European Journal of Orthodontics 32 (2010) 54–59
doi:10.1093/ejo/cjp051
Advance Access Publication 14 August 2009

An evaluation of clinicians' choices when selecting archwires

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SUMMARY The aim of this research was to determine the choices made by clinicians with respect to archwires and arch form during the initial and latter stages of orthodontic treatment with fixed appliances.

A questionnaire-based study was carried out at Bristol Dental Hospital between November 2005 and March 2006. Questionnaires were distributed within the dental hospital and at local meetings in order to obtain a mixed sample of hospital and practice-based orthodontists. The clinicians asked to complete the questionnaire were consultant orthodontists ($n = 37$), specialist practitioners ($n = 36$), senior specialist registrars in orthodontics ($n = 10$), and dentists with a special interest in orthodontics ($n = 17$). The questionnaire consisted of two parts: the first was concerned with the initial alignment phase of treatment and the second with the space-closing phase of treatment in premolar extraction cases. The choice of archwires, significance of arch form, and intra-arch dimensions considered important at both stages were assessed. The clinicians were also asked about their usual practice with regard to adaptation of working archwires and the use of study models and symmetry charts.

One hundred questionnaires were returned, giving a response rate of 92.6 per cent. The majority of clinicians felt that preservation of the pre-treatment arch form was essential in the latter but not in the early stages of treatment. In particular, conservation of the original intercanine width was considered important. However, there was no uniformity in how arch form should be preserved. Some respondents used study models and symmetry charts as an aid, but even then they were used in different ways. There was no uniformity in the landmarks used when adapting stainless steel archwires to arch form. Therefore, even when clinicians do adapt their archwires carefully with the intention of preserving arch form, are they choosing the correct arch form?

Introduction

Following a course of orthodontic treatment, teeth have an inherent tendency to relapse towards their pre-treatment positions. Even when the aim of orthodontic treatment is only to move teeth within the neutral zone of the soft tissues, relapse may occur. Firstly, the gingival and periodontal tissues affected by tooth movement require time to re-organize following completion of treatment. Within the periodontal ligament (PDL), the collagenous fibres may take between 4 and 6 months to re-organize, while the elastic supracrestal fibres of the gingiva can take as long as 7–8 months (Reitan, 1969). Secondly, continued facial growth may also influence the long-term results of orthodontic treatment. A longitudinal study of adults has demonstrated that skeletal growth continues, albeit at a very slow rate, throughout adult life (Behrents, 1985) in the sagittal, vertical, and transverse dimensions, with a great deal of individual variation.

Finally, relapse may also occur when the teeth are placed in inherently unstable positions outside the soft tissue envelope. There is evidence to suggest that the most reliable way of maximizing post-treatment stability is to maintain the original, pre-treatment arch form in which the teeth are presumed to be in a stable position (Felton *et al.*, 1987; Little, 1990; de la Cruz *et al.*, 1995).

Arch form describes the position and relationship of the teeth to one another in all three dimensions. It can be considered to be a result of the underlying skeletal morphology, the surrounding soft tissues, and any additional environmental effects. The soft tissue influence is thought to arise as a result of the resting pressure of the lips, cheeks, and tongue, along with forces from within the PDL (Mills, 1968). The latter, in particular, are thought to play a role in stabilizing the teeth once they have attained their final position within the arch (Proffit, 1978).

Many attempts have been made to find a universal arch form that would fit every individual and their malocclusion. These include the Bonwill-Hawley arch, catenary curve, and trifocal ellipse (Hawley, 1905; McConnail and Scher, 1949; Currier, 1969; Brader, 1972). Indeed, a variety of arch forms are available. However, it is generally acknowledged that no single arch form is characteristic of a specific malocclusion and so customization of archwires is always required (Felton *et al.*, 1987). At each stage during orthodontic treatment, there is the potential for alteration of the arch form, which may have an effect on long-term stability. Studies have shown that maintenance of intercanine width, intermolar width, and arch length contributes greatly to a stable post-treatment result (Glenn *et al.*, 1987; Little, 1990). A meta-analysis by Burke *et al.* (1998) also supported

the view that preservation of the original mandibular intercanine width is important for post-treatment stability, as in almost all instances, it has a tendency to return to its pre-treatment value.

The aim of the present study was therefore to assess clinicians' views with regard to the choice of archwire and arch form and eventually to compare this with their theoretical practice when adjusting working archwires.

