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SCIENTIFIC SECTION

A randomized controlled trial comparing the quadhelix and the expansion arch for the correction of crossbite

M. R. McNally and D. J. Spary
Queen's Hospital, Burton-on-Trent, UK

W. P. Rock
School of Dentistry, University of Birmingham, Birmingham, UK

Objective: To compare the use of the quadhelix and the expansion arch for the correction of crossbite.

Design: A prospective randomized clinical trial supported by preliminary laboratory measurements. The null hypothesis was that there was no difference in the clinical effectiveness of the two expansion devices in terms of crossbite correction.

Setting: Queen's Hospital, Burton on Trent and The University of Birmingham, School of Dentistry.

Participants: The first 60 patients on the orthodontic waiting list at Queen's Hospital who required expansion of the maxillary arch as part of the treatment plan were allocated to be treated with either a quadhelix or an expansion arch by random allocation. Twenty-eight and 27 members of each respective group completed the study.

Materials: Commercial quadhelix arches (3M Unitek) and custom-made expansion arches

Methods: The force produced by the type of expansion arches used in the study was measured in the laboratory to be 1.8 N at 10 mm of expansion. Quadhelix arches of sizes 2 and 3 were found to produce equivalent forces at 5 and 7 mm of expansion respectively. Either expansion device was fitted to the 60 participants according to random allocation and expanded by the standard amount. Intermolar and intercanine expansion was measured after 4, 8 and 12 weeks. Patient opinion was assessed by using a questionnaire.

Results: The quadhelix and the expansion arch were equally effective in producing expansion ($p>0.05$). After 12 weeks, the two types of archwire had produced mean intermolar expansions of 4.54 and 5.09 mm and intercanine expansions of 1.41 and 2.12 mm, respectively. Both types of arch were reported as uncomfortable by a majority of patients, the quadhelix affected mainly the tongue and the expansion arch the cheeks. The appearance of the quadhelix was disliked by 25% of participants, while 70% disliked the expansion arch.

Conclusions: The null hypothesis was confirmed. However, the expansion arch had several advantages that made it a cheap alternative to the quadhelix for crossbite expansion, because it can be made and fitted at the chairside.

Key words: Crossbite correction, arch expansion

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Introduction

Crossbite in the buccal segments of the dental arches is seen when the buccal cusps of the lower teeth occlude laterally to the buccal cusps of the teeth in the upper jaw.[1] A crossbite may be unilateral or bilateral and may develop or improve at any time during eruption of the primary or permanent teeth.[2–5] Unilateral crossbite may be associated with mandibular displacement and studies have suggested that a crossbite may increase the risk of later temporomandibular joint problems, although the association is weak and inconsistent.[6–10] Crossbite associated with no aesthetic or functional disadvantage may be left untreated.

The prevalence of posterior crossbite has been reported to be 1–2% in African American children, 7% in white American children,[12] and between 13 and 23% in European children.[13,14]

Address for correspondence: Dr Peter Rock, School of Dentistry, St Chad's Queensway, Birmingham B4 6NN, UK.
Email: w.p.rock@bham.ac.uk
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Figure 1 A preformed quadhelix

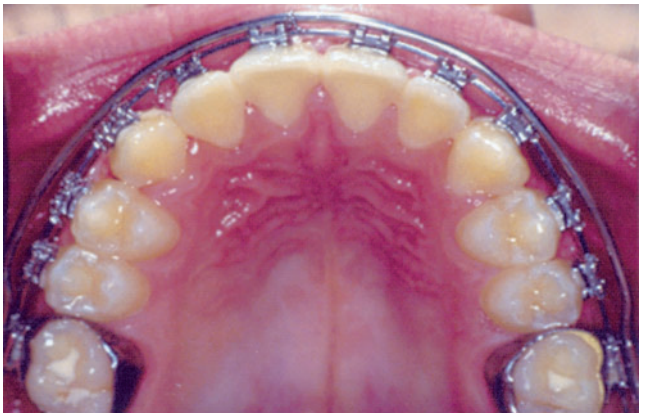

Figure 2 An expansion arch. Note the inset bends

Indications for treatment of crossbite include creation of space and achievement of Andrews' Six Keys.[15] Methods include occlusal grinding to remove cuspal interferences, and the use of removable or fixed orthodontic appliances, with or without surgical assistance, which aim to increase the width of the maxillary arch. Arch width may be increased by buccal tipping of the two halves of the maxilla, with or without sutural separation. The proportionate contribution made by these two effects in a particular case depends upon the age of the patient, the type of appliance used and the rate of expansion. Skeletal movement is maximized by relatively early treatment so that bodily translation of teeth predominates over buccal tipping.[16–18] A significant skeletal component is desirable in crossbite correction, since orthopedic change allows better co-ordination of the dental bases and a more stable correction.[19]

