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How Much Space is Created from Expansion or Premolar Extraction?

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Abstract. *The aim of this study was first to investigate the relationship between maxillary arch expansion and change in arch depth (overjet), and secondly to quantify the reduction in maxillary arch depth following extraction of 4\|4 with complete space closure. A model of maxillary typodont teeth was constructed to allow expansion and premolar removal. Arch dimensions were recorded using a reflex microscope. A linear relationship was found between arch expansion and reduction of the arch depth. When the premolars were removed, there was a greater reduction in arch depth than the mesio-distal width of these teeth.*

Index words: Arch Depth, Expansion, Space Analysis.

Introduction

Space creation in a dental arch may be required to correct certain features of a malocclusion such as crowding, overjet reduction, levelling of the curve of Spee or correction of incisor inclination and angulation. This space may be created by a number of means including the extraction of dental units, extra-oral traction, inter-dental stripping, and arch expansion. The current trend in orthodontics aims for a non-extraction treatment approach where feasible. However, there is little in the literature to quantify the amount of space made available by expansion. Therefore, a decision on whether or not to extract to create space may be left to intuition or 'experience', rather than thorough informed treatment planning with the inclusion of a comprehensive space analysis.

It has been suggested that 1-mm expansion of the arch will produce a net gain of 1 mm space within the arch using Rapid Palatal Expansion (Berlocher *et al*., 1980). Adkins *et al*. (1990) found a linear relationship between an increase in the arch perimeter of 0·7 times that of the posterior arch expansion again using RPE. More recently, Akkaya *et al*. (1998), found that the arch perimeter increases by 0·65 and 0·6 times that of posterior expansion when rapid and slow expansion are used, respectively.

When extractions are undertaken only in the upper arch for overjet reduction, accepting a full Class II buccal segment relationship, it may be assumed that the space created for incisor retraction will be equal to the width of the premolar extracted (Figure 1). However if the posterior arch width is maintained, the teeth anterior to the extraction site will move into a larger arc and so produce an increase in the space available.

Methods

To investigate the effect of posterior arch expansion on arch depth

A working model was constructed of bracketed maxillary typodont teeth where 6\|6 were retained within the acrylic base of the model and 54321\|12345 supported by a rigid

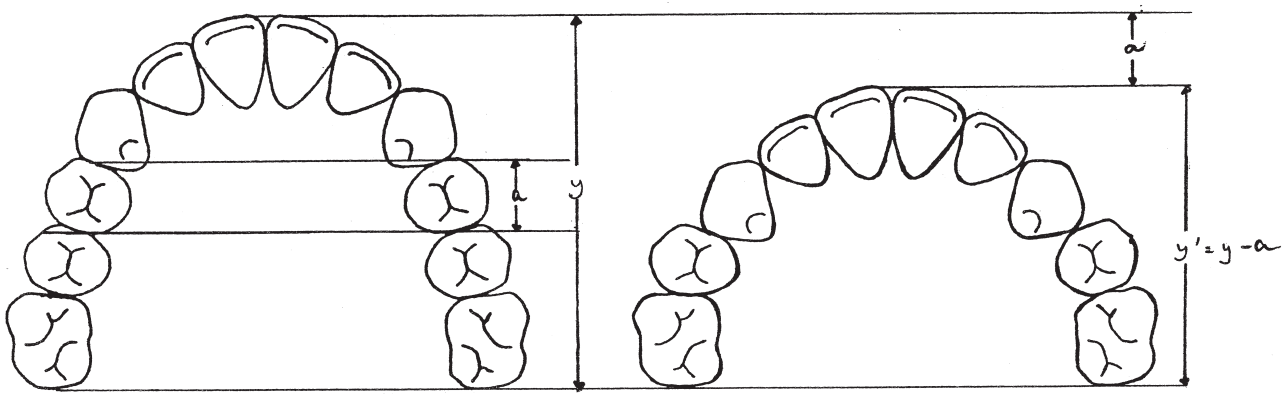

FIG. 1 The theoretical effect on arch depth reduction following removal of 4\|4 and space closure.

