

The scientific evidence for pre-adjusted edgewise attachments and mechanics

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Key points

We provide contemporary scientific evidence for the selection of fixed appliances, orthodontic archwires and auxiliaries.

Educates the clinician as to the most current scientific evidence for orthodontic pre-adjusted edgewise mechanics.

This paper will aid clinicians to make evidence-based decisions in everyday clinical orthodontic practice.

Abstract

Introduction Fixed orthodontic appliance systems continue to evolve with a wealth of evidence emerging to underpin these refinements.

Aims To present the evidence from comparative prospective research informing the selection of fixed appliance design and mechanics.

Design Detailed literature review.

Materials and methods An electronic search to identify randomised controlled trials and clinical controlled trials was undertaken using pre-defined search terms.

Results Based on high-level evidence, no one bracket system has been proven superior in terms of efficiency or outcome. Similarly, a clear advantage associated with one wire type or dimension has not been shown. The effect of lacebacks in terms of anchorage management appears to be limited, while elastomeric chain and nickel titanium closing coils are associated with similar rates of space closure.

Discussion A wealth of high-quality recent evidence to support the selection of fixed appliance attachments, archwires and auxiliaries, including lacebacks and space closing mechanics, was identified.

Conclusions There has been a considerable increase in the amount of high-quality evidence informing the choice of pre-adjusted edgewise mechanics in recent years. This information can be used to make evidence-based decisions in the selection and manipulation of fixed appliances during daily practice.

Introduction

The emergence of aligner therapy has offered an alternative to the use of fixed appliances within contemporary orthodontics. Nevertheless, while some improvement in the predictability of aligner therapy may have occurred in recent

years, fixed appliances continue to form the mainstay of active orthodontic treatment, with continued uncertainty regarding the predictability of aligners in the correction of a range of presentations, including rotational control, transverse correction and overbite reduction.^{1,2} A previous paper by Mandall and Malik (2007)³ has catalogued the evidence underpinning the use of pre-adjusted edgewise attachments and mechanics, including:

- Archwire sequences
- Choice of initial aligning archwire
- Use of lacebacks
- Levelling the curve of spee
- Space closure mechanics
- Customisation of orthodontic appliances.

In view of the wealth of recent research concerning fixed appliance design and mechanics, allied to the continued refinement

of fixed appliance systems, we aimed to update this review on the basis of contemporary research, including randomised and other controlled clinical trials, in order to better inform the selection of fixed appliance design and mechanics.

Method

An electronic search of Medline, Web of Science and the Cochrane Clinical Trials Register from June 2000 to June 2022 was undertaken using pre-defined search terms (Appendix 1). Randomised controlled trials (RCTs) and clinical controlled trials were included, with retrospective studies, case reports and case series excluded. Interventions assessed included any variation on the use of fixed appliance attachments or mechanics. Outcomes assessed included treatment

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Table 1 Levelling the curve of Spee

Title	Year of publication	Authors	Type of study	Interventions	Sample size calculation	Sample size	Results (primary outcomes)	Results (non-primary outcomes)	Limitations
A comparative study between the effect of reverse curve of Spee archwires (RCWs) and anterior bite turbos (ABTs) in the treatment of deep overbite cases: A randomized clinical trial	2022	Al-Zoubi and Al-Nimri	RCT	Group I: lower 0.016 x 0.022 inch NiTi RCWs	Power: 0.8 Alpha: 0.05	48	The lower incisors proclined more in Group II using ABTs by an increased mean value of 2.28 degrees (p <0.001)	The lower face height ratio increased significantly more in Group II (p <0.002)	Small sample size
				Group II: ABTs palatal to upper central incisors				The duration of levelling was significantly shorter (by 1.7 months) in Group II (p <0.001)	
Effect of the timing of second molar bonding on the duration of the mandibular arch levelling: a randomized clinical trial	2022	Dritsas <i>et al.</i>	RCT	Group A: lower second molars bonded at time of 0.016 x 0.022 NiTi wire placement	Power: 0.8 Alpha: 0.05	36	Group A required more days of levelling (mean of 203 days) compared to Group B (mean of 168 days). This difference was not statistically significant (p = 0.128)		
				Group B: lower second molars bonded at the first appointment					

