Envisioning Post-treatment Occlusions after Space Closure Using Temporary Skeletal Anchorage Devices

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Missing posterior teeth and posterior tooth extractions are commonly seen and needed within orthodontic practices. With the invention of temporary skeletal anchorage devices (TSADs), clinicians can now effectively close posterior tooth spaces. Various molar occlusions are discussed to help clinicians envision post-treatment occlusions after posterior teeth space closure using TSADs.

Keywords: *Molar protraction, temporary skeletal anchorage devices (TSADs), occlusion, space closure*

INTRODUCTION

With missing posterior teeth, clinicians must decide whether to close, open, or maintain the spaces. When there is lip protrusion and crowding plus missing molars, it is possible to retract the anterior segment and close the missing molar spaces instead of extracting premolars.[1] Conversely, if there is neither lip protrusion nor crowding, treatment is challenging since no extractions are necessary. In such cases, missing molar spaces should be closed by full mesialization of the posterior teeth. Nowadays, clinicians can more successfully and efficiently close missing first molar spaces using temporary skeletal anchorage devices (TSADs).[1-4]

During diagnosis and treatment planning, clinicians frequently wonder whether orthodontic space closure of missing posterior teeth can establish a stable final occlusion because Class I molar occlusions can be compromised after space closure. There are many possible final combinations of occlusion after closing missing tooth spaces. In this paper, we will discuss the various molar occlusions due to molar protraction using TSADs to help clinicians predict final posterior occlusions without the help of set-up models.

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Classification of various missing molar cases

The reported incidence of permanent tooth agenesis ranges from 1.6 to 9.6%,[5] with the most commonly affected teeth being mandibular second premolars followed by maxillary lateral incisors.[5] Regarding acquired missing teeth, mandibular first and second molars are the teeth most frequently extracted due to caries, especially in patients aged 11 to 20.[6,7]

Missing teeth can exist in both jaws so this paper includes various extraction patterns relating to both arches. Since retained maxillary second deciduous molars without permanent successors are rare, the scenarios relating to them have been excluded. The combination of maxillary and mandibular missing second molars can be treated relatively easily by substituting maxillary and mandibular third molars; therefore, these cases have also been excluded. As a result, there are 7 combinations of missing posterior teeth that are discussed.

1. Maxillary 6(s) extraction and mandibular nonextraction (Fig. 1)
2. Maxillary 6(s) and mandibular 4(5)s extraction (Fig. 2)
3. Maxillary 6(s) and mandibular 6(s) extraction (Fig. 3)
4. Maxillary nonextraction and mandibular 6s extraction (Fig. 4)
5. Maxillary nonextraction and mandibular Es extraction (Fig. 5)
6. Maxillary 4s and mandibular 6(s) extraction (Fig. 6)
7. Maxillary 4s and mandibular Es extraction (Fig. 7)

Regarding classification of molar relationships, Class I, II, and III should be based on the maxillary and mandibular first molars. For missing first molars, however, second molars have been regarded as first molars to describe the molar relationship.

Fig. 1. Maxillary 6(s) extraction and mandibular nonextraction: 20-year-old female patient with extracted maxillary right first molar. As anterior protrusion was not severe, nonextraction treatment was planned, and the missing space was closed by molar protraction. Final molar relationship was Class I. A: Initial, B: During treatment, C: Debonding.

Fig. 2. Maxillary 6(s) and mandibular 4(5)s extraction: 26-year-old male patient with a missing maxillary right first molar. The molar space was closed along with those from the 3 premolar extractions. Molar relationship finished as Class III on the right side, and the canine relationship was Class I. A: Initial, B: During treatment, C: Debonding.

Fig. 3. Maxillary 6(s) and mandibular 6(s) extraction: 26-year-old male patient who was missing the maxillary right first molar and both mandibular first molars. Space closure, accomplished using molar protraction, established molar Class I relationship. A: Initial, B: During treatment, C: Debonding.

