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A Simplified Method of Attachment for the Quadhelix and Transpalatal Arch

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Abstract: *A modification to the standard quadhelix transpalatal expansion arch is presented in which the wire passes distal to the most posterior molar and enters the mesial end of the headgear tube. Laboratory measurements were carried out on small, average and large sized appliances with this modification using a special rig fitted with strain gauges. For the three sizes of appliance, the modified quadhelix is more flexible than the standard quadhelix for both displacement and rotation of the molar arms. Also it is less time consuming to fit and remove It is concluded that this appliance is capable of producing clinically useful forces and couples with increased precision..*

Index Words: Maxillary expansion, Quadhelix, Transpalatal Arch

Refereed Paper

Introduction

The quadhelix is a popular and well established component of fixed appliance systems which can be used to change the transverse dimension of the upper arch and obtain rotational control of upper molars. The simple transpalatal (goshgarian) arch connects upper molars and may increase their anchorage capacity, reduce tipping and rotation, and possibly allow some intrusion. Various modifications have been introduced over the years including changes in the design and material, and the addition of springs and habit deterrents.

The fixed palatal expansion appliance was introduced by Coffin (1881) and modified by Ricketts (1973) to produce the popular design still in current use. The design, construction, and clinical management of the standard quadhelix has been described by Birnie and McNamara (1980). The usual method of attachment is to solder the quadhelix to the upper molar bands, though another modification uses specially constructed weldable attachments which allow the quadhelix to be removed without the bands (Asher, 1985). Jones and Waters (1989a) derived the behaviour of the quadhelix theoretically in terms of the properties of the wire used and its dimensions and spatial geometry. In a further paper (1989b), they examined the effect on the clinical characteristics of altering the relative size of the component parts.

The quadhelix modification (Figs 1 and 2) is a continuous length of wire arranged into four helices around the hard palate, curving bilaterally behind the most distal molar, passing anteriorly in the buccal sulcus and terminating with a reverse bend into the headgear tube of the molar band. The reverse bend is indented in order to receive a retaining ligature or module which may be secured to the buccal hook of the molar band. This method of attachment is also applicable to the transpalatal arch. This variation of the quadhelix will facilitate addition by soldering of various springs, arms or habit deterrants. An acrylic button may also be added to the anterior bridge of the transpalatal arch (Fig. 2). The quadhelix can be removed regularly to clean the acrylic button and examine the palatal mucosa.

Materials and Methods

The modified design was compared with a standard quadhelix (without anterior arms). The aim was to establish whether the modification exerts a clinically useful and safe range of forces. Three modified quadhelices covering the size range likely to be encountered clinically were made in 0·9mm diameter stainless steel orthodontic wire (K.C. Smith Ltd, Monmouth, Wales). The two characteristics necessary to predict the potential clinical behaviour of the springs (Jones and Waters, 1989a), namely, the lateral stiffness and the molar rotational stiffness were measured for each appliance.

The apparatus used (Noble and Waters, 1992) is shown in Fig. 3. It consisted of a thick aluminium baseplate, A, to which two identical mild steel pegs, P, were rigidly mounted through a milled slot in the baseplate which allowed their separation to be altered. Each peg carried a small brass block provided with a hole perpendicular to the long axis of the peg into which the outer arms of a modified quadhelix could be inserted and locked into position with a grub screw. The two pegs with brass blocks, which simulated the left and right upper molar teeth, carried resistance strain gauges L, T, and D connected to a Wheatstone bridge and amplifier (type SGA 800, C.I.L. Electronics Ltd., Lancing, West Sussex, England). The gauges enabled any lateral

