The orthodontic extraction of permanent molars: a literature review

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Abstract: The most common cause of dental crowding is the presence of an arch-length – tooth-size discrepancy. Conventional methods of gaining space in orthodontics involve the extraction of teeth, often premolars. However, there are a number of clinical situations in which the extraction of permanent molars might be considered. This paper highlights the indications, advantages, disadvantages and timing of the extraction of the first, second and third permanent molars in the treatment of a crowded malocclusion.

Introduction
Therapeutic extractions in orthodontics are performed in cases of an arch-length – tooth-size discrepancy, aiming to create additional space for the alignment of irregularly-placed teeth. The permanent molars are not a common extraction choice and many operators avoid this option due to familiarity with premolar extraction, a lack of experience in managing molar extraction cases and interdependence between endodontists, orthodontists and crown and bridge specialists. The following discussion explores the indications for first, second and third permanent molar extractions.

First permanent molar extractions
The reaction to orthodontic extraction of first permanent molars varies from unbridled enthusiasm to scepticism. Studies have indicated that orthodontic treatment following permanent first molar extraction has the same treatment duration as first premolar extraction cases and also provides advantages related to anchorage management. Houston et al. suggested low socioeconomic background and reduced interest in dental care as the underlying reasons for the selection of a first permanent molar extraction plan.

Indications for first permanent molar extractions
According to Sandler et al., first permanent molar extractions are indicated when these teeth are affected by extensive caries, hypoplasia, apical pathoses or significant restorations, or when there is crowding in the posterior region of the mandibular arch, a high mandibular plane angle or an anterior open bite.

Factors to be considered in first permanent molar extractions
Important factors to be considered include the patient’s attitude towards fixed appliance therapy, the standard
of oral hygiene, the amount and site of crowding and the presence or absence of other permanent teeth.¹ A summary can be found in Table I of the factors that, according to Ong and Bleakley, should be considered in compromised first permanent molar cases.⁴

### Table 1. Compromised first permanent molar (FPM) cases (according to Ong and Bleakley).⁴

| Factors to be considered                  | Supplementary notes                                                                 |
|------------------------------------------|-------------------------------------------------------------------------------------|
| **Level of compromise in FPM**           | Compromised first molar teeth that require a complicated and lengthy restorative process that might eventually lead to extraction. |
| **Location and number of compromised FPMs** | Compensating extractions of the antagonistic upper FPM should be considered when extracting a lower FPM in mixed dentition cases. However, there is reduced potential for overeruption of a lower FPM after the extraction of a compromised upper FPM. Balancing extractions may be beneficial to prevent the development of a midline discrepancy, which may occur if space is closed following unilateral extraction. The molar extraction can be performed if the compromised teeth are bilateral or if there is significant crowding. |
| **Dental development of the patient**    | The extraction of FPMs before the age of eight years has the potential to result in distal drifting, tilting and rotation of the adjacent unerupted second premolar. This is most likely to occur if the second premolar is distally inclined and erupts into the FPM space. |
| **Occlusal relationship**                | Class I cases<br>In the mixed dentition, if a lower FPM is compromised, a balancing contra-lateral extraction and a compensating upper FPM extraction should be considered. However, if an upper FPM is compromised, a balancing extraction in the upper arch should be considered to prevent a midline shift and a compensating FPM extraction in the lower arch is generally not required. |
|                                          | Class II division 1 cases<br>In the case of potential overeruption of an upper FPM after the extraction of a compromised lower FPM, a maxillary holding appliance is advised. If the upper FPM overerupts, the extraction of this tooth prior to the placement of fixed appliances can be performed to facilitate the correction of the Class II buccal segment relationship and increased overjet. If an upper FPM is compromised, the preservation of the compromised tooth is recommended until the upper second permanent molar has fully erupted. Overjet reduction, the correction of the Class II malocclusion and dental alignment can be achieved with the space gained from the bilateral extraction of the upper FPMs. |
|                                          | Class II division 2 cases<br>Lower arch extractions are best avoided in cases which present with a brachyfacial pattern. Overbite control and extraction space closure can be challenging. It is advisable to maintain the compromised upper FPM until the upper second permanent molar has fully erupted. |
|                                          | Class III cases<br>An orthodontic opinion is warranted prior to the extraction of any permanent teeth. Inappropriate upper FPM extraction may result in an inability to adequately camouflage cases in which there is decreased anterior and/or buccal overjet. Inappropriate lower FPM extraction may compromise future orthodontic decompensation if later orthognathic surgery is required. |
| **Amount of intra-arch crowding**        | Orthodontic space closure of FPM extraction spaces is much easier in cases with significant intra-arch crowding. In cases with minimal intra-arch crowding, the timing of the extraction of a compromised FPM is important to avoid large residual spaces by maximising the amount of mesial drift of the second permanent molar teeth. |
| **Presence and condition of the other teeth** | The presence of developing third molar teeth can be determined by a panoramic film. The absence of third molars is not an absolute contraindication of compromised FPM extraction. |