Fig. 4. Maxillary nonextraction and mandibular 6s extraction: 18-year-old female patient was missing her mandibular first molars. Nonextraction treatment was planned on her maxillary arch because there was no lip protrusion or crowding. The maxillary right third molar was extracted after orthodontic treatment. Molar protraction was used to close her missing mandibular first molar spaces, which resulted in a Class I molar relationship. A: Initial, B: During treatment, C: Debonding.

Fig. 5. Maxillary nonextraction and mandibular Es extraction: 18-year-old male patient had missing mandibular second premolars, and his deciduous mandibular second molars were extracted. The missing right premolar space was maintained by a space maintainer. The patient's maxillary right second molar and third molar were also missing. To close the spaces, mandibular molars were protracted. The molar relationship was Class III after treatment. Because the distal root of the mandibular second molar was involved with a cystic lesion, it was cut when the mandibular right third molar was extracted. A: Initial, B: During treatment, C: Debonding.

Fig. 6. Maxillary 4s and mandibular 6(s) extraction: 27-year-old female patient had a hopeless right mandibular first molar and three premolars extracted. The resulting molar relationship was Class II. A: Initial, B: During treatment, C: Debonding.

Fig. 7. Maxillary 4s and mandibular Es extraction: The patient, a 15-year-old male, was missing mandibular second premolars and had retained deciduous mandibular second molars. The mandibular molars were protracted for space closure. In the maxilla, the first premolars were extracted for improvement of anterior protrusion. In this case, the molar relationship ended in Class I. A: Initial, B: During treatment, C: Debonding.

Posterior occlusions after molar protraction for various missing posterior teeth

In orthodontic cases with no missing posterior teeth, the American Board of Orthodontics (ABO) standards require that the maxillary molar mesiobuccal cusps align with the buccal grooves of the mandibular molars for a Class I molar relationship.[8] In full-step Class II molar relationships, the maxillary first molar mesiobuccal cusp will align with the interproximal contact between the mandibular second premolars and first molars. In full-step Class III molar relationships, the maxillary second premolar buccal cusps should align with the mandibular first molars.[8] Based on these criteria, the resulting posterior occlusions in the seven cases of posterior missing teeth are as follows.

Maxillary 6(s) extraction and mandibular non-extraction

In the maxillary arch, second molars will replace the first molars, and maxillary third molars will replace second molars. The molar relationship should be Class I because premolars are not extracted. The number and shape of first and second molar cusps are similar; therefore, there is no problem in establishing a sound occlusal relationship in both the buccal and lingual aspects. Due to morphological variations in third molars, it isn't easy to achieve the same exact occlusion when third molars move into the second molar position. If third molar lingual cusps are well-developed, a stable occlusion and function can be achieved. Since the mesiodistal width of maxillary second molars are slightly smaller than that of first molars, third molars must be positioned slightly mesial to the original position of the second molars in a normal occlusion, but the difference isn't significant and doesn't affect the establishment of an optimal occlusal relationship (Fig. 1).

Maxillary 6(s) and mandibular 4(5)s extraction

The molar relationship is Class III because maxillary premolars are not extracted while mandibular premolars are extracted. With missing maxillary first molars, maxillary third molars occlude with mandibular second and third molars. In this scenario, the presence of third molars plays an important role in establishing a stable occlusion. If no mandibular third molars are present, maxillary third molars will extrude due to the lack of an antagonistic tooth. In such cases, a fixed retainer or removable retainer with an occlusal rest can be used on the maxillary third molar after treatment to prevent molar extrusion. In the presented case, the small mesiodistal width of the maxillary third molar allowed it to be mesially positioned to create an occlusal contact with the mandibular second molar (Fig. 2).

Maxillary 6(s) and mandibular 6(s) extraction

In this scenario, since both maxillary and mandibular first molars are missing, second molars replace the first molars, and third molars replace the second molars. Compared with the mandibular first molar, the number of cusps on the second molar is less than that on the first molar. Even so, the mandibular first molar has a small and often minimally functioning distal cusp that makes establishing an appropriate occlusion with the substituted second molar feasible (Fig. 3).

