br>(2.5, 5.5) | 3.5±1<br>(1.8, 4.9) | 3.1±1.1<br>(1.8, 4.9) | −0.4±0.5<br>(0.3, −1.2)<br>$P$=0.03* | −0.4±0.9<br>(0.8, −2)<br>$P$=0.2 | −0.8±0.4<br>(−0.2, −1.7)<br>$P$<0.001* |
| Bleeding on probing | 0.4±0.2<br>(0, 0.7) | 0.4±0.1<br>(0.2, 0.7) | 0.4±0.1<br>(0.3, 0.7) | 0±0.1<br>(−0.2, 0.3)<br>$P$=0.28 | 0±0.2<br>(0.2, −0.3)<br>$P$=0.22 | 0±0.2<br>(0.2, −0.3)<br>$P$=0.27 |

*Denotes statistically significant changes. Significance was determined at the $P$ < .05 (One-sample t test). Positive changes denote gingival recession; attachment loss and increase in probing depth and negative changes indicate root coverage, attachment gain and decrease in probing depth.

during the retention period. On average 1 ± 0.8 mm distal crest resorption took place throughout the entire treatment ($P$ = 0.005) [Table 2].

## DISCUSSION

Several authors have reported successful intrusion of posterior teeth by using minicrews and miniplates,[5-12] that had not been achieved with conventional orthodontic mechanics previously. Similar to other mentioned researches,[28,29] a desired amount of intrusion with the purpose of prosthetic rehabilitation of patients was achieved in the current study.

However, the use of a more precise measuring method made it distinct from the previous ones. In fact, there are few reports on the assessment of periodontal changes following molar intrusion in the literature, none of which is a human evaluation.[20,24]

Unlike previous studies, crestal changes were measured using standardized radiographs and computer software which finally provided a non-invasive and objective technique in order to study those changes. Most of the studies regarding crestal changes were conducted on animals and were also qualitative.[16,18,30-32] The results of this study indicated a crestal resorption with a mean of 1.5 ± 1.3 mm in mesial crest and 0.9 ± 0.7 mm in distal crest during intrusion that were similar to the only other quantitative study by Kanzaki *et al*.[24] on dogs. Likewise, other qualitative studies have shown similar results during intrusion.[30-32] One of the probable factors may be the pressure of supra-alveolar fibers during intrusion. On the contrary, Murakami *et al*.[19] stated that in case of a large amount of intrusion, the transaction of fibers from cementum will take place, and there won't be enough pressure to resorb the alveolar crest. Although the amount of intrusion in the present study (1.5-4.5 mm) was close to theirs, (1.1-5.5 mm), the results are not similar probably due to the differences in study type (human vs. animal), tooth type and mechanics. Another interesting finding was that during the retention period, the mean bone formation of 0.6 ± 1.4 mm occurred on mesial crest simultaneous with the tooth extrusion. Other studies have also shown that extrusion can induce bone apposition on the alveolar crest.[18,28] A possible reason is the tension produced in alveolar crest fibers during extrusion.

**Table 2: Mean ± SD (minimum, maximum) of radiographic variables' changes**

| Variables | Changes during active treatment (T0-T1) | Changes during retention period (T1-T2) | Total change (T0-T2) |
|---|---|---|---|
| Mesial crest (mm) | 1.5±1.3 (0.1, 3.8) $P$=0.008* | −0.6±1.4 (2.1, −2.6) $P$=0.31 | 0.9±0.9 (0, 2.2) $P$=0.013* |
| Distal crest (mm) | 0.9±0.7 (0.1, 2.3) $P$=0.003* | 0.1±0.9 (−0.8, 2) $P$=0.67 | 1±0.8 (0, 2.2) $P$=0.005* |

SD: Standard deviation. *Statistically significant changes. Significance was determined at the $P$ < 0.05 (one-sample $t$-test). Positive changes denote crestal bone resorption and negative changes indicate crestal bone apposition

Just like the results of other studies, the present one showed that probing depth increased during active treatment, though insignificantly.[17,19,24] Gingival inflammation,[33] apical migration of junctional epithelium[34] and accumulation of gingival tissue[19] can cause the deepening of the sulcus during orthodontic tooth movement according to several studies.

