Is orthodontic treatment without premolar extractions always non-extraction treatment?

S Kandasamy,* MG Woods†

Abstract
While it is common in contemporary orthodontic and orthopaedic treatment to commence treatment for many growing patients during the mixed-dentition, the creation of anterior space, often involving the attempted distalization or holding-back of the upper and lower permanent molar teeth has been shown to commonly result in posterior space deficiencies. Although the extractions of permanent premolar teeth may have been avoided, the developing second and third permanent molars are often affected, so that third molar impaction results in many cases. This is not to say that orthodontic treatment carried-out without premolar extractions is not ideal in many cases, but on the available evidence, so-called absolute 'non-extraction' protocols should be questioned, so that both the dental profession and the public at large are not misled.

Key words: Orthodontics, premolar extractions, non-extraction, third molars.
(Accepted for publication 5 May 2005.)

INTRODUCTION
The dental and skeletal effects of orthodontic treatment are usually superimposed on any changes that may be occurring with natural growth in all three dimensions. Therefore, orthodontic treatment carried out during an active growth phase may significantly influence the development of the dentition. For instance, treatment that involves the distalization or the holding-back of the molars, aimed at somehow creating space in the anterior part of the arch and preventing premolar extractions, tends to create a space deficiency in the posterior part of the arch.1 This may significantly affect the eruption of the second and third molars. Although the third molars are generally the last teeth in the arches to develop and are located at the posterior limits of the dentition, the eruption potential of these teeth should be an important consideration for both the general dentist and the orthodontist when planning active treatment and long-term maintenance. Based on a careful assessment of an individual's facial growth and dental development, the clinician should make individual decisions regarding the definitive management of the third molars for each patient. Although many factors may be involved, it has long been recognized that the eruption of the third molars is primarily dependent upon the space available at the posterior ends of the arch. This space is influenced by both natural growth and active treatment.2 Growth influences on these spaces may largely be expressed as arch-lengthening by apposition at the maxillary tuberosities or resorption at the anterior borders of the mandibular rami. This is illustrated in Fig 1 and 2. Several recent studies have involved the assessment of the effects of different orthodontic approaches (i.e., so-called extraction or non-extraction treatment) on posterior space conditions.3-5 The results of those studies have shown that premolar non-extraction approaches often lead to the impaction and eventual extractions of the third molars.3 Selective premolar extraction approaches on the other hand, were found, in many cases, to have improved the chances of successful third molar eruption.3,4 This present article is a review of the relevant historical and contemporary literature, with the aim of directly addressing the question, 'Is orthodontic treatment without premolar extractions always non-extraction treatment?'

The fallacy of so-called 'non-extraction' treatment
The dental and orthodontic literature would seem to include considerable reference to 'non-extraction' treatment, in which third molar development and eruption has not been taken into consideration. There is often little, if any, mention of the ultimate fates of the third molars, and it appears that, in many cases, the third molar question has simply been overlooked. The appropriateness of such absolute non-extraction terminology has been questioned previously and perhaps a clearer distinction could be made between those cases treated with and without the extractions of

*Former graduate student, School of Dental Science, The University of Melbourne, Victoria.
†Professor and Chair of Orthodontics, School of Dental Science, The University of Melbourne, Victoria.
any teeth.\textsuperscript{1,3,4} So-called ‘non-extraction’ treatment has been shown to frequently result in a shortage of space for third molar eruption, eventually resulting in either the removal of those third molars or their inability to emerge into the mouth as useful teeth.\textsuperscript{3}

‘Non-extraction’ treatment

For much of the past century, orthodontic theory and practice was based on the Angle orthodontic ideal.\textsuperscript{6} This ideal assumed that nature intended for all adults to have 16 teeth, perfectly aligned in each dental arch, and interlocking in ideal occlusion. Angle preached that, when this occurred, the face would be in perfect harmony and balance.\textsuperscript{6} The advantages and disadvantages of the extractions of permanent teeth as part of an orthodontic treatment plan have since been discussed and argued over several generations with philosophical trends changing periodically.\textsuperscript{7-9} In recent years there has been a tendency for the philosophy to return to the premolar ‘non extraction’ side, although little consideration seems to have been given to the fates of the third molars. With this in mind, several authors have shown that orthodontic treatment which involves the holding back or attempted posterior movement of the permanent molars may actually reduce posterior arch space, in turn, resulting in the impaction of the third molars.\textsuperscript{10-12}