### Advantages and disadvantages of first permanent molar extractions

Uneventful space closure best occurs in children and young adults⁵ and is usually achieved by moving the roots of the second molar teeth mesially significantly farther than their crowns.⁶ The closure of upper first permanent molar extraction spaces readily occurs and is rarely time consuming.¹ Headgear may be indicated and applied to the upper second permanent molars to support anchorage, prevent excessive mesial molar movement or to relieve crowding and allow overjet reduction.¹ First permanent molar extraction is less likely to have an effect on the facial profile compared with premolar extraction.⁷ However, in a study of unilateral and bilateral first permanent molar space
closure by the mesialisation of the second molar, posterior displacement of the facial soft tissues was seen with a change in profile. There was an improvement in second and third molar inclinations in Class II division 1 cases following first permanent molar extraction. Third molar position improved by significant uprighting following first permanent molar extraction.

The disadvantages of first permanent molar extraction are the tendency for the lower second permanent molar to tilt mesially and roll lingually when subjected to a mesially-directed force. The use of full size stainless steel archwires can reduce this tendency and permit space closure with minimal tipping. Crestal bone loss mesial to the post-treatment second molars has been observed, but root resorption of the second molars has been minimal.

**Timing of first permanent molar extractions**

The recommended timing of the extraction of first permanent molars differs between the arches.

**Upper first permanent molars**

Sandler et al. recommended upper permanent first molar extraction when the second molars are still unerupted, as subsequent closure of the extraction space occurs with minimal need for correction. Ong and Bleakley also stated that the upper second permanent molar can erupt into a satisfactory contact relationship with the second premolar if the second molar was unerupted at the time of first permanent molar extraction. If the upper second permanent molar is located above the cemento-enamel junction of the FPM to be extracted, favourable space closure is likely.

Orton and Carter believed that effective distalisation of upper premolars with a removable appliance may be achieved with early removal of upper first permanent molars. However, this method was dependent on patient co-operation as headgear usage for at least 12 to 14 hours per day is required. If minimal space in the upper arch is needed, the early removal of the upper first permanent molars allows the eruption of second molars and aids space closure. The permanent second molars are usually positioned high and a slight mesial alteration of their eruption pathway will allow their eruption into the first molar spaces. If space is needed in the upper arch, first permanent molar extraction should not be performed until the second molars have erupted sufficiently to enable space maintenance by the placement of a palatal arch with a Nance button or via headgear.

**Lower first permanent molars**

The ideal age for lower FPM extraction is eight to nine years. The maximum amount of spontaneous mesial movement of the unerupted second permanent molar can be expected when a lower FPM extraction is performed at this age. The procedure significantly improves the likelihood of successful eruption of the lower third molar. While the eruptive pathway will allow upper second molars to favourably erupt, the mandibular second molars may not completely replace the lower first molars because of their more vertical path of eruption. If little or no space is required in the lower arch for correction of a malocclusion, it is often advisable to extract lower first molars early, when the bifurcation dentine of the second molars is calcifying and the roots are less than half formed. This facilitates spontaneous space closure in the lower arch. Spontaneous space closure is usually unsatisfactory if the extraction of a lower FPM is performed during or after the eruption of the second molar. The resulting occlusal consequences include mesial tipping and lingual rolling of the lower second molar, overeruption of the opposing upper FPM, incomplete space closure with associated food entrapment (without orthodontic treatment), distal drifting and/or tilting of the lower second premolar and atrophy of the alveolar bone if space closure is incomplete.