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arch wire (Figure 2). An orthodontic expansion screw incorporated into the model base allowed the inter-molar width to be adjusted. Elastic ligatures attached from 6|6 to the hooks on the arch wire ensured that closed contacts were maintained whilst the arch was expanded. Markers were placed on the incisal edges, buccal cusps of canines and premolars, and all four cusps of the first molars. The expansion screw was altered, and the incisal and occlusal markers were recorded using a reflex microscope linked to an IBM computer. The computer program was designed specifically to measure the inter-molar width and the arch depth between a line bisecting 6|6 to the midpoint of 1|1 (Figure 3).

To investigate the effect of 4|4 extraction on arch depth

A similar model was constructed which allowed the removal of teeth whilst maintaining closed contacts. The arch length, as measured through the incisal and occlusal markers of 654321|123456, was recorded using a reflex microscope linked to a PC as described above. The 4|4 were then removed and the premolar spaces were fully closed. The new arch length of 65321|/12356 was recorded.

To record the effect of premolar extraction in dental arches of different dimensions, the model was reassembled to include the 4|4 and the posterior arch width was expanded using the orthodontic screw in the base plate of the model. The measurements of the arch length with and without the premolars were repeated as above, at the new arch dimension. This procedure was repeated for varying arch width dimensions.

Results

To investigate the effect of posterior arch expansion on arch depth

The ratio of posterior arch expansion to a reduction in arch depth was found to be 1:0·283. The correlation coefficient for this relationship is –0·998. The results are illustrated in Figure 4 and in Table 1.

FIG. 2 The working model.

TABLE 1 *The effect of posterior arch expansion on arch depth*

6|6 width (mm) *x*	Arch depth (mm) *y*
44·60	33·93
44·98	33·81
45·63	33·62
45·87	33·55
46·23	33·44
46·73	33·27
47·23	33·15
47·32	33·12
47·93	32·94
48·46	32·76
48·85	32·64
48·98	32·66
49·67	32·48
49·83	32·51
50·19	32·32

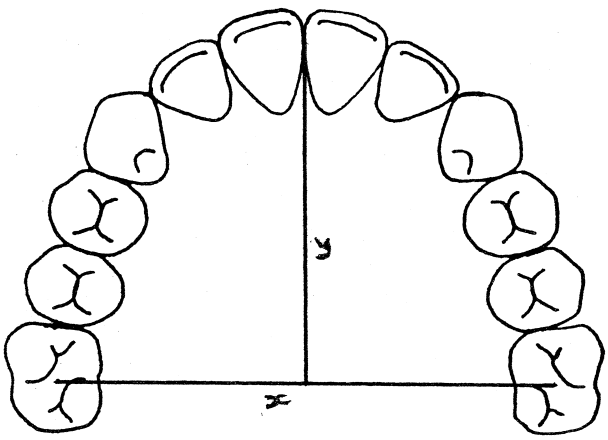

FIG. 3 Measurement of inter-molar width and arch depth.

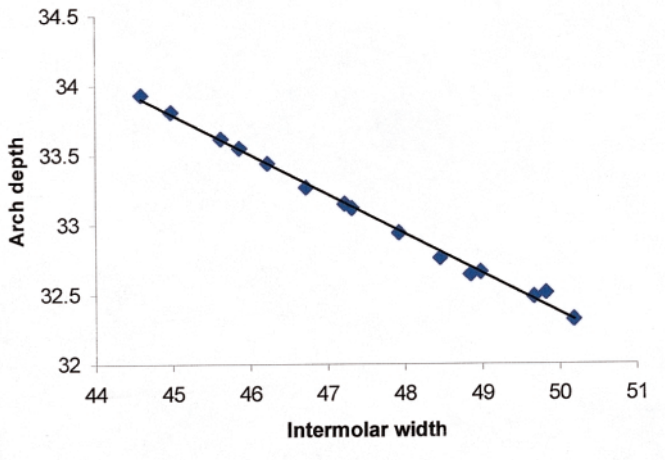

FIG. 4 The effect of posterior arch expansion on arch depth.