The present study was designed to compare the effectiveness of two auxiliary devices, the quadhelix and the expansion arch, which are added to upper fixed appliances for the expansion of maxillary dental arches. The null hypothesis was that there was no difference in the clinical effectiveness of the two expansion devices in terms of crossbite correction.

Materials and methods

There were three parts to the study:

- Laboratory investigations designed to calibrate the two expansion devices so that they would deliver similar forces.
- A clinical study to investigate the relative effectiveness of the two arches.
- A survey of the attitudes of participants towards the appearance and comfort of the two arches.

Laboratory investigations

The quadhelix is a W-shaped arch with four helical loops that is inserted into sheaths on the palatal aspects of the upper first molar bands.[20] Those used in the present study were preformed in 0.9 mm stainless steel wire (Figure 1; 3M Unitek, PO Box 1, Bradford, West Yorkshire BD5 7BR, UK).

The expansion arch used in the study is the type used by one of the authors (DJS) at the Queen's Hospital, Burton-on-Trent. The arch is made from 1.135 mm round stainless steel wire bent into the shape of a dental arch and inserted into the extra-oral traction tubes on the upper first molar bands. Expansion arches were placed over the main appliance archwire and held away from the brackets by means of small inset bends mesial to the buccal tubes (Figure 2). Anterior support was provided by a stainless steel ligature on one central incisor bracket (Figure 3).

The impetus for the present study came from the observation by DJS over years of clinical experience that most crossbites were corrected within 4 months if an expansion arch was expanded by 10 mm. An expansion

Figure 3 Anterior view of expansion arch showing the steel ligature on UL1

arch of standard size was developed by measuring the arch length and width of 20 consecutive pretreatment models. The mean values of 42.3 and 54.1 mm, respectively, were similar to the dimensions of a Euro Arch Form 105 (Precision Orthodontics, 2 Esher Road, Walton on Thames, Surrey, KT12 4JY). Fifteen arches were therefore made to this template and then expanded by 10 mm. When the 15 arches were compressed by 10 mm on an Instron machine the mean force was 1.8 N.

Quadhelix arches are commercially available in 5 sizes. Sizes 2 and 3 give the best fit in most situations and were used throughout the study. Instron tests on 15 arches of each size showed that the expansions needed to produce 1.8 N of force were 5 and 7 mm, respectively, for arches of sizes 2 and 3.

The clinical study

In order to test for the reliability of arch width measurement a reproducibility exercise was carried out by measuring intermolar width blindly for 20 sets of study models, selected at random from the model store at Birmingham Dental Hospital, on two occasions separated by 1 week.

A quadhelix of appropriate size was cut and adjusted to fit passively before being expanded by either 5 or 7 mm according to size prior to final fitting. Elastomeric separators were used to hold the appliance securely in the lingual sheaths (Figure 1). Phosphate cement was placed on the occlusal surfaces of lower first molars to free cusp locks.

Expansion arches were bent at the chairside and fitted passively into the extra-oral traction tubes on the upper molars and then expanded symmetrically by 10 mm before fitting.

An expansion device of either type was fitted by random allocation to 60 consecutive participants (30 males and 30 females) aged 11–16 years with either a unilateral or bilateral crossbite that in view of a consultant orthodontist (DJS) required to be corrected. Using random number tables the first 30 participants were allocated for treatment with either appliance according to an odd or even number. The next 30 were then allocated in order to receive the alternative treatment to those in the initial allocation. Forty-one participants had unilateral crossbites, these were corrected in order to treat associated mandibular deviation. The remaining 19 bilateral crossbites were corrected as part of the space creation aspect of the treatment plan. However, justification of the decision to expand the maxillary arch as part of the treatment plan or, indeed, the type of the crossbite, was of no consequence to the study outcome, which depended only upon the ability of either device to achieve effective expansion.