Insignificant changes of bleeding on probing and also significant gain of attachment level during active treatment in this study showed that the increase in probing depth may have been resulted from the accumulation of gingival tissue. Murakami *et al*.[19] research confirmed this finding as well, although accurate conclusion requires histological evaluation. Furthermore, the present research indicated that the mentioned increase in probing depth was temporary and relapsed into pretreatment values during the retention period. The probing depth change was not dealt with in the previous study.[19] A mean of 0.8 ± 0.4 mm clinical attachment gain was obtained during the treatment. The relatively high amount of bleeding on probing (0.4) implied that lessening gingival inflammation and thus bleeding on probing through more precise oral hygiene control may lead to a higher amount of clinical attachment gain. Other animal studies reported a variety of findings ranging from gaining of attachment[16,18] and no change in attachment level[19] to attachment loss in poor oral hygiene situation during intrusion.[16] Although an accurate determination of the nature of attachment gain requires histological evaluation that cannot be assessed in human studies for ethical reasons, related animal studies showed that the attachment can be achieved either by connective tissue formation[16,18] or long junctional epithelium.[16] Even if a long junctional epithelium has been formed during treatment, it won't be incompatible with long preservation of periodontal health.[35] Theoretically, orthodontic molar intrusion with or without periodontal surgeries may be used to treat furcation lesions as shown by Da Silva *et al*.[20] in dogs. One of the patients in this study with grade II furcation involvement showed no change in probing depth after intrusion. The rest of the patients didn't have any furcation lesions.

It is suggested to conduct further researches with bigger sample size and more controlled method to investigate the issue.

Since the amount of intrusion and changes in the gingival margin was determined in this study, by dividing these two factors the percentage of clinical crown height changes (increase or decrease) relative to intrusion amount could be obtained. It was shown in this study that gingival margin had been migrated toward apical direction with a magnitude of 57% of intrusion amount. Mean reduction of clinical crown length was 43% of intrusion amount as compared with 40% in Murakami *et al*.[19] study, 21% in Erkan *et al*.[22] research and 50% in Re *et al*.[23] investigation. On the contrary, Abdel-Kader[36] reported no significant crown reduction in their study. Incomplete apical migration of the gingival margin may cause a great concern in anterior teeth region, because of the potential for gummy smile aggravation. However, this is a valuable outcome in posterior over-erupted teeth with naked roots, because it may decrease the symptoms of the root hypersensitivity in addition to improving esthetics.

Crestal changes in neighboring teeth were not evaluated in this study. Therefore, the authors suggest further studies regarding this matter. This study had certain limitations regarding the small number of patients and a wide range of patients' age. Further studies with greater sample size and better matching of the cases also would be valuable.

## CONCLUSION

A mean bone resorption of 0.9 ± 0.9 mm in mesial crest and 1 ± 0.8 mm in distal crest had occurred in total treatment (T0-T2). A mean of 0.6 ± 1.4 mm of bone was deposited on mesial crest during the retention period (T1-T2) following tooth relapse. On average 0.8 ± 0.4 mm attachment gain was obtained. Gingival margin coronalized a mean of 0.8 ± 0.6 mm throughout the entire treatment. Probing depth showed no significant change during treatment. This study indicated a clinical attachment gain and shortening of clinical crown height during intrusion, which may finally result in a new non-invasive mean for periodontal improvement.

## ACKNOWLEDGMENTS

We would like to thank the Vice Chancellor of Mashhad University of Medical Sciences for financial support. The authors report no conflicts of interest related to this study.

## REFERENCES

1. Norton LA, Lopes I. Specific mechanics for abutment uprighting. Aust Dent J 1980;25:273-8.
2. Spalding PM, Cohen BD. Orthodontic adjunctive treatment in fixed prosthodontics. Dent Clin North Am 1992;36:607-29.
3. Schoeman R, Subramanian L. The use of orthognathic surgery to facilitate implant placement: A case report. Int J Oral Maxillofac Implants 1996;11:682-4.
4. Kim YH. Anterior openbite and its treatment with multiloop edgewise archwire. Angle Orthod 1987;57:290-321.
5. Umemori M, Sugawara J, Mitani H, Nagasaka H, Kawamura H. Skeletal anchorage system for open-bite correction. Am J Orthod Dentofacial Orthop 1999;115:166-74.
6. Park YC, Lee SY, Kim DH, Jee SH. Intrusion of posterior teeth using mini-screw implants. Am J Orthod Dentofacial Orthop 2003;123:690-4.
7. Yao CC, Lee JJ, Chen HY, Chang ZC, Chang HF, Chen YJ. Maxillary molar intrusion with fixed appliances and mini-implant anchorage studied in three dimensions. Angle Orthod 2005;75:754-60.
8. Park HS, Kwon OW, Sung JH. Nonextraction treatment of an open bite with microscrew implant anchorage. Am J Orthod Dentofacial Orthop 2006;130:391-402.
9. Xun C, Zeng X, Wang X. Microscrew anchorage in skeletal anterior open-bite treatment. Angle Orthod 2007;77:47-56.
10. Kuroda S, Sakai Y, Tamamura N, Deguchi T, Takano-Yamamoto T. Treatment of severe anterior open bite with skeletal anchorage in adults: Comparison with orthognathic surgery outcomes. Am J Orthod Dentofacial Orthop 2007;132:599-605.
11. Erverdi N, Usumez S, Solak A, Koldas T. Noncompliance open-bite treatment with zygomatic anchorage. Angle Orthod 2007;77:986-90.
12. Kuroda S, Sugawara Y, Tamamura N, Takano-Yamamoto T. Anterior open bite with temporomandibular disorder treated with titanium screw anchorage: Evaluation of morphological and functional improvement. Am J Orthod Dentofacial Orthop 2007;131:550-60.
13. Thilander B. Orthodontic tooth movement in periodontal yherapy. In: Lindhe J, editor. Textbook of Clinical Periodontology. Copenhagen: Munksgaard; 1984.
14. Vanarsdall RL, Musich DR. Adult orthodontics: Diagnosis and treatment. In: Graber TM, Swain BF, editors. Orthodontics: Current Principles and Techniques. St. Louis: CV Mosby; 1985. p. 791.
15. Melsen B. Tissue reaction following application of extrusive and intrusive forces to teeth in adult monkeys. Am J Orthod 1986;89:469-75.
16. Melsen B, Agerbaek N, Eriksen J, Terp S. New attachment through periodontal treatment and orthodontic intrusion. Am J Orthod Dentofacial Orthop 1988;94:104-16.