Maxillary nonextraction and mandibular 6s extraction

Since there is an equal number of premolars in both arches, Class I molar relationship can be achieved. In the final occlusal scheme, the mandibular third molar is needed to establish a stable end result. In this case, the maxillary right third molar was extracted after treatment because there wasn't an antagonistic tooth after mesialization of the mandibular molars (Fig. 4).

Maxillary nonextraction and mandibular E extraction

Since the mandibular second premolar is missing and the deciduous molar is extracted, the final occlusion will be Class III. In this case, if a maxillary second molar is present, eruption of mandibular third molar is needed to occlude with the maxillary second molar (Fig. 5).

Maxillary 4s and mandibular 6(s) extraction

Extraction of maxillary premolars may need to be performed due to protrusive lips and the proclination of maxillary incisors. In this case, the mandibular second molars will replace the first molars creating a Class II molar relationship. The mandibular third molar is needed to occlude with the maxillary second molar (Fig. 6).

Maxillary 4s and mandibular Es extraction

In the presented case, maxillary first premolars were extracted due to severe proclination of maxillary incisors, and the deciduous mandibular second molars were retained due to missing second premolars. After extraction of the retained deciduous mandibular molars and protraction of the mandibular posterior segments, the final occlusion results in a Class I dental relationship (Fig. 7).

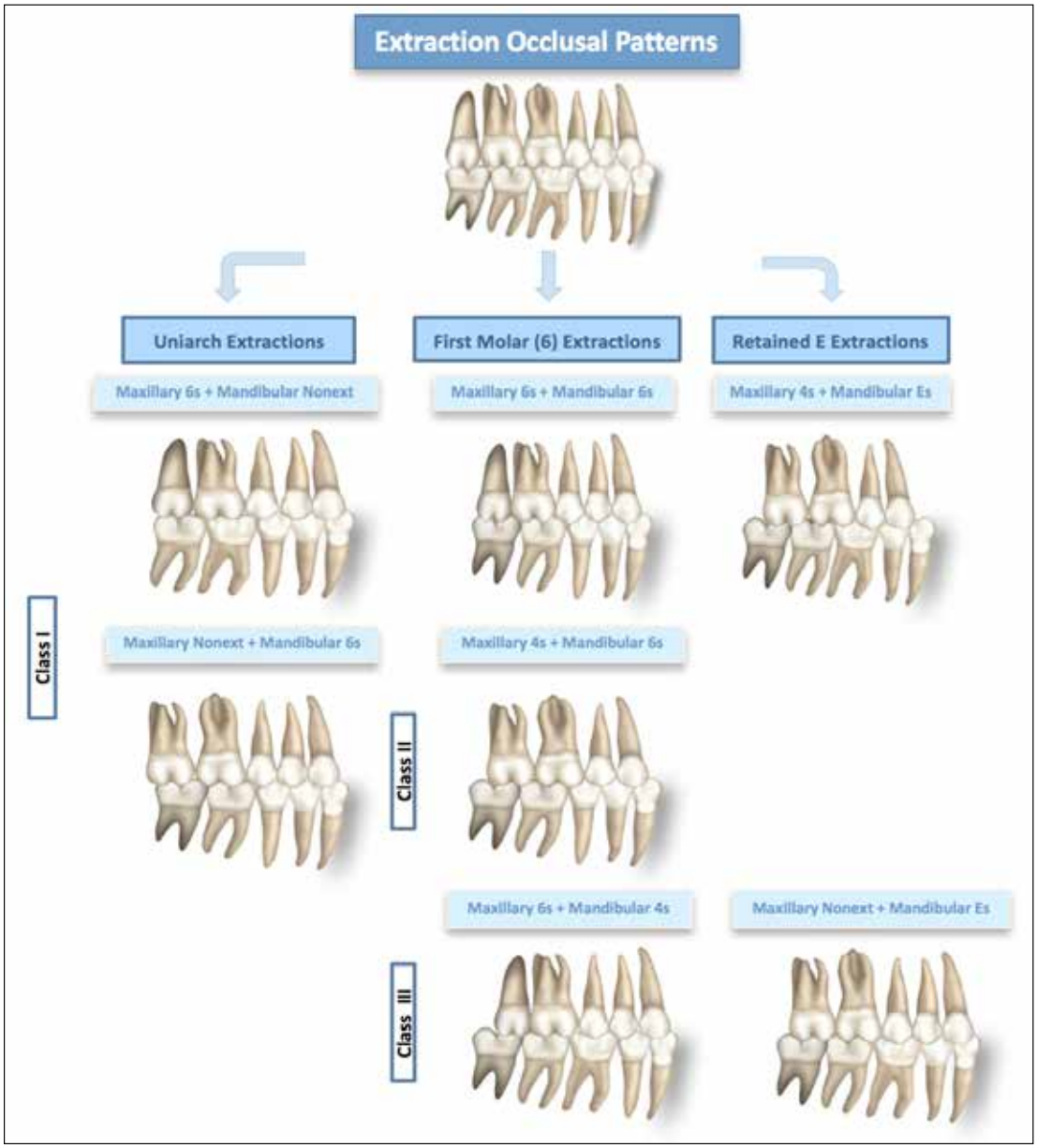
The molar relationships described above assume that the canine relationship should always be finished in a Class I relationship.