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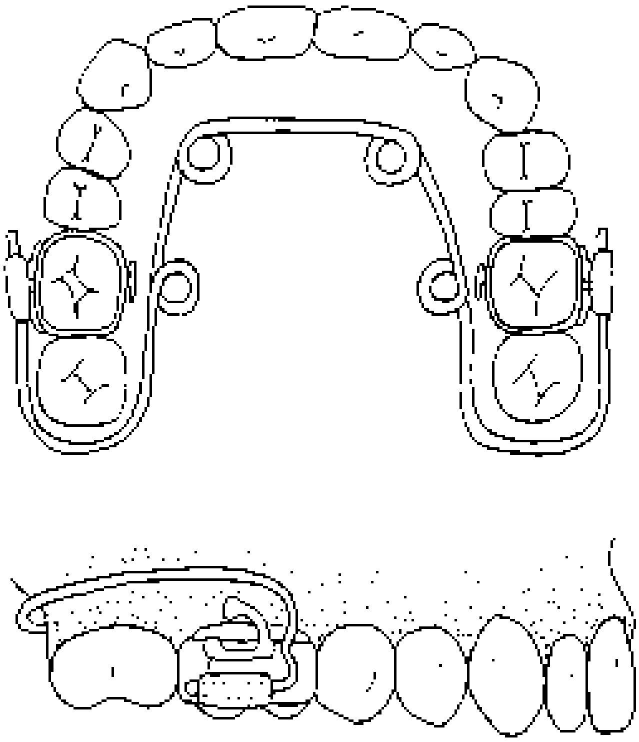


FIG. 1 Diagram showing palatal and buccal view of modified quadhelix.

FIG. 2 Palatal view of modified quadhelix.

(bucco-lingual) force and also any couple acting around the peg (tooth) axis to be recorded.

The apparatus was calibrated by applying a series of increasing lateral forces to each peg in turn by means of dead loads and recording the strain gauge output (in millivolts). Known moments about the long axis of each peg were applied by locking a lever arm of known length into the hole in the brass block and recording the strain gauge outputs with a series of suspended weights. In each case three readings were taken at each loading and a mean value calculated. A stable linear relationship was obtained for each output plot with no hysteretic effects.

The lateral stiffness of each spring was obtained by mounting it between the strain gauge pegs by inserting and then locking the ends of the molar arms into the holes simulating the molar tubes. The separation of the pegs on the base plate was adjusted until the output from the strain gauge recording the buccal force on the pegs was close to zero. The separation of the pegs was then carefully measured with a vernier micrometer reading to 0·001-inch. The buccal force produced by a spring when the separation of the pegs was gradually decreased by known amounts was measured for five peg positions.

The molar couple activated by a one degree angulation of the molar arm was deduced by measuring the molar couple produced when the molar arms were rotated from their passive positions to become parallel to one another with the peg separation adjusted so that there was no lateral force. This was accomplished as follows: The appliance was inserted in the transducer pegs, and the separation and orientation of the pegs adjusted until the strain gauge output indicated that the appliance was passive. The pegs were then re-orientated by rotation about their vertical axes until the molar tubes were parallel to one another. One peg was then locked. Minor adjustment to the separation of the other peg was made until the strain gauge output indicated that the lateral force was minimal.

The molar couple was then recorded. The procedure was repeated three times and a mean molar couple determined in this way for each spring. The angle the molar arms needed to be rotated for each appliance such that each pair of arms were parallel to one another was determined in the following way :

