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# Mandibular Molar Protraction for Edentulous Space Closure: A Systematic Review

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## Abstract

Objective: Orthodontic molar protraction into the edentulous space is a treatment option for patients with missing mandibular molars or premolars. Space closure by moving the molars mesially into edentulous ridge is difficult, especially in the mandible. This systematic review aimed to evaluate the dental and periodontal changes after mandibular molar protraction into an edentulous ridge. Material and Methods: Literature search was conducted using PubMed, Medline (Ovid), Cochrane Library, Web of Science, and Scopus until September 2019 limited to English publications. Specific inclusion and exclusion criteria were extracted and analyzed. Study quality was objectively assessed. Results: In total, 490 studies were identified for screening, and eight studies were eligible. All studies were of low quality. Eight included studies were retrospective studies. The mean amount of molar protraction in crown movement and root movement varied from 3.01 mm to 9.83 mm and from 7.1 mm to 10.1 mm, respectively. The root length changes varied from −1.3 mm to +1.3 mm. The alveolar bone height changes varied from −2.0 mm to +1.3 mm in mesiodistal plane and from +0.95 mm to +1.91 mm in buccolingual plane, and the buccolingual alveolar bone width/thickness changes varied from −0.66 mm to +2.60 mm. Conclusions: Mandibular molars can be successfully protracted into the edentulous ridge, especially using skeletal anchorage. The subsequent dental and periodontal changes, in terms of external apical root resorption and alveolar bone loss, are minimal and not clinically relevant. Alveolar bone width/thickness increases after molar protraction into the edentulous ridges in adolescents, but it does not consistently occur in adults.



## Keywords

molar protraction; edentulous space; space closure.





## Cover Page Footnote

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Review Article

# MANDIBULAR MOLAR PROTRACTION FOR EDENTULOUS SPACE CLOSURE: A SYSTEMATIC REVIEW

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**Objective:** Orthodontic molar protraction into the edentulous space is a treatment option for patients with missing mandibular molars or premolars. Space closure by moving the molars mesially into edentulous ridge is difficult, especially in the mandible. This systematic review aimed to evaluate the dental and periodontal changes after mandibular molar protraction into an edentulous ridge.

**Material and Methods:** Literature search was conducted using PubMed, Medline (Ovid), Cochrane Library, Web of Science, and Scopus until September 2019 limited to English publications. Specific inclusion and exclusion criteria were extracted and analyzed. Study quality was objectively assessed.

**Results:** In total, 490 studies were identified for screening, and eight studies were eligible. All studies were of low quality. Eight included studies were retrospective studies. The mean amount of molar protraction in crown movement and root movement varied from 3.01 mm to 9.83 mm and from 7.1 mm to 10.1 mm, respectively. The root length changes varied from −1.3 mm to +1.3 mm. The alveolar bone height changes varied from −2.0 mm to +1.3 mm in mesiodistal plane and from +0.95 mm to +1.91 mm in buccolingual plane, and the buccolingual alveolar bone width/thickness changes varied from −0.66 mm to +2.60 mm.

**Conclusions:** Mandibular molars can be successfully protracted into the edentulous ridge, especially using skeletal anchorage. The subsequent dental and periodontal changes, in terms of external apical root resorption and alveolar bone loss, are minimal and not clinically relevant. Alveolar bone width/thickness increases after molar protraction into the edentulous ridges in adolescents, but it does not consistently occur in adults. ***(Taiwanese Journal of Orthodontics. 31(4): 207-215, 2019)***

**Keywords:** molar protraction; edentulous space; space closure.

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## INTRODUCTION

Missing mandibular molar or premolar is common due to caries, periodontal disease,[1-4] or tooth agenesis[5] which could cause bite collapse, supraeruption of the opposing teeth into the edentulous area, tipping or drifting of adjacent teeth, formation of pseudopockets, or reduced alveolar bone height and width.[6-12]

The treatment options for an edentulous space could include prostheses, dental implants, tooth autotransplantation, or orthodontic space closure.[13-21] The prosthetic approach comprises maintaining or opening the edentulous spaces by uprighting the molars and closing the spaces using prostheses. The advantage of the prosthetic approach is a shorter treatment time, but its disadvantage is the risk of caries, periodontal disease, and dislodgement or breakage of prostheses.[22] Reportedly, the 20-year survival rate of a fixed partial denture ranges from 52.8%–66%[23,24] and the 16-year survival rate of a dental implant is 82.94%.[25]