\textbf{Molar distalization}

Attempted distalization of the maxillary posterior teeth is one of the more common methods used for increasing available dental arch length or for attempting Class II molar correction. In contemporary orthodontics, Class II molar correction may be accomplished in a number of ways. First, through the direct distal movement of the upper molars. Secondly, through the indirect distal movement of the upper molars, as a consequence of the downward and backward displacement of the maxilla associated with orthopaedic cervical-pull headgear or functional appliance treatment. Thirdly, through a combination of the above, with distal molar movement occurring within the body of the maxilla, while the maxilla is itself being displaced downward and backward in relation to the cranial base. Finally, through the holding of the upper teeth and jaw while the mandible and its arch are translated downward and forward with natural growth.

While various headgears have been used to apply extra-oral force to the maxillary molars,\textsuperscript{14-17} the major disadvantage with their use has been their heavy dependence on patient compliance. This potentially-poor patient compliance may lead to an increased treatment duration or a change in the overall treatment plan, or both.\textsuperscript{18} Therefore, various other appliances
have been introduced, with the aim of somehow reducing the amount of patient compliance necessary for treatment success.\textsuperscript{19-24} Timing for the use of such appliances is very important since molar distalization is recognized to be most easily accomplished when attempted in the late-mixed dentition stage, before the eruption of the second permanent molars.\textsuperscript{21} Following the eruption of those second molars, the potential for and the rate of distal molar movement is seen to decrease.\textsuperscript{26}

Another posterior limiting factor is the strong muscular pressure being exerted by the buccinator, masseter, temporalis and pterygoid muscles.\textsuperscript{22} When adequate space does not already exist in the upper arch and distal forces are applied to the first molars, the second molars are often driven disto-buccally, with the third molars becoming deeply impacted (Fig 1). This occurs essentially because there is simply not enough tuberosity growth to accommodate all these teeth in the arch.\textsuperscript{27} Participants at a high-profile international workshop on early orthodontic treatment in 1997 concluded that there was a real need to guard against such potential iatrogenic problems that might accompany the distalizing of first molars.\textsuperscript{28}

**Preservation of E-spaces/leeway spacing**

Depending upon the type of underlying vertical muscle pattern and the overlying soft tissue lateral profile, the late-mixed dentition stage would seem to provide opportunities to alleviate mild to moderate crowding by maintaining arch perimeter, and therefore reducing the need for premolar extractions in selected cases.\textsuperscript{29} The primary maxillary and mandibular second molars are on average 1.5mm and 2.5mm larger respectively than their second premolar successors. However, one should be aware of the wide range of individual variation that exists in these measurements.\textsuperscript{29} This potential extra space is capable of providing, on average, 3mm and 5mm of arch space in the maxilla and mandible respectively, as the permanent premolars replace their primary predecessors.\textsuperscript{30,31} A decrease in arch perimeter would normally occur from the mixed to the permanent dentition, because of the natural mesial migration of the first permanent molars and the lingual movement of the incisors. Treatment aimed at arch length preservation, commenced in the late mixed dentition, may therefore prevent the extractions of premolars in some cases. If instead the same cases had presented later in the permanent dentition, these spaces would not have been available and premolar extractions may have been necessary.\textsuperscript{32} The overall leeway space may be preserved for the alignment of teeth anterior to the first molars with the use of an active or a passive lingual arch\textsuperscript{33-35} or various other appliances such as utility arches\textsuperscript{36,37} or lip bumpers.\textsuperscript{38-40}