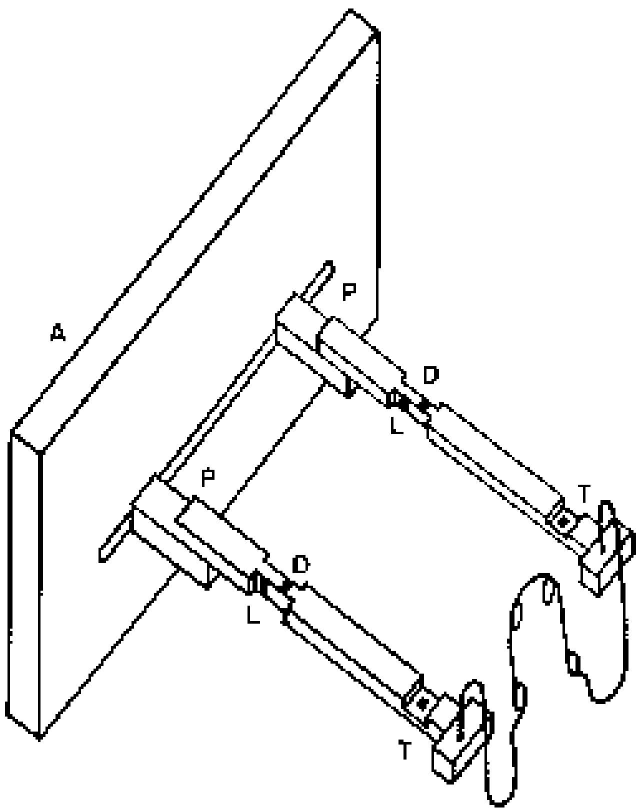


FIG. 3 Diagram of two transducer pegs, P (simulating the molar teeth), held horizontally by baseplate, A, with modified quadhelix in position. D, L, and T, pairs of resistance strain gauges for recording the forces and couple acting about the root axis.

An appliance was placed on millimetre feint graph paper such that it rested on the molar arms. With one arm aligned to the grid the mesial and distal ends of both arms were marked on the graph paper. The included angle between the directions determined by the two marks was measured with the aid of a ruler and protractor. This procedure was also repeated three times and a mean included angle calculated. For each spring the mean molar rotational stiffness was obtained by dividing the mean molar couple, as measured above, by the mean included angle between the arms.

Results

A linear relationship between buccal force and lateral contraction was obtained for each spring (Fig. 4). Using linear regression analysis the lateral stiffness (the slope of the force-deflection plot) was obtained for each appliance together with the 95% confidence limits (see Table 1). Also included in this table are the mean molar rotational stiffnesses for the springs together with their standard deviations. These experimental results are for appliances made in 0·9 mm wire. The figures presented in Table 2 are for identically shaped springs made in 1·0-mm K. C. Smith wire as deduced from the known ratio of their flexural rigidities. These figures enable a comparison to be made between the modified quadhelices and the data that has been presented in the literature for models of the standard quadhelices made with this wire.

Discussion

The laboratory tests demonstrate that the modified quadhelix when activated produces lateral forces which are proportional to the amount of contraction (Fig. 4) and when made with 1·0-mm diameter 18/8 stainless steel wire is capable of applying clinically useful forces across the molars (Table 2). The additional length of wire effectively makes the appliance more flexible thereby reducing the risk of applying excessive forces or rotational couples to the molar teeth. Indeed, it is clear that the modified appliances are too flexible when made (as for the laboratory measurements) in 0·9-mm diameter wire and should be made in 1·0-mm diameter wire.

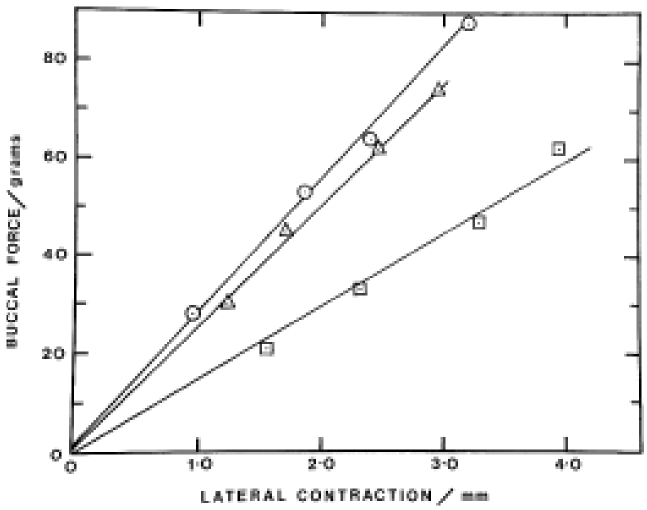


FIG. 4 Experimental plots of buccal force (grams) versus lateral contraction (mm) for the three experimental modified quadhelices: ⊙ small; △ average; ⊡ large appliances

TABLE 1 *Deformation characteristics for the modified quadhelices made in 0·9-mm diameter stainless steel wire*

Size	Lateral stiffness (g/mm)	Molar rotational stiffness (gmm/degree)
Small	27·1 (0·7)	71·6 (4·2)
Average	25·2 (0·6)	66·1 (0·8)
Large	15·0 (0·5)	82·4 (5·1)

Lateral stiffness with 95% confidence limits in brackets ($n = 5$).
Molar rotational stiffness with standard deviation in brackets ($n = 3$).