Materials and methods

Ethical approval to survey the clinicians was requested from the Royal United Hospital Bath, local research ethics committee and a letter was subsequently received to the effect that no ethical committee approval was required.

The study comprised a questionnaire survey of clinicians carried out between November 2005 and March 2006. In order to ensure a good response rate, the questionnaire was personally handed to 108 clinicians and a follow-up telephone call was made to those not returning the questionnaire within 4 weeks. The clinicians asked to complete the questionnaire included consultant orthodontists (n = 37), specialist practitioners (n = 36), senior specialist registrars in orthodontics (n = 10), and dentists with a special interest in orthodontics (n = 17).

The questionnaire was divided into two parts. The first part was designed to determine clinical practice during initial alignment with particular regard to:

1. Archwire material choices, dimensions, and trade name of the routinely used wires, if known.
2. Which arch form was used and whether this was considered important during initial alignment.
3. If a particular arch form was used, what intra-arch dimensions, if any, were considered important in choosing this arch form?

The second part of the questionnaire was concerned with the archwires and arch forms used during the space-closing phase of treatment. The scenario given was a Class I incisor relationship, premolar extraction case. The questions considered the following:

1. The archwire material and dimensions used.
2. Whether study models were used for the adaptation of archwires to the original arch form.
3. If study models were used, then what landmarks on the study models were considered important?
4. The use of symmetry charts with regard to adaptation of archwires.

Statistical analysis

No formal statistical analysis was carried out as it was considered that this would not be helpful in view of the large number of variables and possible presence of confounders.

Results

The questionnaire was returned by 100 clinicians giving an excellent response rate of 92.6 per cent. The responses to the two parts of the questionnaire were as follows.

Questionnaire part 1—initial alignment

Ninety-nine per cent of respondents used a 0.022 inch slot system for labially placed pre-adjusted edgewise fixed appliances. All but one (99 per cent) used nickel–titanium (NiTi) as their initial aligning archwire. A straight length of 0.014 inch multistranded stainless steel was routinely placed by one clinician.

Clinicians were then asked the type and trade name of their preferred NiTi archwire. Twenty-three clinicians stated that they used classic type (martensitic stable), 34 super-elastic (austenitic active), and 34 heat-activated (martensitic active) NiTi at the start of treatment. Nine stated that they did not know what type of NiTi they used. The clinicians were then asked the trade name of the archwire routinely used. Of the clinicians who stated the type of NiTi they used, 32 per cent did not know the trade name of the archwire. Of those who did know, few knew the actual name of the archwire, but did know the manufacturer. Therefore, the percentage of clinicians who did not know the actual name of the archwire they used could potentially be much higher than 32 per cent. In one case, Timolium® was cited as a classic NiTi archwire, whereas it is in fact a nickel-free titanium alloy archwire.

The arch form of the initial NiTi archwire was considered important by 16 per cent of clinicians and arch width by 23 per cent. When asked what dimensions within the arch clinicians considered important during initial alignment, a variety of responses were observed (Table 1). The most common combination took into account the upper and lower intercanine and first molar widths. All but one respondent felt that the lower intercanine width was an important dimension to consider during initial alignment.

Of those clinicians who returned their questionnaires, 83 per cent felt that the arch form of the initial NiTi was not important and 77 per cent felt that the arch width was not important. Of the clinicians using a pre-formed NiTi archwire at bond up, 53 per cent appeared to use a particular arch form and again, an array of arch forms were used, with the most common known arch form being the catenary curve (Figure 1). Nearly 50 per cent of respondents did not know which arch form they used, perhaps because it was not thought to be necessary at this time. Other named arch forms used included Euroform (n = 10), Damon (n = 6), and European Progressive (n = 1).

Questionnaire part 2—selection of archwires and arch form for space closure

Once again 99 per cent of respondents stated that they used stainless steel as a preferred archwire material for closure

Table 1 Arch width dimensions considered important by 23 per cent of clinicians in initial alignment.