It seems that, in recent times, there has been a push for an almost non-extraction \textit{at all cost} approach, with various authors claiming superiority of their techniques in all respects. Unfortunately, the message received by the public seems to be that clinicians who request extractions, no matter how few, are somehow providing a disservice which is old-fashioned and out of date. It is interesting to note that little, if any, evidence is provided by such promoters regarding the medium to long-term success of their arch-enlargement treatments. In fact, non-selective arch-enlargement treatment, regardless of whether it has been achieved with fixed appliances, lip bumpers, removable appliances or active lingual arches, has been found again and again to provide little in the way of long-term stability. Little \textit{et al.}, for instance, found the relapse-tendency associated with such non-selective treatment to be greater than that for any other method of treatment.\textsuperscript{41} In any case, it is now widely accepted that such treatment strategies do require permanent life-time retention even just for the maintenance of anterior tooth alignment.\textsuperscript{42,43}

Whatever one's view on the selectivity of premolar extractions, it should be noted that various proposed 'non-extraction' treatment philosophies, which might involve molar-distalizing mechanics, tipping back of the molars or the holding of the E-spaces, do not necessarily create extra space to accommodate all 32 permanent teeth.\textsuperscript{23} Richardson, for instance, found that in a group of orthodontic patients who had been treated without premolar extractions in the lower arch, 56 per cent had eventual impaction of the lower third molars.\textsuperscript{44} In a later study, she found once again that in another group of orthodontic patients who had been treated without premolar extractions, 54 per cent had eventual lower third molar impactions, when compared with only 12 per cent of a group who had been treated with premolar extractions.\textsuperscript{45} Similarly, Silling found that approximately 68 per cent of a group of patients who had been treated without premolar extractions showed eventual impaction of mandibular third molars. He concluded that the loss of teeth anterior to the third molars somehow encourages the normal anti-clockwise rotational movements of the third molar crowns, in turn decreasing the likelihood of their impaction.\textsuperscript{46}

**Premolar extractions**

When selectively chosen according to appropriate diagnostic criteria, premolar extractions may in many cases provide increased space for the eruption of the third molars, by enabling the buccal segments to move forward with growth and treatment. Ricketts, for instance, reported a 25 per cent increase, on average, in the space available for lower third molar eruption in patients who had been treated with premolar extractions. He proposed that the prognosis for the third molars should be assessed early, with the third molars being removed if no premolar extractions were to be part of the planned treatment, because he also found that 45 per cent of a group of patients treated without premolar extractions eventually required third molar extractions. He noted that 15 to 20 per cent of orthodontic patients required third molar extractions,
even when premolar extractions had been part of active orthodontic treatment.\textsuperscript{37,46}

Other authors have also concluded that premolar extractions have generally resulted in greater space in the third molar region, and a general improvement in the angulations of the lower third molars in relation to the occlusal plane.\textsuperscript{4,41–51} Most have also found clinically significant reductions in the rate of impaction for both maxillary and mandibular third molars in patients who have had premolar extractions, when compared with those treated without premolar extractions. This potentially greater increase in space in the third molar region has been attributed to the mesial movement of the first and second molars during space closure, following premolar extractions. This seems to be especially so if mandibular molar protraction through premolar extraction spaces has been used in the correction of Class II buccal relationships.\textsuperscript{41} When third molar impaction has occurred, even after premolar extractions, it has been considered to be due to insignificant resorption along the anterior border of the ramus, associated with an increase in vertically-directed condylar growth.\textsuperscript{47} Along with all this work on premolar extractions in general, others have shown that greater forward molar movement tends to follow second premolar extractions than first premolar extractions.\textsuperscript{52,53}

All this work might lead one to believe that it is unlikely for most humans to be able to retain 32 permanent teeth in good alignment and functional occlusion without artificial retention. This does not mean that all will necessarily end up with 28 teeth. Some individuals may indeed be able to maintain 32 well-aligned teeth but, at times, even fewer teeth will remain. Forsberg, for instance, proposed that there may simply be a larger tooth-size arch-length discrepancy in many premolar extraction cases anyway. He suggested that these large discrepancies might still make third molar impaction likely to occur in some premolar extraction cases as well as in the premolar non-extraction cases.\textsuperscript{41} Similarly, others have also reported that the extractions of premolars do not always improve the chances of normal eruption of third molars.\textsuperscript{49–55} It really does seem that individual decisions should be made by assessing third molar behaviour in each patient over a long period. In two recent Australian retrospective studies\textsuperscript{4,16} involving patients treated with and without premolar extractions, it was shown that almost 100 per cent of the third molars had eventually been extracted in an E-space/non-extraction group because of impaction, with or without partial eruption.\textsuperscript{46} On the other hand, in a premolar extraction group, it was shown that 32 per cent of the third molars had been extracted and 68 per cent had been retained. The findings of these studies would strongly suggest that a clinically-significant reduction in the rate of third molar impaction is likely to occur following selective premolar extractions, in comparison with patients treated without premolar extractions.