Table 2 Archwire sequence

Title of study	Year of publication	Authors	Type of study	Interventions	Sample size calculation/ per protocol	Sample size	Results (primary outcomes)	Results (non-primary outcomes)	Limitations of study
Alignment efficiency and discomfort of three orthodontic archwire sequences: a randomized clinical trial	2011	Ong <i>et al.</i>	RCT	Three archwire sequence groups (18 x 25 inch slot): <ul style="list-style-type: none"> • 3M Unitek 0.014 Nitinol, 0.017 x 0.017 inch heat-activated NiTi • GAC international 0.014 inch Sentalloy, 0.016 x 0.022 inch Bioforce • Ormco corporation 0.024 inch Damon CuNiTi 	Power: 0.99 Alpha: 0.05	132	No statistically significant differences in the reduction of irregularity, the time to reach the working archwire or discomfort between the different archwire sequences (p = 0.29)	Nil	Clinician not blinded to each archwire group Missing data decreased the power of the irregularity index and discomfort analysis
Which orthodontic archwire sequence? A randomized clinical trial	2006	Mandall <i>et al.</i>	RCT	Three archwire sequence groups: <ul style="list-style-type: none"> • Group A = 0.016 inch NiTi, 0.018 x 0.025 inch NiTi, and 0.019 x 0.025 inch SS • Group B = 0.016 inch NiTi, 0.016 inch SS, 0.020 inch SS, and 0.019 x 0.025 inch SS • Group C = 0.016 x 0.022 inch CuNiTi, 0.019 x 0.025 inch CuNiTi, and 0.019 x 0.025 inch SS 	Power: 0.99 Alpha: 0.05	154	No statistically significant differences for patient discomfort or root resorption between the different archwire sequences (p = 0.05)	Nil	Yes

outcome using a validated scale or a measure of treatment efficiency with assessments both during and after treatment.

The following search terms were used:

- Archwire sequence
- Initial aligning archwire
- Bracket variations
- Customisation of orthodontic appliances
- Local bracket variations
- Levelling the curve of Spee
- Lacebacks
- Space closure
- Rate of space closure
- Nickel titanium (NiTi) closing coils
- Powerchain
- Elastomeric ligatures
- Pre-adjusted edgewise mechanics
- Straightwire appliance.

Table 3 Effect of brackets slot and prescription

Title of study	Year of publication	Authors	Type of study	Interventions	Sample size calculation/per protocol	Sample size	Results (primary outcomes)	Results (non-primary outcomes)	Limitations of study
A randomized clinical trial of the effectiveness of 0.018-inch and 0.022-inch slot orthodontic bracket systems: part 1 – duration of treatment	2019	Yassir <i>et al.</i>	RCT	0.018 inch and 0.022 inch MBT slot bracket systems	Power: 0.80 Alpha: 0.05	187	No statistically significant differences between the two treatment groups for treatment duration ($p > 0.05$)	Nil	Unable to blind clinician and patients to allocation
				Outcome measures included duration of: 1) overall treatment; 2) levelling and alignment; 3) working and finishing; and 4) appointment numbers and other treatment-related factors					
A randomized clinical trial of the effectiveness of 0.018-inch and 0.022-inch slot orthodontic bracket systems: part 2 – quality of treatment	2019	Yassir <i>et al.</i>	RCT	0.018 inch and 0.022 inch MBT slot bracket systems	Power: 0.80 Alpha: 0.05	187	There was an improvement in patient perception of aesthetics after treatment for both groups ($p < 0.05$)		Unable to blind clinician and patients to allocation
				Outcome measures included: 1) ABO cast-radiograph evaluation (CR-EVAL); 2) PAR scores; 3) incisor inclination; and 4) patient perception using the Index of Orthodontic Treatment Need aesthetic component (IOTN AC) and three validated questionnaires before, during and after treatment			No statistically or clinically significant differences in the quality of occlusal outcomes, incisor inclination and patient perception of treatment ($p > 0.05$)		
A randomized clinical trial of the effectiveness of 0.018-inch and 0.022-inch slot orthodontic bracket systems: part 3 – biological side-effects of treatment	2019	El-Angbawi <i>et al.</i>	RCT	0.018 inch and 0.022 inch MBT slot bracket systems	Power: 0.80 Alpha: 0.05	187	No significant effect on the severity of OIIRR and patient perception of pain ($p = 0.115$ and $p = 0.08$, respectively)		Unable to blind clinician and patients to allocation
				Outcomes included OIIRR and patient perception of pain					