Tooth autotransplantation may result in root resorption, ankyloses, or infection.[16,26,27] Tooth germ autotransplantation could be sufficiently promising only in the earlier stages of development.[14,16] The 10–12-year cumulative survival rates of tooth autotransplantion ranges from 68.2%–74%.[28,29]

Orthodontic mandibular molar protraction for edentulous space closure has been an achievable and practical approach.[17-21,30-34] This could be more difficult in the mandible than in the maxilla due to a thicker cortical plate, coarser trabecular, wider mandibular root width, or an atrophic dental ridge.[35] It also could be more difficult in adults than in adolescents because of lower cell activity, higher bone density, narrower and atrophic edentulous ridge, or periodontal tissue breakdown.[36,37]

This systematic review aimed to evaluate the dental and periodontal changes after mandibular molar protraction into an edentulous ridge.

## MATERIAL AND METHODS

Inclusion of studies in this systematic review was performed according to the PRISMA guidelines[38] (Figure 1), and the research question was defined according to PICO format in the inclusion criteria.

### Eligibility criteria

#### Inclusion criteria

1. Population: subjects with missing mandibular molar or premolar edentulous spaces treated with molar protraction; only humans
2. Intervention: molar protraction method
3. Comparison: subjects with missing mandibular molar or premolar edentulous spaces closed before and after molar protraction or non-missing contralateral mandibular molars or premolars
4. Outcome: dental and periodontal changes after mandibular molar protraction into an edentulous ridge
5. Study design: case series, case-control study, cohort study, retrospective studies, or randomized controlled trials.

#### Exclusion criteria

1. Systemic disease
2. Subjects with missing mandibular molar or premolar edentulous spaces treated without molar protraction.
3. Signs of generalized periodontal bone loss or other severe periodontal conditions
4. Abstracts, editorial letters, commentaries, laboratory studies, case reports, reviews, and meta-analyses

### Search strategy and study selection

Research databases including PubMed, Medline (Ovid), Cochrane Library, Web of Science, and Scopus were searched until September 2019 using key terms focused on the specific search strategy (molar protraction, molar mesialization, molar space closure, and molar


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edentulous space). We limited the search to English publications. Additional studies were searched in the reference lists of all articles included. After removing the duplicates, the articles were independently screened based on the title and abstract according to the inclusion criteria. If the abstract did not provide the information to judge whether to include the study or not, the full text was reviewed for final inclusion.

### Data items and collection

A data extraction form was developed and included the following items: authors, year of publication, study design, sample size, age of the patients, edentulous spaces, protracted teeth, protracted anchorage, analysis used, amount of molar protraction, root length changes, and alveolar bone height and buccolingual alveolar bone width/thickness changes. Conflicts between authors were resolved by consensus discussion.

The quality of each paper was independently evaluated according to PRISMA[38] and MOOSE[39] statements with five criteria: random sampling, subject selection described, valid methods, confounding factors considered, and adequate statistics provided. The quality of each article was categorized as low (≤3 criteria fulfilled), moderate (4 criteria fulfilled), or high (5 criteria fulfilled). Data were extracted and the quality of each paper was independently assessed by the authors without blinding. Conflicts between authors were resolved by discussing each paper to reach a consensus.

## RESULTS

### Study selection and characteristics

Using the search strategy, 1481 articles were identified with an additional 1 article identified from the review of references and journal indices. After the exclusion of duplicate articles, the database search resulted in 490 articles. From these, eight articles fulfilled the inclusion criteria in the present systematic review (Figure 1).[17,18,40-45]