All the studies listed above have somehow involved the assessment of the effects of premolar extractions on later third molar eruption or impaction. Unfortunately, most of the studies have not included a detailed consideration of the way in which any residual space has been resolved. Residual space refers to that space remaining following the initial relief of arch-crowding. In many cases, premolar extraction spaces may be completely consumed during the relief of crowding, leaving little, if any, further space for either the forward movement of molars or the retraction of the incisors. Therefore, many other factors must be taken into account when attempting to make prognoses regarding tooth movements, soft tissue effects and third molar eruption probability. Such factors would include molar anchorage considerations, the management of the residual space, the treatment goals for final lower incisor positioning, the amount of expected mandibular growth and the amount of resorption of the anterior border of the ramus.\textsuperscript{16}

In summary, one must seriously question the absolute use of the term ‘non-extraction treatment’ which is, unfortunately, often used to support the sale of various commercial devices. Such self-promotion is not usually supported with peer-reviewed evidence-based literature. It may also serve to mislead the public and to divide the dental profession.

**CONCLUSIONS**

Malocclusions can be treated, if necessary, in many ways. In actively growing patients, the chosen orthodontic treatment may itself have a significant influence on the further development of the dentition. Treatment that involves the attempted distalization or holding-back of the molars, aimed at creating anterior space and preventing premolar extractions, tends to create posterior space deficiencies. This may have a significant effect on the developing second and third permanent molars. Treatment involving the extractions of premolars is generally accepted to result in a greater amount of space in the third molar region, as a result of the mesial movement of the first and second molars during space closure. Third molars would seem to be significantly more likely to become impacted, in patients who have been treated with the holding of the E-spaces without premolar extractions than in those treated with premolar extractions. Many factors such as the orthodontic mechanics used, molar anchorage considerations, the management of the residual space, the goals for final lower incisor positioning, the amount of expected mandibular growth and the amount of resorption of the anterior border of the ramus will play important roles in determining the eventual space available for third molar eruption.

Although so called ‘non-extraction’ treatment approaches may be ideal in certain meso- to brachyfacial growing patients, the terminology can be misleading, because the avoidance of premolar extractions will often lead to the extractions of other
teeth, such as the second or third molars. Orthodontic
diagnosis and treatment planning involves the full
assessment of the anteroposterior, vertical and transverse
dentofacial patterns and growth status for each
individual patient. Less emphasis should perhaps be
spent on attempting to treat every patient without
premolar extractions rather than actively addressing
each set of individual dentofacial problems. Neither non-
removal nor non-premolar extraction treatment
should be goals of treatment in themselves, but merely
different paths taken to best meet the diagnosed needs of
individual patients at the time of presentation.