Ethical approval was obtained from Staffordshire Health Authority and a consent form was signed by a parent of each participant.

Superficial upper arch impressions were taken to include only the occlusal surfaces of the teeth using rapid-setting alginate at the time of appliance fitting and after 4, 8 and 12 weeks. Using digital calipers arch widths were measured on the resulting models between the intersection points of the buccal fissures and the ridge joining the buccal cusps on the upper molars and between cusp tips of the canine teeth. The group of the participant was obvious from the model since the imprint of each type of appliance could be seen. However, since all measurements were made without reference to previous values, there could be no bias.

Comfort questionnaire

After 3 months of expansion, participants were asked to answer 5 questions relating to the comfort and appearance of their expansion device (Table 1).

Statistical methods

A sample size calculation was carried out on the basis that a clinically relevant difference between the two methods of expansion would be 1.5 mm, approximately 30% of the 5 mm needed for complete correction of a unilateral crossbite. Use of the Altman nomogram[21] for a standard deviation of 1.5 mm at 80% power and 1% significance level suggests a total sample size of 46 subjects, with 23 in each group.

Table 1 The comfort questionnaire

1	Did you find the expansion part of your brace comfortable at the start of treatment? 1–5 scale. *Scale 1=Extremely uncomfortable, 5=Comfortable
2	Did you find the expansion appliance uncomfortable after the first week? 1–5 scale.
3	If it was uncomfortable, which was most sore, cheeks, tongue or lips?
4	Did you have to use wax or take painkillers?
5	Did you mind the appearance of the expansion appliance?

A paired *t*-test was used to analyse the results of the reproducibility study.

Preliminary analysis of the main study data using the Anderson–Darling normality test showed measurements for both canine and molar expansion to be normally distributed at baseline, and at the end of the study, although there was slight skewing of the data for canine expansion with the quadhelix after 4 and 8 weeks ($p=0.047$ and 0.042, respectively). Since the overall impression was of a normal distribution the effects of arch type and treatment time on the amount of expansion were studied by means of ANOVA using the General Linear Model program in Minitab. Chi-square was used to test for qualitative differences, as recorded in the patient questionnaire.

Results

Reproducibility study

The results of a paired *t*-test for the repeat measurements of intermolar width on 20 sets of study models are shown in Table 2. The mean difference between the pairs of repeat measurements was only 0.2 mm and this was not statistically significant ($p=0.410$).

Main study

Sixty participants were entered into the study. A complete data set for molar expansion was available for 55 participants and canine data were complete for 52 participants. A CONSORT diagram[22] showing the flow of participants through each stage of the trial is shown as Figure 4. Measurements for expansion across the first molar and canine teeth respectively are shown in Tables 3 and 4. After 12 weeks the quadhelix arches had produced mean width increases between the first molars and canines of 4.54 (SD 1.27) and 1.4 mm (SD 1.27), respectively. Comparable expansions in the expansion arch group were 5.09 (SD 1.67) and 2.12 mm (SD 1.11), respectively.

Analysis of variance showed no significant difference between the effectiveness of the two methods of expansion ($F=0.23$, $p=0.63$). According to post-hoc Tukey tests a significant amount of molar expansion had taken place at every recall ($p=0.00$). Canine expansion was more gradual so that intercanine width was significantly increased only between the baseline and the measurements after 12 weeks ($p=0.03$).

At the start of treatment 75% of participants found the quadhelix slightly uncomfortable and 3.7% found it extremely uncomfortable. Figures for the expansion arch were 79% and 3.7%, respectively (Table 5). After 1 week perceptions of the relative comfort of the two devices had changed somewhat in that 19.7% of participants reported the quadhelix to be totally comfortable. Of those with an expansion arch, 51.9% found it comfortable, compared with 39.3% who found the quadhelix comfortable.

Discomfort was mainly to the cheeks with the expansion arch (63%) and to the tongue with the quadhelix (50%). The reliability of the responses is somewhat cast into doubt by the fact that 29% of participants reported that the quadhelix was uncomfortable to the cheeks! Thirty-seven per cent reported the need to take painkillers when wearing an expansion arch, whilst only 21% of the quadhelix group did so, However, this difference was not significant, $\chi^2=1.62$, $p=0.20$.