Arch dimensions	Number of clinicians
Lower canine width only	5
Lower canine and molar widths	4
Upper and lower canine widths	1
Upper and lower canine and first molar widths	9
Upper and lower canine, first molar, and second molar widths	1
Upper and lower premolar and first molar widths	1
Upper and lower canine, premolar, first molar, and second molar widths	2

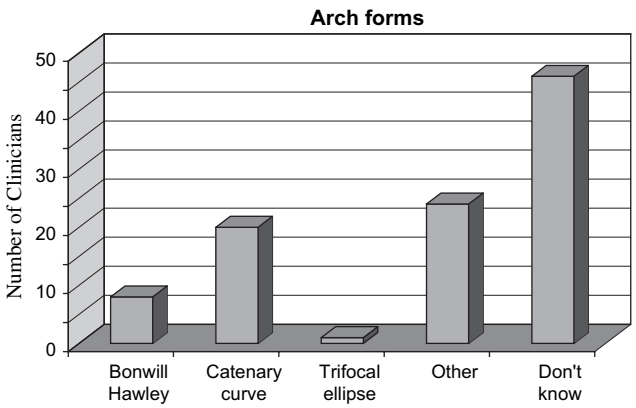

Figure 1 Arch forms used in initial alignment.

of premolar extraction spaces. The wire cross-sectional dimension varied, but the majority of clinicians used 0.019 × 0.025 inch stainless steel in both the upper and lower arches. One clinician performed space closure using 0.018 × 0.025 inch NiTi archwires.

When selecting a working archwire, 28 per cent of the clinicians stated that they always used study models when doing so, 16 per cent said they often but not always used them, 39 per cent occasionally, and 17 per cent never used study models when selecting working wires.

Of those using study models (n = 83), 57 used the lower model to choose the lower arch form, while interestingly 26 used the upper models to select the lower arch form. When choosing the upper arch form, there was greater variety as to what model was used. Twenty clinicians used the lower study model only, 18 the upper study model only, and 40 a combination of both.

When adapting an archwire to a study model, several different combinations of teeth were used: incisor, canines, premolars, or molars. While 21 (25.3 per cent) of the respondents used the actual teeth as landmarks for archwire adaptation, 59 (71.1 per cent) used the imagined bracket position as the landmark. Within this, different combinations of teeth were chosen to act as the landmarks (Table 2). Of

Table 2 Landmarks used for working archwire adaptation (n = 83).

Landmarks chosen	Combinations of teeth chosen	Number of clinicians
Actual teeth	Incisal edge/canine cusp tip	1
	Incisal edge/canine cusp tip/first molar cusps	5
	Incisal edge/canine cusp tip/premolar cusps/first molar cusps	7
	Canine cusp tip	3
	Canine cusp tip/premolar cusps	1
	Canine cusp tip/premolar cusps/first molar cusps	1
	Canine cusp tip/first molar cusps	2
	Premolar cusps	1
Imagined bracket position	Incisor/canine	1
	Incisor/canine/first molar	8
	Incisor/canine/premolar	2
	Incisor/canine/premolar/first molar	4
	Incisor/canine/premolar cusps/first molar/second molar	18
	Incisor/premolar/first molar	1
	Incisor/first molar	1
	Canine	5
	Canine/first molar	17
	First molar	2
Other	WALA ridge	2
	Buccal faces of teeth	1

the remainder, two used the WALA (Will Andrews Larry Andrews) ridge and one the buccal faces of the teeth. The most popular combination was the imagined bracket position of the incisor/canine/premolar/first molar and second molar teeth. All but five respondents included the canines, with some combination of canines and first molars in the majority of cases. However, there was a large variety in the landmarks and positions on these landmarks used to identify arch form, with no particular pattern predominating.

The current survey also highlighted that a large number of respondents (46 per cent) never used symmetry charts when selecting and adapting working archwires. Only 10 per cent stated that they always used them, with 14 per cent often and 28 per cent occasionally using them. The question was not answered by two respondents. One symmetry chart trade name predominated, namely Euroarch. Others were used to a lesser extent and included Euroform, MBT™, and 3M (Figure 2). The most common use of the symmetry chart was to check for archwire symmetry alone or in combination with the checking of arch size. Symmetry charts were used to determine arch size, form, and symmetry in different combinations (Table 3).

Of those using a symmetry chart for arch size (n = 24), 83.3 per cent stated that they used it on the lower study model to choose the lower arch form. Following this, the upper archwire was then coordinated to the lower archwire.