REFERENCES
1. Vaden JL, Kiser HE. Straight talk about extraction and
nonsurgically: a differential diagnostic decision. Am J Orthod
2. Bjork A, Jensen E, Palling M. Mandibular growth and third
3. Sable DL, Woods MG. Growth and treatment changes distal
to the mandibular first molar: a lateral cephalometric study. Angle
4. Sheridan CS, Woods MG. Growth and treatment changes distal
to the maxillary first molar: a lateral cephalometric investigation.
Angle Orthod (in press).
molar impaction in orthodontic patients treated nonextraction and
with extraction of 4 premolars. Am J Orthod Dentofacial Orthop
6. Angle EH. Treatment of malocclusion of the teeth. 7th edn.
Philadelphia: SS White Dental Manufacturing, 1907.
7. Pollock HC. The extraction debate of 1911 by Case, Dewey and
8. Tweed CH. Indications for the extraction of teeth in orthodontic
9. Bowman SJ. More than lip service: facial esthetics in
1983;83:131-137.
12. Ricketts RM, Bench RW, Gugino CF, Hilgers JJ. Bio-Progressive
Angle Orthod 1961;31:91-104.
14. Weislander L. The effect of orthodontic treatment on the
concurrent development of the craniofacial complex. Angle
1983;17:396-413.
16. Cangialosi TJ, Meistrell ME Jr, Leung MA. A cephalometric
appraisal of edgewise Class II nonextraction treatment with
324.
17. Tulloch CJF, Phillips C, Profit WR. The effect of early
intervention on skeletal pattern in Class II malocclusion: A
randomized clinical trial. Am J Orthod Dentofacial Orthop
1997;111:391-400.
18. Bussick TJ, McNamara JA Jr. Dentoalveolar and skeletal changes
associated with the pendulum appliance. Am J Orthod
19. Itoh T, Tokuda T, Kiyosue S, Hirose T, Matsumoto M, Chaconas
20. Gianelly AA, Bednar J, Dietz VS, Japanese NiTi coils used to
move molars distally. Am J Orthod Dentofacial Orthop
1991;99:564-566.
21. Locatelli R, Bednar J, Dietz VS, Gianelly AA. Molar distalization
22. Hilgers JJ. The pendulum appliance for class II non-compliance
23. Carano A, Testa M, Siciliani G. The lingual distalizer system. Eur
24. Ghosh J, Nanda RS. Evaluation of an intraoral maxillary molar
distalization technique. Am J Orthod Dentofacial Orthop
25. Armstrong NM. Controlling the magnitude, duration and
26. Haas AJ. Headgear Therapy: The most efficient way to distalize
27. Merrifield LL. Dimensions of the denture: back to basics. Am J
workshop discussions on early treatment. Am J Orthod
29. Woods MG. Mandibular arch dimensional and positional
changes in late mixed-dentition Class I and II treatment. Am J
Orthod Dentofacial Orthop 2002;122:180-188.
30. Nanda SK. The developmental basis of occlusion and
31. Profit WR, Fields HW. Contemporary Orthodontics. 2nd edn. St
32. Gianelly AA. Crowding: timing of treatment. Angle
33. Singer J. The effect of the passive lingual archwire on the lower
34. Rebellato J, Lindauer SJ, Rubenstein LK, Vroom K. Lower arch
perimeter preservation using the lingual arch. Am J Orthod
35. Brennan M, Gianelly AA. The use of the lingual arch in the mixed
dentition to resolve incisor crowding. Am J Orthod Dentofacial
36. Ricketts RM, Bench RW, Gugino CF, Hilgers JJ. Bio-Progressive
Therapy, Part 7: The utility and sectional arches in bioprogressive
37. Woods MG. Lower incisal changes on basal bone and in relation
to the lower face: combined growth and treatment effects in the
38. Ten Hoeve A. Palatal bar and lip bumper in nonextraction
39. Nevant CT, Buschang PH, Alexander RG, Steffen JM. Lip
bumper therapy for gaining arch length. Am J Orthod
40. Werner SP, Shivapuja PK, Harris EF. Skeletodental changes in the
adolescent accruing from the use of the lip bumper. Angle
41. Little RM, Riedel RA, Stein A. Mandibular arch length increase
during the mixed dentition: postretention evaluation of stability
42. Sadowsky C, Schneider BJ, BeGole EA, Tahir E. Long-term
stability after orthodontic treatment: nonextraction with
prolonged retention. Am J Orthod Dentofacial Orthop
1994;106:243-249.
43. Little RM. Stability and relapse of mandibular anterior
alignment. University of Washington studies. Semin Orthod
1999;5:191-204.
44. Richardson M. The development of third molar impaction. Br J
45. Richardson M. The etiology and prediction of mandibular third
46. Silling G. Development and eruption of the mandibular third
molar and its response to orthodontic therapy. Angle Orthod
47. Ricketts RM. A principle of arietal growth of the mandible. Angle

Address for correspondence/reprints:
Professor Michael Woods
School of Dental Science
The University of Melbourne
711 Elizabeth Street
Melbourne, Victoria, 3000
Email: mgwoods@unimelb.edu.au