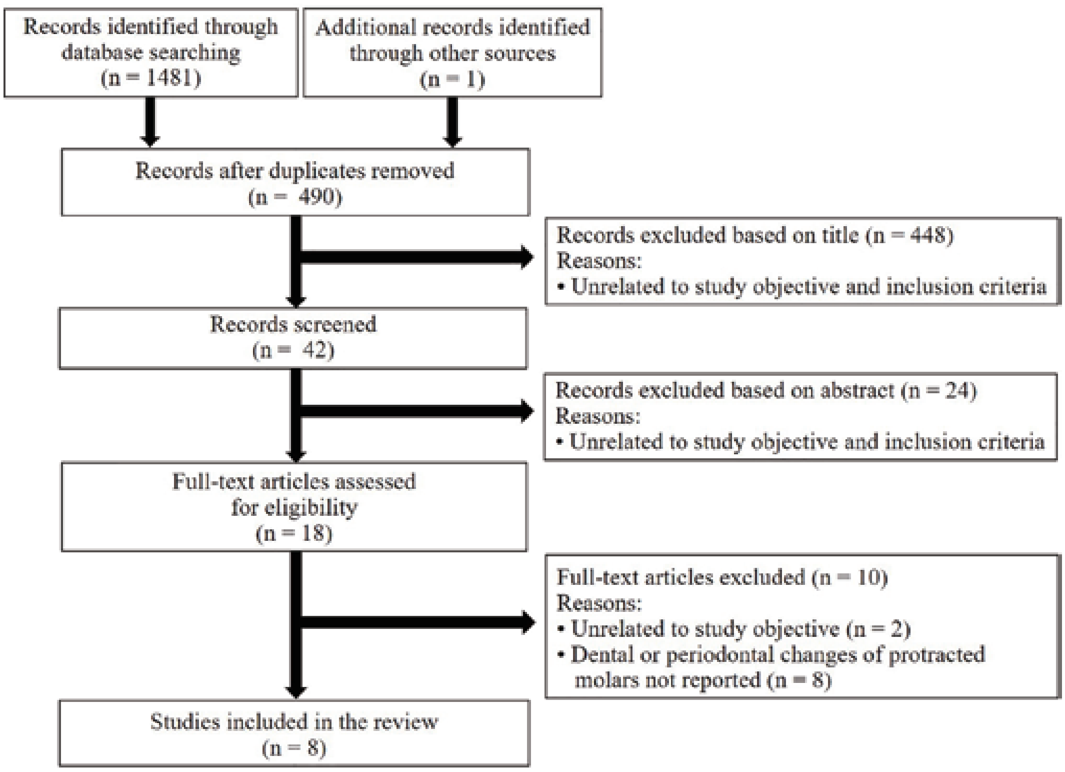


***Figure 1.*** *PRISMA Flow diagram summarizing the literature search.*


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The characteristics of the included studies in the review are presented in Table 1. Eight included studies were retrospective studies. The number of study participants ranged from 14 to 51 (total n = 202), with a mean age of 22.64 years old. Six studies reported that edentulous spaces existed in molars or premolars with space closure by second or third molar protraction, and the other two studies reported edentulous spaces existed in second premolars with space closure by first molar protraction. Two studies used dental anchorage for molar protraction,[33,34] and the other six studies used temporary skeletal anchorage devices (TADs).[42,55,56] The results of the included studies are summarized in Table 2. The eight included studies reported the amount of molar protraction in crown movement from 3.01 to 9.83 mm, and four among these eight studies simultaneously reported root movement from 7.1 to 10.1 mm. Four studies reported the root length changes from −1.3 to +1.3 mm. Six studies reported the alveolar bone height changes from −2.0 mm to +1.3 mm in mesiodistal plane and from +0.95 mm to +1.91 mm in buccolingual plane, and four studies reported the buccolingual alveolar bone width/thickness changes from –0.66 to +2.60 mm.

### Study quality analysis

The criteria examined in the eight studies and the results of quality assessment according to a checklist are shown in Table 3. The studies reviewed had common methodological problems, and all studies were categorized as having a low degree of quality.

**Table 1.** *Summary of study design, sample size, edentulous spaces, protracted teeth, protracted anchorage, analysis used in included studies.*