Results

Levelling the curve of Spee

Clinical trials have been performed to evaluate the relative merits of the use of fixed anterior bite planes and reverse curve of Spee NiTi (0.016 x 0.022 inch) wires,⁴ in addition to the impact of the timing of inclusion of second molars within the appliance.⁵ The efficiency of overbite reduction was found to be independent of the latter.⁵ However, overbite reduction appeared to be more efficient with the use of bite turbos, while also culminating in less lower incisal advancement (Table 1).⁴

Archwire sequence

Ong *et al.* (2011) evaluated the efficiency of orthodontic archwire sequences produced by three manufacturers. In total, 132 patients completed the study.⁶ There were no differences between the groups either in relation to the time to reach the working archwire or in the

alleviation of irregularity in the lower anterior segment.

Similarly, Mandall *et al.* (2006)⁷ compared different archwire sequences, highlighting no statistically significant differences in the level of discomfort or risk of root resorption with either sequence. The time to reach the working (0.019 x 0.025 inch stainless steel [SS]) archwire was significantly longer with one of the three sequences (Table 2).

Effect of bracket slot and prescription

Slot size

Yassir *et al.* (2019)^{8,9} and El-Angbawi *et al.* (2019)¹⁰ in a series of articles considered the effectiveness of an 0.018 inch and an 0.022 inch slot MBT orthodontic bracket system in terms of the duration, outcomes and impacts, noting no difference between the variants concerning the quality of occlusal outcomes (Peer Assessment Rating score reduction), incisor inclination change, patient perception of treatment, or

the development of orthodontically induced inflammatory root resorption (OIIRR) (Table 3).

Bracket prescription

Mittal *et al.* in an RCT investigated the effect of bracket prescription on the outcome of treatment.¹¹ Overall, 40 sets of post-treatment study models were used (20 Roth and 20 MBT). The crown inclinations of the 21, 13 and 41 were assessed from the digital images. The Roth and MBT bracket prescriptions were compared in terms of the Incisor and Canine Aesthetic Torque and Tip score. No statistically significant difference in the final inclination of the anterior teeth was observed ($p = 0.132$). This mirrors the findings elucidated within an allied subjective evaluation of incisor inclination change with MBT and Roth.¹² However, the evaluation was undertaken in subjects with crowding being treated on a non-extraction basis. It is therefore conceivable that the effect of bracket prescription was not fully elucidated.

Table 4 Initial aligning archwires (cont. on page 5)

