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The timing of significant arch dimensional changes with fixed orthodontic appliances: Data from a multicenter randomised controlled trial

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ABSTRACT

Objectives: To identify the timing of significant arch dimensional increases during orthodontic alignment involving round and rectangular nickel-titanium (NiTi) wires and rectangular stainless steel (SS). A secondary aim was to compare the timing of changes occurring with conventional and self-ligating fixed appliance systems.

Methods: In this non-primary publication, additional data from a multicenter randomised trial initially involving 96 patients, aged 16 years and above, were analysed. The main prespecified outcome measures were the magnitude and timing of maxillary intercanine, interpremolar, and intermolar dimensions. Each participant underwent alignment with a standard Damon (Ormco, Orange, CA) wire sequence for a minimum of 34 weeks. Blinding of clinicians and patients was not possible; however, outcome assessors and data analysts were kept blind to the appliance type during data analysis.

Results: Complete data were obtained from 71 subjects. Significant arch dimensional changes were observed relatively early in treatment. In particular, changes in maxillary inter-first and second premolar dimensions occurred after alignment with an 0.014 in. NiTi wire ($P < 0.05$). No statistical differences in transverse dimensions were found between rectangular NiTi and working SS wires for each transverse dimension ($P > 0.05$). Bracket type had no significant effect on the timing of the transverse dimensional changes.

Conclusions: Arch dimensional changes were found to occur relatively early in treatment, irrespective of the appliance type. Nickel-titanium wires may have a more profound effect on transverse dimensions than previously believed.

Clinical significance: On the basis of this research orthodontic expansion may occur relatively early in treatment. Nickel-titanium wires may have a more profound effect on transverse dimensions than previously believed.

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1. Introduction

Orthodontic treatment with fixed appliances typically commences with initial alignment of grossly displaced teeth prior to arch levelling, overbite reduction, overjet reduction and space closure in extraction cases.[1] Throughout this process, arch form changes occur in tandem with alignment producing marked alteration in transverse dimensions including inter-canine, inter-premolar and inter-molar dimensions.[2,3] These changes are necessary for alleviation of crowding in non-extraction cases, while also potentially affecting dental aesthetics, and occlusal inter-digitation and function.

Typical increases in maxillary arch dimensions during orthodontic alignment in non-extraction cases range from 0.55 to 2.13 mm in the inter-canine region, peaking at up to 4.94 mm in inter-premolar dimensions, while expansion in intermolar width ranging from 1.53 mm to 2.96 mm has been reported.[2,3] Classically, it is believed that arch expansion is produced in stiff, rectangular stainless steel (SS) arch wires, as these wires have sufficient rigidity to promote buccal movement of posterior teeth. More recently, use of flexible Copper Nickel-Titanium (CuNiTi) archwires with broad arch forms has been proposed as a means of producing transverse arch development.[4,5]

Self-ligating brackets (SLBs) are ligatureless brackets and are classified as either active or passive. Active clips encroach on the archwire during the later stages of alignment, while in passive systems the clip or gate mechanism does not actively press on the arch wire. The renewed interest in self-ligating brackets and associated use of expanded nickel-titanium (NiTi) alloy wires has raised the possibility of significant expansion earlier during fixed appliance therapy than previously thought realistic.[5,6] A recent prospective study highlighted inter-premolar increases of up to 3.65 mm despite not progressing beyond use of 0.016 in. round NiTi.[7] It is, therefore, possible that significant transverse dimensional changes may be produced at a relatively early stage of treatment. Moreover, despite a dearth of supporting evidence,[8] passive self-ligating appliances have been claimed to lend themselves to non-extraction based treatment. The possibility of non-extraction treatment with these systems relates to this potential for transverse expansion, prompting the advancement of self-ligating brackets as an alternative to more conventional approaches involving active expansion with auxiliaries, such as rapid palatal expanders.[9]

The specific aims of this non-primary report of a clinical trial were to pinpoint the timing of significant arch dimensional increases during orthodontic alignment involving round and rectangular nickel-titanium wires and rectangular stainless steel. A secondary aim was to assess whether differences arise in the timing of changes with conventional and self-ligating appliances.

2. Materials and methods

A multi-centre, three-arm, parallel-group randomised trial was undertaken in 3 U.K. centres. Participants were recruited from the orthodontic treatment waiting lists from April 2009 to June 2011 with ethical approval from the Cambridgeshire 1 Research Ethics Committee, U.K. (09/H0304/45; Protocol: NCT01320657). The selection criteria and treatment protocol for much of this project has been outlined previously but are summarised below.[10]

Inclusion criteria:

- Young adults aged 16 years and over.
- Fit and well and on no medication.
- In the permanent dentition with maxillary second molars erupted.
- Maxillary arch crowding less than 6 mm.
- Amenable to non-extraction treatment in the maxillary arch.

Exclusion criteria:

- Cleft lip and palate and other craniofacial anomalies.
- Previous orthodontic treatment.
- Complex medical history and taking medications.
- Congenital absence of teeth in the maxillary arch other than 3rd molars.

Each participant had study models taken a maximum of 1 month before placement of the fixed appliances (T1). An unpredictable allocation sequence was developed using an electronic randomisation programme with stratified randomisation for each centre. Randomisation was carried out in random permuted blocks of size 12 in a ratio of 1:1:1. The assignment of each subject was concealed from the clinician until the appointment at which the appliance was to be placed using sequentially numbered, opaque and sealed envelopes. Outcome assessors and data analysts were kept blind to the appliance type during data analysis.

Self-ligating (DamonQ™, Ormco Co, Orange, CA; InOvation C™, Dentsply GAC, NY) or conventional (Ovation™, Dentsply GAC, NY) pre-adjusted edgewise brackets with .022 in. slots were placed based on the random allocation procedure. A .013 or 014 in. round copper nickel-titanium archwire (Damon, Ormco Co, Orange, CA) of uniform arch form was placed in all cases with attachments on all teeth from maxillary second molar to second molar. The conventional twin brackets were ligated with elastomeric modules. Subjects underwent treatment with a pre-determined ''Damon archwire sequence'' involving .013 or .014 in. round CuNiTi; 0.014 × 0.025 in. CuNiTi; 0.018 × 0.025 in. CuNiTi; 0.019 × 0.025 in. Stainless Steel. All wires were of Damon arch form uncoordinated to the original arch form or dimensions. Nickel-titanium wires were changed after intervals of 10 weeks, 10 weeks and 6 weeks, respectively. The 0.019 × 0.025 in. Stainless steel wire was left in place for a minimum of 8 weeks.

2.1. *Data collection*

Alginate impressions of the maxillary arch were taken before treatment (T1), after alignment with 0.014 in. CuNiTi (T2), 0.014 × 0.025 in. CuNiTi (T3), 0.018 × 0.025 in. CuNiTi (T4) and 0.019 × 0.025 in. SSW (T5), at which stage a 0.019 × 0.025 in. stainless steel archwire was engaged passively. Data relating to overall changes (T1–T5) has previously been reported.[10]