Seventy per cent of participants disliked the appearance of the expansion arch to some extent, only 25% of Quad Helix wearers expressed concern.

Table 2 Results of repeat measurements of intermolar width

	Mean	SD	CI
1st Measurement	52.09	3.81	−0.29–0.69
2nd Measurement	51.89	3.80	

Key: CI=confidence interval.

Table 3 Mean intermolar widths at each recall (mm)

	n	Start		4 weeks		8 weeks		12 weeks	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Expansion arch									
Width	27	49.54	2.9	51.35	2.67	53.02	2.70	54.63	2.86
Change		N/A	N/A	1.81	1.04	3.48	1.44	5.09	1.67
Quad helix									
Width	28	49.48	2.67	51.46	2.79	52.85	2.68	54.02	2.71
Change		N/A	N/A	1.98	1.04	3.37	1.26	4.54	1.27

Table 4 Mean intercanine widths at each recall (mm)

	n	Start		4 weeks		8 weeks		12 weeks	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Expansion arch									
Width	26	32.02	1.93	32.86	1.96	33.51	2.02	34.13	2.33
Change		N/A	N/A	0.84	0.91	1.49	1.01	2.12	1.11
Quad helix									
Width	26	33.09	3.24	33.95	3.15	34.31	3.21	34.5	3.27
Change		N/A	N/A	0.86	1.33	1.22	1.41	1.4	1.75