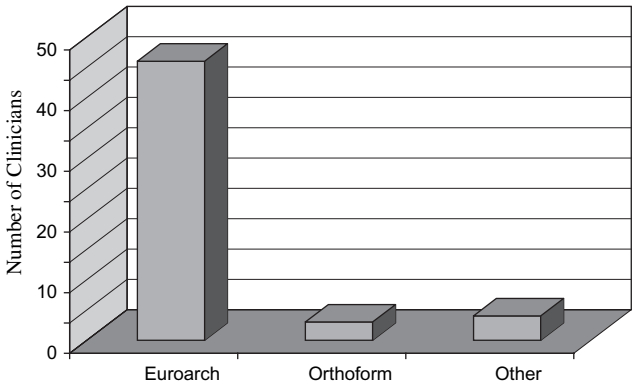

Figure 2 Symmetry charts used by the clinicians during treatment.

Table 3 The reasons stated for the use of symmetry charts (used by 54% of clinicians).

To check for	Number of clinicians
Arch size	2
Arch symmetry	23
Arch form	2
Size and symmetry	11
Form and symmetry	5
Form and size	2
Size, symmetry, and form	9

Of those using a symmetry chart to select arch form (n = 18), two used it on its own just to check for symmetry, with the majority again using it on the lower study model to choose the lower arch form and then coordinating the upper archwire to this chosen lower arch form.

Discussion

The questionnaire used in the present research was designed in order to determine clinicians' theoretical views concerning arch form, both in the early stages of treatment, when light flexible wires would be expected to be used, and during space closure when stiffer, larger dimension wires might be expected to be employed.

From this study, the majority of clinicians were found to be using NiTi archwires in the initial stages of treatment. This corresponds with the findings of a previous US survey (Keim *et al.*, 2002) in which the percentage of clinicians using NiTi archwires during alignment increased from 75.8 per cent in 1996 to 80.2 per cent in 2002. With the introduction of both super-elastic and, more recently, thermo-elastic NiTi archwires, the clinician is able to make use of larger dimension rectangular wires from the initial levelling and aligning phase of treatment (Miura *et al.*, 1990). It is possible that the use of such large archwires early on in treatment may contribute to the development of an arch form in the early stages of treatment, over which the clinician may have little or no control.

NiTi archwires are available in a number of different shapes and sizes and, therefore, for the clinician to have some control of arch form, it would mean having to stock a large inventory of archwires. It is not really until the stainless steel phase of treatment that the clinician can truly adapt the archwire to each patient. In this questionnaire, arch form was not considered important by the majority of clinicians (83 per cent) at the initial stage of treatment, becoming more important in the later archwires used in treatment.

Interestingly, many clinicians did not know the name of the manufacturer, or indeed the trade name, of the wires they used. Although a number of practitioners (53 per cent) used a specific arch form, with the catenary curve being the most popular, few considered arch form to be significant during initial alignment. This questionnaire identified the large number of different arch forms that are in use, which perhaps shows a general lack of agreement between clinicians as to what is the most appropriate one to use (Figure 1).

Even though the overall arch form was not considered to be important, the majority of clinicians still felt that lower intercanine width dimension was an important consideration and should be taken into account when choosing an aligning archwire (Table 1). This is an interesting finding when considering the NiTi archwires actually available on the market. A study carried out using NiTi archwires from different manufacturers, which varied in shape and size (Braun *et al.,* 1999), found that the average mandibular intercanine width exceeded the natural intercanine width by 5.95 mm. Maintaining this shape throughout treatment will result in alteration of the original arch form and the problems that have been associated with this, e.g. increased incidence of relapse. On the other hand, if the clinician wishes to regain the patient's initial arch form, then significant 'round tripping' of the teeth will be required. From these findings, it might appear reasonable to design NiTi archwires with a reduced intercanine width. Although producing a customized NiTi archwire would be impractical, due to natural variation in arch form with race and gender (Burris and Harris, 2000), it could be argued that a reduction in intercanine width of currently available arch forms would at least more closely correspond to most patients' arch forms.

From the current questionnaire on the initial alignment phase of treatment, it would seem that the majority of operators feel that it is not important what arch form is used. Indeed, it has been suggested that bending only a very simple arch form in light stainless steel or even using just a straight piece of stainless steel for initial alignment would be sufficient (Mills, 1987).

In the second part of this study, the questionnaire concentrated on the choice of archwire and the importance of arch form during the space-closing phase of fixed appliance treatment. From the results, there appears to be

general agreement as to the choice of archwire for space closure, with an almost universal use of 0.019 × 0.025 inch stainless steel wire in a 0.022 inch bracket slot. The use of the 0.022 inch bracket slot certainly differs considerably from the results of the survey of American orthodontists (Keim *et al.*, 2002), where by contrast, only just over half (54 per cent) of respondents used a 0.022 inch slot.