| Authors, year | Study design | Sample/ Mean Age (years) | Edentulous spaces | Protracted teeth | Protracted anchorage | Analysis used |
|---|---|---|---|---|---|---|
| *Stepovich,[17] 1979* | Retrospective | 8 young adults, 8 adults / 13.6; 31.5 | 16 1st molars | 16 2nd molars | dental anchorage | Cephalometric, panoramic, periapical X-ray, and dental cast |
| *Hom and Turley,[18] 1984* | Retrospective | 14 adults/ 20-39 | 19 1st molars | 19 2nd molars | dental anchorage | Cephalometric, panoramic, periapical X-ray, and dental cast |
| *Kim et al.,[40] 2015* | Retrospective | 37 adults/ 23.2 | 51 1st and 2nd molars | 36 2nd molars, 15 3rd molars | miniscrews | Panoramic |
| *Santos et al.,[41] 2017* | Retrospective, case-control | 18 patients/ 36.1 | 27 1st molars | 27 2nd molars | dental anchorage/ min-implants | Cone-beam computed tomography (CBCT) |
| *Sanches et al.,[42] 2017* | Retrospective, case-control | 16 patients/ 34.17 | 26 1st molars | 26 2nd molars | dental anchorage/ min-implants | Digital model, Panoramic |
| *Winkler et al.,[43] 2017* | Retrospective | 25 patients/ 14.9 | 25 unilateral 2nd premolars | 25 1st molars | miniscrews/ palatal implants | Panoramic |
| *Göllner et al.,[44] 2019* | Retrospective | 25 patients/ 14.9 | 25 unilateral 2nd premolars | 25 1st molars | miniscrews/ palatal implants | Panoramic |
| *Baik et al.,[45] 2019* | Retrospective | 51 patients/ 19.6 | 51 2nd premolars and 1st molars | 51 2nd molars and 3rd molars | TADs | Panoramic |


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**Table 2.** Summary of results of included studies.

| Authors, year | Amount of molar protraction (mm) | Root length changes (mm) | Alveolar bone changes: Alveolar bone height (mm) | Alveolar bone changes: Buccolingual alveolar bone width/thickness (mm) |
|---|---|---|---|---|
| *Stepovich,[17] 1979* | 6.1 (CM);10.1 (RM)[a]<br>3.7 (CM);9.6 (RM)[b] | +1.3[a]<br>−0.38[b] | −1.1[a]<br>−2.0[b] | +2.4[a]<br>+0.62[b] |
| *Hom and Turley,[18] 1984* | 4.1 (CM);7.1 (RM) | −1.3 | 1.3 (M) | +1.2 |
| *Kim et al.,[40] 2015* | 4.97 (CM);8.64 (RM) | −0.80 | −0.56 | NA |
| *Santos et al.,[41] 2017* | 3.65 (CM) | NA | +1.91 (B)<br>+0.95 (L) | -0.66 (B)<br>+0.52 (L) |
| *Sanches et al.,[42] 2017* | 3.01 (CM) | NA | NA | +2.6 |
| *Winkler et al.,[43] 2017* | 9.83 (CM) | −0.89 | NA | NA |
| *Göllner et al.,[44] 2019* | 9.83 (CM) | NA | +0.18 (M)<br>+0.06 (D) | NA |
| *Baik et al.,[45] 2019* | 6.3 (CM);7.2 (RM) | NA | -0.5 (M)<br>-0.9 (D) | NA |

[a]: young adult; [b]: adult; CM: crown movement; RM: root movement; M: mesial; D: distal; B: buccal; L: lingual; NA: not available.

**Table 3.** Quality assessment of the included studies ($N = 8$).

| No | Author, year | Random Sampling | Subject selection described | Valid method | Confounding factors considered | Adequate statistics provided | Study quality |
|---|---|---|---|---|---|---|---|
| *1* | *Stepovich[17] 1979* | No | Yes | No | Not declared | No | Low |
| *2* | *Hom and Turley[18] 1984* | No | Yes | No | Yes | Yes | Low |
| *3* | *Kim et al[40] 2015* | No | Yes | No | Yes | Yes | Low |
| *4* | *Santos et al[41] 2017* | No | Yes | No | Not declared | Yes | Low |
| *5* | *Sanches et al[42] 2017* | No | Yes | No | Not declared | Yes | Low |
| *6* | *Winkler et al[43] 2017* | No | Yes | No | Not declared | Yes | Low |
| *7* | *Göllner et al[44] 2019* | No | Yes | No | Yes | Yes | Low |
| *8* | *Baik et al[45] 2019* | No | Yes | No | Not declared | Yes | Low |

## DISCUSSION

Although a comprehensive literature search was conducted, eight included studies had a retrospective study design, indicating a shortage of high-quality clinical trials. The variations of the study results were owing to the heterogeneity of samples, edentulous spaces, protracted teeth and anchorage, and analysis methods.