In summary,

1. Maxillary 6s extraction and mandibular nonextraction: Class I molar relationship
2. Maxillary 6s and mandibular 4(5)s extraction: Class III molar relationship
3. Maxillary 6s and mandibular 6s extraction: Class I molar relationship
4. Maxillary nonextraction and mandibular 6s extraction: Class I molar relationship
5. Maxillary nonextraction and mandibular Es extraction: Class III molar relationship
6. Maxillary 4s and mandibular 6s extraction: Class II molar relationship
7. Maxillary 4s and mandibular Es extraction: Class I molar relationship

If two molars are planned for the occlusal finish, (1)-(3) cases will require maxillary third molars and (2)-(7) cases will require mandibular third molars (Fig. 8).

Fig. 8. Schematic of the resulting Class I, II, or III occlusions that resulted from different extraction patterns. The third molars are shadowed to highlight the importance of their presence in specific extraction occlusion patterns.



DISCUSSION

First molars, especially mandibular first molars, often have dental caries and require premature extraction. When posterior tooth space is orthodontically closed, patients often benefit more from utilizing a natural tooth rather than from a dental implant. With mesialization of molars, pericoronitis associated with third molars,[9] distal caries of second molars,[10,11] and third molar impaction can be prevented.[1,2] Protracting third molars can also mitigate the need for extractions that can lead to surgical trauma and nerve injury.[12,13]

The influence of morphologic differences when establishing a stable molar occlusion is minimal because mandibular first and second molars are similar in crown morphology except for the often diminutive distobuccal cusp on the first molar. With regards to second and third molars, third molars mesiodistally are 0.6 mm larger than second molars in the mandible, while in the maxilla, third molars are 0.7 mm smaller than second molars.[14] In cases involving retained Es, mesiodistal widths of deciduous and permanent dentition need to be addressed. Each side of the maxillary arch has about 1.5 mm of leeway space, while it is 2.5 mm in the mandible arch.[15] This discrepancy between the arches should be considered when extracting maxillary first premolars and retained deciduous mandibular second molars. In this case, the final molar relationship after protraction will be Class I, but the mandibular first molar will be positioned slightly more mesial due to greater mandibular leeway space and size discrepancy between deciduous molars and permanent premolars.[15] Mandibular third molars might also be necessary to stabilize the final occlusion.

When third molars are utilized, clinicians need to predict the prognosis of the third molars so they can erupt into occlusion. Tooth size and morphology vary from patient to patient, particularly for third molars which have the greatest variation in tooth shape.[16,17] Even so, favorable functional occlusions have been reported with erupted third molars after the extraction of second molars.[18] Also, the molars settle some after debonding due to remodeling of the periodontal tissues and vertical eruption force of the molars.[19-23] Studies have demonstrated that erupted third molars maintain good periodontal health over time,[13,20 so] with missing molars or when molars are to be extracted, clinicians should be careful when considering prophylactic extraction of third molars.