17. Melsen B, Agerbaek N, Markenstam G. Intrusion of incisors in adult patients with marginal bone loss. Am J Orthod Dentofacial Orthop 1989;96:232-41.
18. Melsen B. Tissue reaction to orthodontic tooth movement — A new paradigm. Eur J Orthod 2001;23:671-81.
19. Murakami T, Yokota S, Takahama Y. Periodontal changes after experimentally induced intrusion of the upper incisors in Macaca fuscata monkeys. Am J Orthod Dentofacial Orthop 1989;95: 115-26.
20. da Silva VC, Cirelli CC, Ribeiro FS, Leite FR, Benatti Neto C, Marcantonio RA, *et al.* Intrusion of teeth with class III furcation: A clinical, histologic and histometric study in dogs. J Clin Periodontol 2008;35:807-16.
21. Michaeli Y, Steigman S, Harari D. Recovery of the dental and periodontal tissues of the rat incisor following application of continuous intrusive loads: A long-term study. Am J Orthod 1985;87:135-43.
22. Erkan M, Pikdoken L, Usumez S. Gingival response to mandibular incisor intrusion. Am J Orthod Dentofacial Orthop 2007;132:143.e9-13.
23. Re S, Cardaropoli D, Abundo R, Corrente G. Reduction of gingival recession following orthodontic intrusion in periodontally compromised patients. Orthod Craniofac Res 2004;7:35-9.
24. Kanzaki R, Daimaruya T, Takahashi I, Mitani H, Sugawara J. Remodeling of alveolar bone crest after molar intrusion with skeletal anchorage system in dogs. Am J Orthod Dentofacial Orthop 2007;131:343-51.
25. Lee M, Shuman J. Maxillary molar intrusion with a single miniscrew and a transpalatal arch. J Clin Orthod 2012;46: 48-51.
26. Xun CL, Zhao H, Zeng XL, Wang X. Intrusion of overerupted maxillary molars with miniscrew implant anchorage: A radiographic evaluation. J Huazhong Univ Sci Technolog Med Sci 2013;33:780-5.
27. Ainamo J, Bay I. Problems and proposals for recording gingivitis and plaque. Int Dent J 1975;25:229-35.
28. Kessler M. Interrelationships between orthodontics and periodontics. Am J Orthod 1976;70:154-72.
29. Rateitschak KH. Orthodontics and periodontology. Int Dent J 1968;18:108-20.
30. Dellinger EL. A histologic and cephalometric investigation of premolar intrusion in the Macaca speciosa monkey. Am J Orthod 1967;53:325-55.
31. Bondevik O. Tissue changes in the rat molar periodontium following application of intrusive forces. Eur J Orthod 1980;2:41-9.
32. Ninomiya T. Histologic study on the periodontal structures incident to experimental tooth movement in macata fuscata. Investigation of periodontal structures on the artificial intruded teeth. J Tokyo Dent Coll Soc 1984;84:1423-79.
33. Zachrisson S, Zachrisson BU. Gingival condition associated with orthodontic treatment. Angle Orthod 1972;42:26-34.
34. Ericsson I, Thilander B. Orthodontic forces and recurrence of periodontal disease. An experimental study in the dog. Am J Orthod 1978;74:41-50.
35. Magnusson I, Runstad L, Nyman S, Lindhe J. A long junctional epithelium — A locus minoris resistentiae in plaque infection? J Clin Periodontol 1983;10:333-40.
36. Abdel-Kader HM. Clinical crown length and reduction in overjet, overbite, and dental height with orthodontic treatment. Am J Orthod 1986;89:246-50.

**How to cite this article:** Bayani S, Heravi F, Radvar M, Anbiaee N, Madani AS. Periodontal changes following molar intrusion with miniscrews. Dent Res J 2015;12:379-85.

**Source of Support:** Nil. **Conflicts of Interest:** The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.