The major concern regarding molar protraction is the need for an adequate anchorage unit to avoid anterior anchorage loss, especially in cases with no crowding in the mandibular anterior arch and acceptable lip protrusion. Class II intermaxillary elastics can increase anchorage in mandibular protraction, but the molars may be extruded, and this requires patient compliance.[46] Contemporary strategies for orthodontic anchorage reinforcement involve TADs, which have the advantages of absolute anchorage, intrusive mechanics, and immediate loading.[20,31-34,40-45,47] In the present review, Hom and Turley[18] used dental anchorage for molar protraction and found that premolars adjacent to edentulous spaces moved 2.0 mm distally, indicating anterior anchorage loss during molar protraction. Six studies used skeletal anchorage for molar protraction, showing that the edentulous spaces were effectively and completely closed by molar protraction without anterior anchorage loss.[40-45]

The present review has shown that mandibular molars can be protracted into edentulous space, which changed the alveolar dimension and tooth condition. Regarding amount of molar protraction, the mean crown movement varied from 3.01 to 9.83 mm, with the longest (9.83 mm) protraction observed by Winkler et al.[43] and Göllner et al.[44] The mean root movement varied from 7.1 to 10.1 mm, with the longest (10.1 mm) protraction observed in young adult patients by Stepovich.[17] Molar protraction often requires considerable root movement because an untreated missing molar usually causes tipping of the adjacent molars. Thus, the amount of root movement is usually greater than that of crown movement for bodily movement with molar uprighting.[17,18,40,45]

Regarding root length changes in the present review, the root length changes varied from −1.3 mm to +1.3 mm after molar protraction.[17,18,40,43] The results of these studies revealed that: (1) no root resorption occurred in younger adults compared with adults;[17] (2) root resorption (mean, 1.3 mm) of the second molars was minimal for adult patients;[18] (3) the root length significantly decreased by 0.80 mm (5.53%) but external apical root resorption (EARR) greater than 2 mm occurred only in 4.0% of molars;[40] and (4) a statistically significant difference between mesialized and nonmesialized first molars (0.73 mm), with a mean total EARR below 1 mm (0.89 mm) for mesialized molars.[43]

Regarding alveolar bone changes in the present review, the alveolar bone height changes varied from −2.0 mm to +1.3 mm in the mesiodistal plane measured using 2D radiography[17,18,40,44,45] and from +0.95 mm to +1.91 mm in the buccolingual plane measured using 3D radiography.[41] The results of these studies indicated that: (1) the crestal bone loss was less in young adults;[17] however, alveolar bone resorption in the distal roots of protracted second molars may be present in older patients and in those with mesially tilted third molars before treatment;[45] (2) adult patients with the least amount of molar bone loss had a mesiodistal space ≤ 6.0 mm, buccolingual ridge width ≥ 7.0 mm, and mesial molar bone level 1.0 mm apical to the cementoenamel junction;[18] (3) the alveolar bone height was significantly decreased by 0.56 mm, but alveolar bone loss (ABL) more than 2 mm occurred only in 2.0% of molars;[40] and (4) a significantly higher ABL was observed at the mesial sites of mesialized versus non-mesialized first molars without clinical relevance in the difference.[44]

The buccolingual alveolar bone width/thickness changes varied from −0.66 mm to +2.60 mm measured using dental cast/digital model, or CBCT.[17,18,40,42] The results of these studies showed that: (1) the alveolar bone followed the protracted molars into the smaller


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buccolingual width of the edentulous area and exhibited a greater alveolar bone development in young adults;[17] (2) a space closure of missing mandibular first molars caused slight buccal and lingual dehiscences at the mandibular second molar areas;[41] and (3) the alveolar ridge thickness increased in the space closure with molar protraction.[42]

The included studies concluded that space closure through extensive tooth movement in the mandible was a risk factor for EARR and ABL, but the amounts of EARR and ABL attributed to space closure were not considered clinically significant. Alveolar bone width/thickness increased after molar protraction into the edentulous ridges, especially in adolescents. However, the results should be interpreted carefully due to a low degree of quality.

## CONCLUSION

Mandibular molars can be successfully protracted into the edentulous ridge, especially using skeletal anchorage. The subsequent dental and periodontal changes, in terms of EARR and ABL, are minimal and not clinically relevant. Alveolar bone width/thickness increases after molar protraction into the edentulous ridges in adolescents, but it does not consistently occur in adults.

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