Recognizing molars' proximity to important landmarks is also significant in treatment planning. Maxillary first molar space can be closed by bodily movement of maxillary second and third molars through the maxillary sinus. Since maxillary roots can sometimes move through the maxillary sinus floor, orthodontists must be cautious. The difficulty of moving a tooth in the maxillary sinus is similar to that of moving a tooth in the atrophic posterior mandibular ridge. For successful orthodontic tooth movement, anatomic relationships between the inferior wall of the maxillary sinus and the surrounding structures must be carefully evaluated and proper mechanics with light forces should be applied.[24-26]

When molars are extracted, atrophic edentulous ridges may not always deter molar protraction. Nagaraj *et al* demonstrated that protracting mandibular second molars into edentulous first molar extraction space increased the buccolingual width of the alveolar bone, and the protraction resulted in no evidence of fenestration or dehiscence around the protracted molar.[27] Even long spaces do not deter protraction as Stepovitch concluded that it was possible to close spaces of 10 mm or more in adults.[28] Since maintaining these lengthy space closures is difficult, a fixed buccal archwire can be placed from molar to premolar during retention.[27]

Although molar protraction can eliminate ridge resorption, tipping of adjacent teeth, supraeruption of opposing teeth, and the need for a dental prosthesis, the technique has limitations. Baik *et al* had great difficulty producing pure protraction movements of second and third molars and treating cases that involved anterior open bites or long edentulous spaces with molar protraction.[3] Root resorption is also possible. Nagaraj *et al* reported minor root blunting when protracting bilateral mandibular second molars more than 8mm.[27] Although the use of TSADs does provide sufficient anchorage, Kravitz and Jolley reported buccal crown tipping during mandibular molar protraction with miniscrews.[29] During molar protraction, a long buccal hook, uprighting spring, toe-in-bend in the posterior portion of the archwire, or balancing lingual force can be used to prevent undesirable side-effects such as posterior teeth tipping, mesial rotation, and buccal crown tipping.[4]

In spite of the advantages TSADs provide in molar protraction, some studies have noted how fixed functional appliances can aid in molar protraction. Chhibber and Upadhyay demonstrated that en-masse protraction of an entire posterior segment of mandibular teeth can be accomplished with a passive Forsus appliance. The fixed functional appliance was used to provide anchorage reinforcement during posterior dentition protraction. The appliance minimized wire deformation which facilitated better sliding mechanics and provided a mesially directed force on the mandibular anterior teeth that ultimately prevented anchorage loss.[30,31]

Periodontal considerations are also key in molar protraction. Hom and Turley have noted a mesial crestal bone loss on second molars after protraction through narrow ridges, and that second molar crowns moved almost twice as far as their roots.[32] To prevent these periodontal defects, Carvalho *et al* reported that it was possible to avoid compromised periodontal support of an edentulous space by repairing the alveolar ridge with guided bone regeneration and decalcified free-dried bone allograft. The type and magnitude of the defect, however, highly influence the success rate of the regenerative procedures.[33]

Long *et al* have concluded corticotomy is effective and safe in accelerating orthodontic tooth movement.[34] However, the effects of corticotomies have only been proven advantageous for a short term ranging from 1-3 months.[35] Current techniques using mini-implant facilitated micro-osteoperforations have also shown promise in accelerating tooth movement. Micro-osteoperforations create more rapid bone remodeling due to increased osteoclast quantity in the bone. Cheung *et al* demonstrated that micro-osteoperforations accelerated tooth movement in rats without increased risk of root resorption.[36] Despite the many unknown variables that once limited molar protraction, TSADs, corticotomies, and other surgical interventions might help establish favorable, predictable final occlusal results.

CONCLUSIONS

Clinicians can use TSADs to effectively close space caused by missing posterior teeth. The resulting occlusions from molar protraction can be functionally stable with proper planning.

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