TABLE 2 Comparison of the deduced deformation characteristics of modified quadhelices made in 1·0-mm diameter wire with published data for model standard quadhelices in a similar size range

Size	Lateral stiffness (g/mm)		Molar rotational stiffness (gmm/degree)	
	Model standard quadhelix	Modified quadhelix	Model standard quadhelix	Modified quadhelix
Small	112	41	216	109
Average	52	38	168	100
Large	34	29	143	125

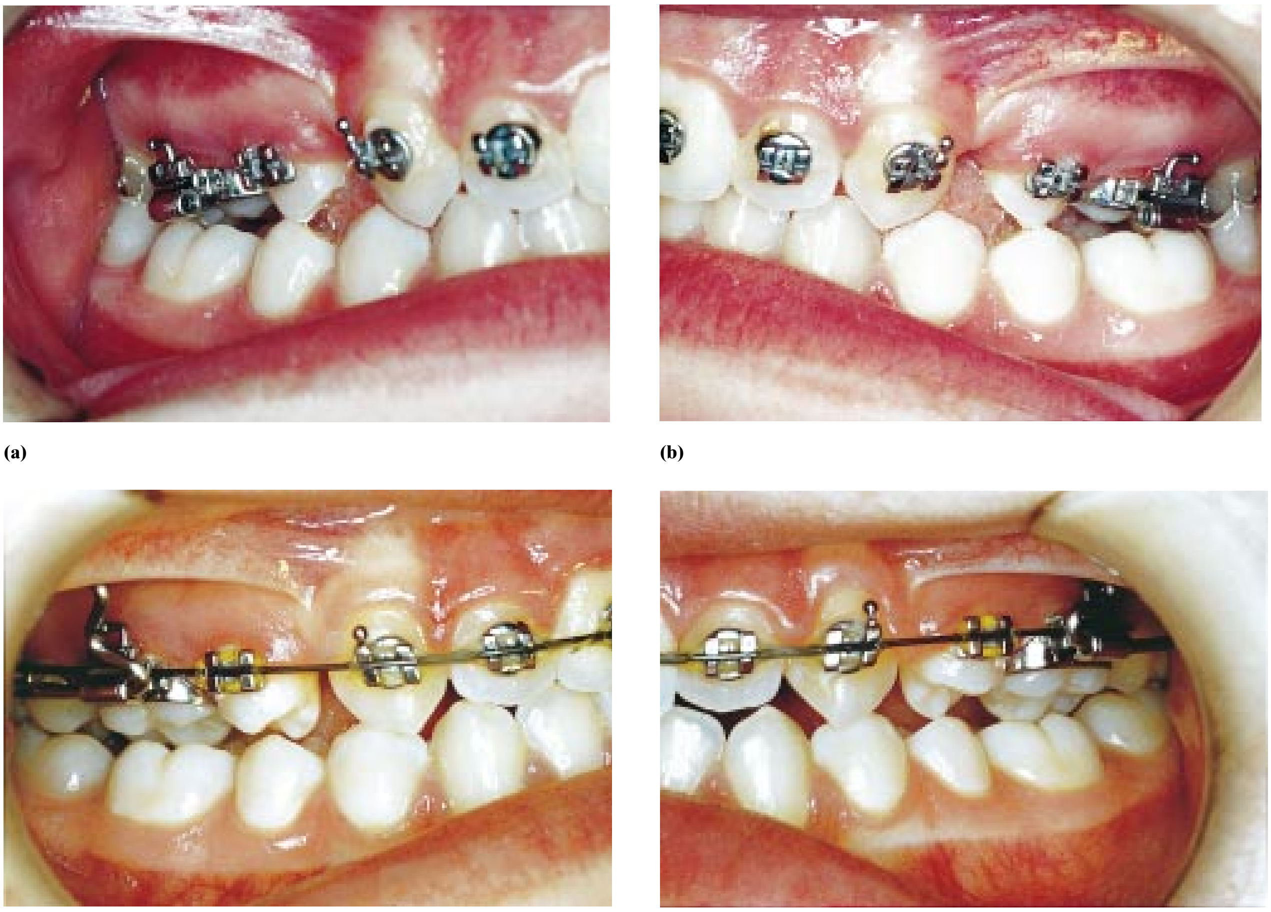
Unlike the standard quadhelix, this modification is attached to the buccal rather than lingual surface of the first molar and, hence, the length of wire required for the modified form will always be greater. This additional length of wire will ensure that it will always have a greater flexibility for both lateral expansion and angulation of the molar arms. This is borne out by the comparison given in Table 2 between the results obtained for small, average, and large modified appliances, and the measurements obtained by Jones and Waters (1989a,b) for a similar, but not, of course, identical, range of model quadhelix springs.