**Second permanent molar extractions**

Orthodontic treatment involving permanent second molar extraction has been extensively studied. Although second molar extractions are not common, studies have shown satisfactory outcomes following second molar extraction protocols. A report by Greatrex et al. showed favourable results in cases treated with the Tip-Edge appliance and accompanying second molar extraction. Similarly, a preliminary study on lower second molar extraction for the management of a severe skeletal Class III malocclusion produced a successful outcome. A remarkable soft-tissue change was noted after treatment, and concave facial profiles improved to straight profiles.
Indications for permanent maxillary second molar extractions

A summary of indications and criteria for permanent maxillary second molar extraction can be found in Table II.

Indications for permanent mandibular second molar extractions

The extraction of lower second molars can be performed in severe skeletal Class III malocclusions with a super Class I molar or a full Class III molar relationship with well-aligned upper and lower arches or minor crowding.\(^{17}\)

Indications for four permanent second molar extractions

Several authors\(^{27,28}\) have proposed extractions of all four permanent second molars under certain circumstances. Chipman\(^{27}\) suggested this option when the permanent second molars are severely carious, ectopically erupted or severely rotated. The extraction of permanent second molars is also indicated in mild-to-moderate arch length deficiency cases in which there is a good facial profile and crowding in the tuberosity region with a need to facilitate distal movement of the first permanent molar. Lehman\(^{28}\) showed favourable results following the extraction of permanent second molars in the treatment of skeletal Class I malocclusion cases with an associated posterior arch length discrepancy. In addition, mild anterior crowding in Class II skeletal cases was also successfully treated. Quinn\(^{14}\) advocated four permanent second molar extractions in cases in which the third molars were present, normal in morphology, with a partially- or fully-formed crown and reasonably upright. It was also suggested that this extraction sequence temporarily reduced the functioning molar area and moved the mandibular fulcrum one molar forward, which assisted in the closure of an anterior open bite. The removal of permanent second molars was also indicated at the end of active treatment of a Class III malocclusion in which anterior retraction had increased lower molar crowding.\(^{14}\)

Contraindications for permanent maxillary second molar extractions

A thorough evaluation is needed to determine a detailed treatment plan with this extraction protocol. The contraindications for maxillary second molar extraction are described in Table III.

Advantages of permanent second molar extractions

The literature\(^{13,29,30,31}\) has proposed the following benefits of permanent second molar extractions:

- Stability and retention following orthodontic
PERMANENT MOLAR EXTRACTIONS

therapy is increased by the occlusal interlocking of the eight bicuspids.

• Reduction in the amount and duration of appliance therapy.
• Improving or maintaining good facial aesthetics.
• Prevention of a ‘dished-in’ facial profile at the end of growth as the extraction of these teeth has a lesser effect on the position of the maxillary incisors in orthodontic treatments compared with maxillary premolars.
• Providing the appropriate amount of space needed for orthodontic correction.
• Ease of space closure in borderline cases.
• Chances of increasing the overbite are reduced as permanent first molars tend to move more mesially in premolar extraction cases and more distally in second molar extraction cases.
• Eliminates the possible complications related to the surgical removal of third molars and pericoronitis.
• Faster eruption of third molars.
• Allows the replacement of the carious, malformed, malpositioned or badly restored permanent second molars with a sound third molar.
• Eliminates the third molars as a possible cause of relapse.
• Prevention of late incisor imbrication.
• Distal movement of the dentition to correct an overjet.
• Fewer residual spaces at the end of orthodontic treatment.
• Good functional occlusion.
• Good mandibular form.
• Reduction in incisal overbite.