TABLE 2 *To investigate the effect of 4|4 extraction on arch depth*

Average 6|6 width	Arch depth (mm) 4|4	Arch depth (mm) No 4|4	Arch depth reduction (mm)	Net increase in reduction (mm)
45·20	33·52	25·82	7·70	0·49
45·55	33·48	25·68	7·80	0·59
46·77	33·18	25·28	7·90	0·69
46·86	33·16	25·17	7·99	0·78
47·04	33·11	25·11	8·00	0·79
47·54	33·03	24·91	8·12	0·91

To investigate the effect of 4|4 extraction on arch depth

The mesio-distal width of each 4|4 as measured using the reflex microscope was 7·21 mm. The space implication on the arch depth following the removal of 4|4 with complete space closure, is shown in Table 2. It can be seen that for all arch sizes there was a net increase the space available, which was greater than the size of the premolars removed. This value increased with an increase in the inter-molar width.

Discussion

An increase in the inter-molar width produced a linear reduction in the arch depth. For each millimetre expansion of the inter-molar width there was a reduction in the arch depth of 0·283 mm (i.e. overjet). In terms of space creation within the arch, a figure of twice the arch depth reduction should be calculated (i.e. 0·566 mm), as space is required on both halves of the dental arch for overjet reduction. These figures are smaller than those shown by both Berlocher *et al.* (1980), Adkins *et al.* (1990), and Akkaya *et al.* (1998), based on their clinical results using rapid palatal expansion where the amount of space creation was variable being on average 1:1, 1:0·7, and 1:0·65, respectively. The expansion in this experimental model was greatest across the first molars allowing tapering in the premolar region, similar to that expressed by arch wire expansion. Whereas the rigid design of RPE, as used by the authors above, does not allow the tapering effect of the normal arch form and, therefore, this is likely to produce a greater increase in arch dimensions relative to posterior arch expansion. The results from this study most closely relate to the published figures of 1:0·60 by Akkaya *et al.* (1998) for slow maxillary expansion (SME). However, these figures are still greater and this is probably due to the design of the SME appliance being a rigid bonded expansion device, which will have similar spacial effects on the arch form as those of the RPE described above. It has also been shown that tooth morphology and contact areas will vary among individuals, and this will have an effect on the space used within the dental arch and also contribute to clinical variability (O'Higgins *et al.*, 1999).

When 4|4 were removed from an intact arch, the arch depth reduced to a greater extent than the mesio-distal width of the premolars. For example, the model demonstrated that, for a stable inter-molar width of 46·86 mm (using a 100 per cent Euro arch form), the removal of the upper first premolars (each having a mesio-distal width of 7·21 mm) allowed an overjet reduction of 7·99 mm. Therefore, there is a net increase in space available within the arch of 0·78 mm when maintaining this inter-molar width. This was found for a range of different arch forms, the value increasing with the size of the arch form.

This net increase in space within the arch may be due to the dynamics of moving the canines and incisors into a larger arc formerly occupied by the premolars, whilst maintaining the inter-molar width. In the clinical environment, this increase in the space produced may not be evident if the inter-molar width is not maintained. The utilization of extraction space is also determined by the balance of anchorage dictated by the clinician, taking into consideration the overjet, inclination of the incisors, and molar relationship.

Conclusions

A 1-mm increase in the inter-molar width will allow approximately 0·3 mm reduction in overjet or, alternatively, this may be expressed as the creation of 0·6 mm of space within the arch. This figure may be incorporated into a comprehensive space analysis at the outset of orthodontic treatment planning to allow an informed assessment of space creation that may be achieved from arch expansion.

The removal of 4|4 will allow a reduction in overjet of a greater magnitude than the average width of the teeth removed, provided that the inter-molar width is maintained.

References

Adkins, M. D., Nanda, R. S. and Currier, G. F. (1990)
Arch perimeter changes on rapid palatal expansion,
American Journal of Orthodontics and Dentofacial Orthopedics, **97,** 194–199.

Akkaya, S., Lorenzon, S. and Ucem, T. T. (1998)
Comparison of dental arch and arch perimeter changes between bonded rapid and slow maxillary expansion procedures,
European Journal of Orthodontics, **20,** 255–261.

Berlocher, W. C., Meuller, B. H. and Tinanoff, N. (1980)
The effect of maxillary palatal expansion on the primary dental arch circumference,
Pediatric Dentistry, **2,** 27–30.

O'Higgins, E. A., Kirschen, R. H. and Lee, R. T. (1999)
The effect of maxillary incisor inclination on arch length,
British Journal of Orthodontics, **26,** 97–102.