Here, it may be seen that, for each 'size', the modified spring has a lower lateral stiffness and molar arm rotational stiffness than its model standard quadhelix counterpart, the increased flexibility being greatest for the smallest springs.

It will be observed that although the differences in the values are small the values of the molar rotational stiffness of the modified quadhelix do not correlate with the nominal size of the appliances. However, it should be noted that whereas the appliances used by Jones and Waters (1988) were model appliances of differing size, but identical spatial geometry, the present appliances examined were those fitted to small, average, and large clinical models.

This brings out the important point that although the appliances have been characterized as small, medium, and large, their mechanical properties depend on their three-dimensional geometry (i.e. on the overall size and the disposition on the component parts in space), rather than on their overall palatal width or anterior length. A case requiring molar expansion is shown at the commencement of treatment and four months later (Fig. 5a–d).

The modified appliance is simple to construct using a



(a) **(b)** **(c)** **(d)**

FIG. 5 (a–d) Bilateral posterior crossbites at start of treatment and 4 months later showing expansion.

study model which is prepared by laying a 2-mm thick sheet of wax over the soft tissue area. It can be very quickly removed, adjusted extra-orally, and replaced. It is inexpensive to construct in a laboratory and requires less chairside time to fit than the MIA quadhelix, which involves the time consuming welding of special attachments. Acrylic may be added to the anterior arm, and springs may be soldered to the appliance using lighter wire to allow more appropriate forces to be applied where indicated (Fig. 2). The appliance may pass distal to the first molar if the second molar is either absent or unerupted. If the second molar or third molar is present or near eruption the appliance will cross the alveolus in a more distal position.

In order to visualize the amount and angle of activation, adjustment to a quadhelix should be made extra-orally. The soldered quadhelix does not readily lend itself to such adjustment and there is a temptation to adjust the appliance intra-orally. Such adjustment is inadvisable as it is impossible to quantify the amount and direction of the various couples. The main advantage of the removable (MIA system) quadhelix is the facility to remove the arch without disturbing the molar bands. Recementing the molar bands frequently alters their position and may cause difficulty in replacing a heavy archwire, and can further allow excessive forces to be set up in this area. The modified quadhelix may be introduced at any time during treatment without the need to disturb the molar bands. Since the modified quadhelix is inserted into the buccal aspect of the molar band, it is possible to retain the use of a palatal cleat. Though it would not be possible to use a facebow with the modified arch in place, there is no reason why extra-oral forces cannot be applied to the archwire with alternative types of headgear.

Conclusions

1. The modified quadhelix is more flexible than its standard counterpart, producing forces and couples with less danger that these are excessive.
2. The greater flexibility of the appliance and its ease of removal for adjustment should enable forces and couples to be applied with greater precision.

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