Disadvantages of permanent second molar extractions

The following are noted disadvantages of permanent second molar extractions:13,26,30,32,33

• Too much tooth substance is removed in Class I malocclusions with mild crowding.
• Extraction sites are far from the area of concern in moderate-to-severe anterior crowding.
• Patient cooperation is needed in wearing extra-oral appliances in order to move the dentition distally en-masse in the correction of antero-posterior discrepancies.
• Potentially insufficient size and form of third molars.
• Unpredictable path of eruption of maxillary third molar.
• Possible impaction of third molars even with second molar extraction.
• Frequently unacceptable positions of erupted third molars necessitating a second, late stage of fixed appliance therapy.
• An estimated 9–20% of the population will have one or more molars missing.

Timing of extraction of permanent second molars

Upper permanent second molars

Magness34 suggested that permanent maxillary second molars should be extracted when the maxillary third molars reach the vertical middle of the maxillary second molar root in a Class I malocclusion. Alternatively, when managing a Class II malocclusion, maxillary third molars should be approximated at the eruptive level of the cemento-enamel junction of the

| Contraindication | Supplementary notes |
|------------------|---------------------|
| Third molar size14,16 | Small, unusually large or poorly formed third molars. |
| Third molar position14,16,27 | Third molar sinus involvement, severely mesio-angularly orientated third molars. |
| First permanent molar condition16 | Heavily restored, carious and/or periodontally-involved first permanent molars. |
| Unfavourable malocclusions16 | Severe bimaxillary protrusion, severe dental crowding, open bite. |
| Congenitally missing teeth14,16 | Missing third molars, premolars or incisors. |
maxillary second molars at the time of extraction if the distalisation of the permanent maxillary first molars is required.34

Lower permanent second molars
According to several authors,28,30,35,36,37 the third molar crowns should be completely formed and extractions should be performed before the roots begin to develop. The axial inclination of the third molar buds should not be greater than 30° in relation to the occlusal plane.36 The third molar should also be in close proximity to the second molar roots to ensure adequate mesial drift of the third molar as it erupts.36 The optimum age for this treatment is between 12 and 14 years.38,39 According to Wilson,40 permanent second molars should be extracted as soon as they erupt especially in patients with severely tipped third molars. Third molars should be observed for 6 to 12 months for possible spontaneous correction or for the need to use separating mechanisms and/or other appliance therapy. Wilson40 agreed with Rix41 and proposed that the extraction of permanent second molars should be done upon eruption provided that the mesial angulation of the third molar is not greater than 45°. Early diagnosis and possible enucleation of the second molar has been proposed by Liddle.42 However, Breakspear43 suggested that permanent second molar extraction should not be performed if the third molar roots are half formed, even if the latter have a favourable angulation.

Effect of permanent second molar extraction on third molar eruption
A study by Orton-Gibbs et al.44 assessed the eruptive path of third molars after second molar extraction in 63 patients. It was concluded that, following the extraction of permanent second molars, the upper and lower third molars erupt in good or acceptable positions. There was a continued improvement in the angulation of the mandibular third molar at the end of treatment, which further improved during the first two to three years after treatment. This was supported by Moffitt,45 who stated that the maxillary third molars often erupted into favourable positions with acceptable inter-arch and intra-arch occlusal relationships following permanent maxillary second molar extraction. A model analysis by Richardson and Richardson46 on 63 subjects showed that 96% of the lower third molars erupted into a good or acceptable position. A study of 11 cases to evaluate the effect of enucleation of permanent second molar buds on the occlusal position of the third molars showed generally good results in positioning of the third molars, while three cases showed third molar displacement, which required further treatment.47 The study concluded that the final axial inclination of the third molars was typically good. Nevertheless, mechanical straightening of these teeth must be considered in identified cases.

Moffitt45 assessed the periodontal status of the third molar – first permanent molar contact and showed no interproximal loss of attachment.