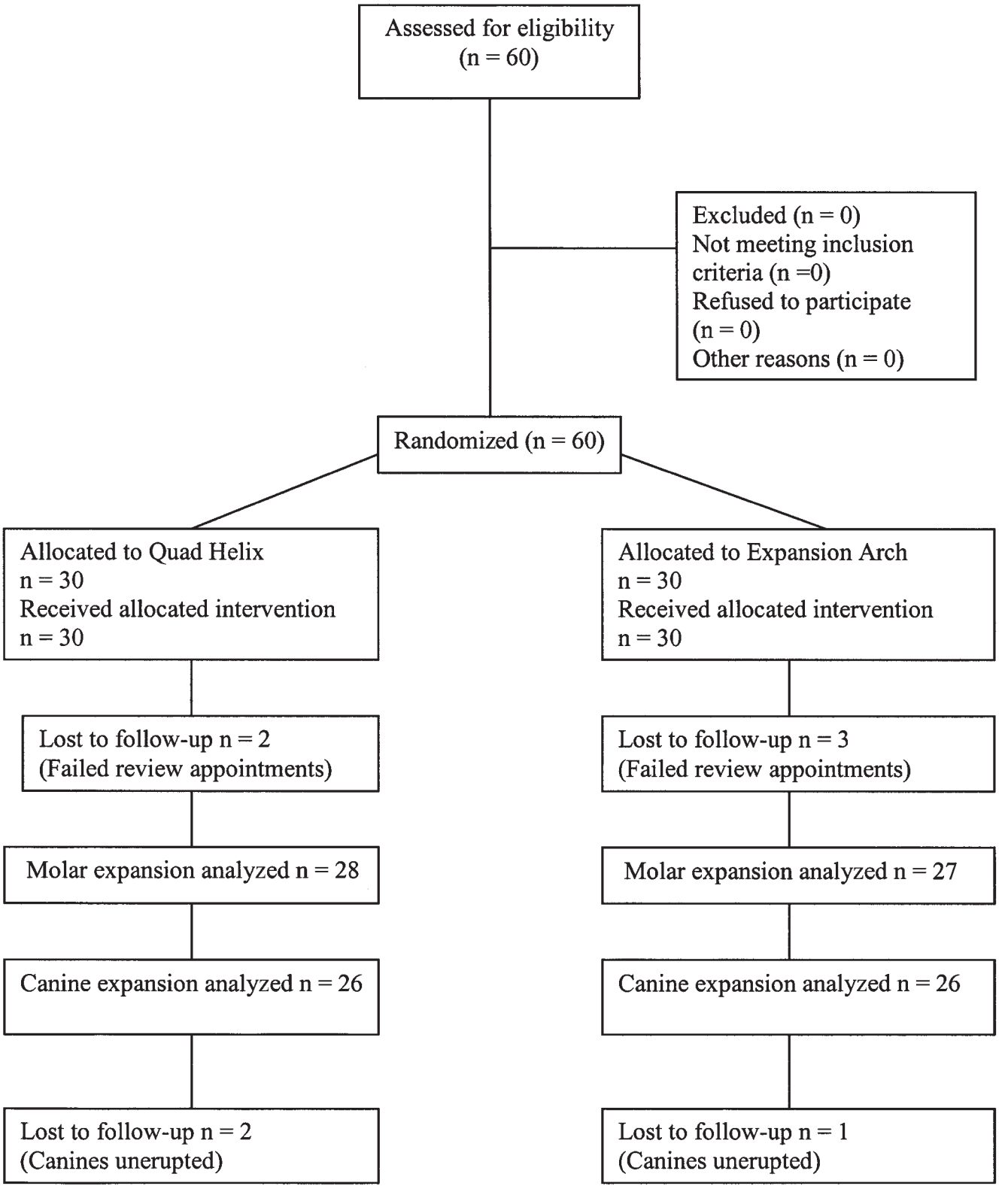

Figure 4 A CONSORT diagram showing the flow of participants through each stage of the trial

Table 5 Reports of patient discomfort

x	1		2		3		4		5		Participants
	No	%	No	%	No	%	No	%	No	%	
Start of treatment											
Quadhelix	1	3.7	5	17.9	21	75	1	3.7	0	0	28
Expansion arch	1	3.7	4	14.8	21	79	1	3.7	0	0	27
After 1 week											
Quadhelix	0	0	1	3.7	11	39.3	11	39.3	5	19.7	28
Expansion arch	1	3.7	3	11.1	8	29.6	14	51.9	1	3.7	27

Scale: 1=extremely uncomfortable, 5=comfortable.

Discussion

Recommendations concerning the amount of activation that should be incorporated into a quadhelix have varied from 4 to 5 mm, or half the bucco-palatal width of a tooth to 8 mm,[23,24] enough to produce a force of 14 oz.[25] In the present study, both types of arch were expanded to produce a force of 1.8N and fitted along with a light nickel-titanium initial aligning arch that would not have contributed appreciable expansion force. After 12 weeks mean intermolar expansion in the expansion arch group was 5.09 mm, in the quadhelix group it was 4.54 mm. There was no statistically significant difference between the groups at baseline or at any recall ($p=0.631$). However, there was some evidence that the expansion arch was slightly more reliable for producing expansion since the data for quadhelix intercanine width increase are skewed at both the 4 and 8 week recalls. Also the standard deviations for canine expansion with the Quad Helix are higher than those following use of the expansion arch. This finding is of little consequence since the more important molar expansion figures are similar in the two groups throughout the study.

The study was designed on the basis that 5 mm of expansion is required to correct a crossbite and this was therefore successfully achieved.

It is possible that the way in which a quadhelix fits into the palatal sheaths on the molar bands might provide better support to the arch and therefore greater torque control than is possible when using an expansion arch of round section in round buccal tubes. However, root torque should be fully expressed later in treatment when fitting a 19×25 working arch into the archwire tubes on the molar bands. Each type of arch had its advantages and disadvantages in terms of comfort and patient acceptance. There appears little difference between the overall comfort ratings of the two types of arch, although the quadhelix produced tongue discomfort and the expansion arch affected the cheeks in substantial proportions of participants. The appearance of the expansion arch caused more complaints than the palatally placed quadhelix.

Expansion arches cost only a few pence, whilst the quadhelix costs £15.20 per arch, equivalent to 3 APC brackets. Whether or not this saving is considered worthwhile is a matter of opinion. This paper describes the use of a cheap and effective alternative to the quadhelix that can be bent and fitted at the chairside without the need for laboratory support, and without the need for palatal attachments on the molar bands.

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Contributors

David Spary has used expansion arches of the type tested for a number of years. Peter Rock was responsible for study design, data interpretation and the drafting, critical revision and final approval of the article. Maria McNally carried out the laboratory tests. Maria McNally and David Spary organized, and carried out the clinical part of the study. Peter Rock is the guarantor.

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