When choosing an arch form, the percentage of clinicians routinely using study models was quite low, at just 28 per cent. Of those who did use them, the majority used only the lower model to select both upper and lower arch forms. This does seem the most reasonable approach as it is the lower intercanine width which is prone to relapse if expanded. A meta-analysis by Burke *et al.* (1998) suggested that this measurement returns to its pre-treatment dimension following the end of retention. Conversely, some expansion of the upper intercanine and intermolar widths has proved to be stable in the longer term (Sadowsky, 1994). The use of just the lower model was not universal, with some respondents using both upper and lower models, while others used only the upper model to select arch form.

Using only the upper model for adjustment of the upper archwire may not be the most appropriate approach. For instance, if the upper archwire is adjusted without reference to the lower archwire, the two arches may not be coordinated. Also, in the case of some malocclusions, the upper study model will not accurately represent the actual arch form. For example, in a patient with a Class II division 2 incisor relationship, retroclination of the upper incisors and a scissor bite on the first premolars will give an incorrect impression of both arch length and arch form. The first approach, using the lower study model, seems more logical as the upper arch will then be coordinated with the lower arch for a correct transverse occlusal result.

The questionnaire also highlighted differences between clinicians concerning the teeth and landmarks used to identify the arch form and which will then be used to adapt the archwires during treatment (Table 2). Most clinicians considered mandibular intercanine width important, and indeed the majority used a combination of teeth, including the canines and molars. However, the differences once again highlight a general lack of agreement between the clinicians surveyed. Previously, it has been recommended taking into account incisor, canine, and molar position when choosing the arch form (Cozzani, 2000). Even when focussing on particular teeth, when deciding on the arch form in the present study, some respondents used the cusp tips as landmarks, others the buccal surfaces, and others still the imagined bracket positions. No single landmark choice predominated (Table 2). If there are so many combinations of teeth and landmarks in use, then there must also be several different opinions as to where on the dental arch the arch form actually lies. Therefore, in the case of clinicians who painstakingly adjust each archwire using pre-treatment models, where is the arch form? In particular, where is it on a pre-treatment model with malaligned teeth? This lack of consistency with regard to arch form selection was an interesting finding.

Approximately half of those questioned in the present research used symmetry charts during treatment. Again, there was no uniformity in how they were used. Although symmetry charts were most often used in combination with the lower study model when choosing the arch shape (83 per cent), a minority of clinicians (2 per cent) made their archwires conform to the symmetry chart without reference to study models or the patient. In these cases, a particular size was chosen for all non-extraction cases and a second size for all extraction cases. Such an approach will not allow an accurate adaptation to the majority of patients' pre-treatment arch forms.

Additional comments written on two of the completed questionnaires raised other issues, when it came to the use of pre-treatment models for adaptation of archwires to the arch form. The comments suggested that in an ideal world, the clinicians in question would have used study models routinely. However, the study models were stored off site, due to lack of space, and as a result were not readily available for each appointment. The intimation is that little if any consideration was being given to pre-treatment arch form. The use of digital models would reduce storage problems and perhaps make virtual models more readily available at the patient appointment. Certainly, a comparison of measurements on digital and cast study models, with regard to tooth size and overjet, found that digital measurements were slightly smaller than those from plaster study models. The differences ranged from 0.16 to 0.49 mm but were not thought to be clinically relevant (Santoro *et al.*, 2003). Digital models do allow a static view from any direction (Joffe, 2004), but how easy it would be to accurately adjust an arch form to a virtual study model remains unresolved.

Conclusions

1. The majority of clinicians felt that preservation of the pre-treatment arch form was essential in the latter stages of treatment. In particular, conservation of the original intercanine width was considered important. However, it was not considered important in the early stages of treatment when NiTi archwires were used for initial alignment.
2. There was no uniformity in how arch form was preserved. Some clinicians used study models and symmetry charts as an aid, but even then they were used in different ways. There was also no consistency in the landmarks that were used when adapting stainless steel archwires to the arch form. Therefore, even when clinicians do carefully adapt their archwires, with the intention of preserving arch form, are they choosing the correct arch size and arch form?

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