Third molar extractions
Considerable research48-58 has been conducted regarding the development of the third molar and its effect on the lower arch. Third molar extractions are often recommended at the end of orthodontic treatment or indicated for pathological reasons.59 Late crowding of anterior teeth in the upper and lower arches has been shown to affect individuals with previously regular dental arches.60 The third molar, as a contributory factor of crowding, has been reported by many authors61-64 and anterior relapse after orthodontic treatment has been linked to these teeth.56,57

Indications for third molar extractions
a) Severe lower anterior crowding
A survey by Laskin58 involving more than 600 orthodontists and 700 oral surgeons revealed that 65% of the clinicians were of the opinion that crowding of the mandibular anterior teeth was sometimes caused by third molars.

A study conducted by Lindqvist and Thilander,60 which examined the extraction of an impacted third molar on one side and molar retention on the contralateral side, showed a differential arch length change in most cases. However, 70% of the cases also showed more favourable development on the extraction side compared with the control side.

Vego64 conducted a longitudinal study of 40 patients who possessed lower third molars and 25 patients with congenitally-missing lower third molars over a period from 13 years to 19 years and concluded that molar eruptive force transmitted to the anterior teeth could lead to crowding of the arch.
Bergstrom and Jensen\textsuperscript{65} refuted this and stated that the presence of a third molar might influence the development of the dental arch. However, the removal of the tooth germ or extraction of the third molars could not be justified.

\textit{b) Patients with a strong tendency to crowding and relapse}

Schwarze\textsuperscript{66} found an average of 1.5 mm greater mesial movement in 49 patients when third molars were retained compared with 100 patients who underwent early third molar germtomy. The results showed approximately 1 mm less mesial drift of the upper first molars in cases in which the extraction of third molars was performed.

Several studies found no correlation between third molars and lower incisor crowding. Kaplan\textsuperscript{61} investigated the influence of the mandibular third molars on post-treatment changes, particularly anterior tooth relapse. Pretreatment, post-treatment and 10-year post-retention study models and lateral cephalograms of 75 orthodontically-treated patients were obtained. It was concluded that minor lower anterior crowding occurs in most cases. However, a greater degree of lower anterior crowding or rotational relapse after the cessation of retention was not caused by the presence of third molars.

A cephalometric study by Ades et al.\textsuperscript{67} found that there were no substantial differences in the mandibular growth pattern between erupted, impacted or congenitally missing third molar groups and also with and without premolar extractions. The authors concluded that incisor crowding was present in the majority of the cases. Lifshitz\textsuperscript{68} found a significant decrease in arch length and a substantial increase in mandibular incisor crowding following an evaluation of lower premolar extraction versus non-extraction in the presence and absence of third molars. However, there was no significant difference between the groups.

The eruption of permanent second molars was facilitated by the extraction of mandibular third molars, especially in cases of crowding and space deficiency in the mandibular posterior region.\textsuperscript{69}

The extraction of third molars is indicated when there is pathology such as infection, non-restorative lesions, cysts, tumours or the destruction of adjacent teeth and bone.\textsuperscript{70,71}

Third molar extraction is also indicated to manage or avoid their impaction and facilitate the retraction of the permanent first and second molars.\textsuperscript{33}

\textbf{Contraindications for third molar extractions}\textsuperscript{33}

When mandibular premolars are extracted or congenitally missing and space closure is conducted in the lower arch against a non-extraction approach in the upper arch, the first permanent molar relationship will be Class III. In these circumstances, little or no occlusal contact of the maxillary second permanent molar is likely with the mandibular second permanent molar. Hence, the preservation and alignment of third molars is essential to allow contact with opposing teeth.

The third molars should be preserved when an orthodontic treatment plan involves the extraction of permanent first or second molars, or due to extensive caries or periapical involvement in these teeth. This is particularly indicated in cases of non-growing patients with Class II malocclusions or in patients with a tendency towards an open bite.

\textbf{Conclusion}

Rather than more conventional premolar extractions, the extraction of molars can be an alternate method of gaining arch space. If molars are carious and present with a poor prognosis, their extraction may prove beneficial to the patient in conjunction with appropriate treatment planning and mechanics. However, it is crucial that the biologic and mechanical requirements of a treatment plan are well considered before proceeding with molar extractions.

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