Title	Year	Author	Type of study	Intervention	Sample size calculation	Sample size	Results (primary outcomes)	Results (secondary outcomes)	Limitations
Comparison between heat activated NiTi vs super elastic NiTi									
A comparative assessment of clinical efficiency between premium heat-activated copper nickel-titanium and superelastic nickel-titanium archwires during initial orthodontic alignment in adolescents: a randomized clinical trial	2019	Atik <i>et al.</i>	RCT	CuNiTi vs NiTi	Power: 0.95 Alpha: 0.05	50 patients	No statistically significant difference between groups regarding efficiency of alignment (p = 0.581)	No difference between groups regarding incisor inclination and arch width	No blinding
Pain experience during initial alignment with three types of nickel-titanium archwires: a prospective clinical trial	2015	Abdelrahman <i>et al.</i>	RCT	Superelastics NiTi vs CuNiTi vs Conventional NiTi	Power: 0.80 Alpha: 0.05	75 patients	No statistically significant difference in pain intensity between the wires (p = 0.63)	No differences found in pain experience in terms of sex, age, lower arch crowding, and incisor irregularity	No statistical blinding
				Pain score using Visual Analogue Scale (VAS) over seven-day period post bond-up					
Tooth alignment and pain experience with A-NiTi versus Cu-NiTi: a randomized clinical trial	2021	Azizi <i>et al.</i>	RCT	NiTi vs CuNiTi	Power: 0.80 Alpha: 0.05	88 patients	Pain perception, duration of pain and analgesic intake were not statistically significant between both groups: (p = 0.487, p = 0.546, p = 0.102, respectively)		
A clinical comparison of three aligning archwires in terms of alignment efficiency: A prospective clinical trial	2015	Abdelrahman <i>et al.</i>	RCT	Superelastics NiTi vs CuNiTi vs Conventional NiTi	Power: 0.80 Alpha: 0.05	87 patients	No difference between groups in efficiency of alignment using little irregularity index (p = 0.98)	Nil	Attrition bias
Comparison between other archwires vs super elastic NiTi									
Comparison of changes in irregularity and transverse width with nickel-titanium and niobium-titanium-tantalum-zirconium archwires during initial orthodontic alignment in adolescents: A double-blind randomized clinical trial	2018	Nordstrom <i>et al.</i>	RCT	TiNbTaZr vs NiTi	Power: 0.80 Alpha: 0.05	28 patients	No difference between groups regarding efficiency of alignment (p = 0.29)	There was no significant difference between the two groups in the changes in intercanine and intermolar width (p = 0.80)	No examiner blinding
A randomized clinical trial investigating pain associated with superelastic nickel-titanium and multistranded stainless steel archwires during the initial leveling and aligning phase of orthodontic treatment	2013	Sandhu <i>et al.</i>	RCT	Superelastic NiTi vs Multistranded SS primary outcome pain score using VAS	Power: 0.90 (to detect a difference of 3 mm in a 10 mm VAS) Alpha: 0.05	96 patients	No statistically significant difference was found for overall pain (p = 0.1071)	Nil	

Initial aligning archwires

Comparison between different types of NiTi wires

Four trials have investigated the efficiency of initial alignment using heat-activated copper NiTi (CuNiTi), superelastic NiTi and/or conventional NiTi archwires (Table 4). Atik *et al.* (2019), in a trial involving 50 patients, found no difference between CuNiTi and

superelastic NiTi archwires in relation to the efficiency of alignment, arch width changes and incisor inclination.¹³ Similarly, Azizi *et al.*, identified no difference between CuNiTi archwires and conventional NiTi archwires in terms of both efficiency of alignment and pain perception.¹⁴ Abdelrahman *et al.* also observed no difference between CuNiTi, superelastic NiTi and/or conventional NiTi

archwires concerning either the efficiency of alignment or pain perception.¹⁵

NiTi archwires versus other non-NiTi wires

Sandhu *et al.* (2013) investigated the differences in pain perception among 96 patients having initial alignment with either superelastic NiTi or multistranded SS wires.¹⁶ There was no difference between

Table 4 Initial aligning archwires (cont. from page 4)

Title	Year	Author	Type of study	Intervention	Sample size calculation	Sample size	Results (primary outcomes)	Results (secondary outcomes)	Limitations
Comparison between different shape of NiTi archwires									
Alignment efficiency of coaxial tubular superelastic nickel-titanium vs single-stranded superelastic nickel-titanium in relieving mandibular anterior crowding in extraction cases: A single-centre randomized controlled clinical trial.	2019	Sebastian <i>et al.</i>	RCT	Coaxial NiTi vs Single Strand NiTi	Power: 0.80 Alpha: 0.05	40 patients	The largest mean irregularity index reduction was at four weeks for both archwires; however this was not statistically significant ($p = 0.122$)	There was no statistically significant correlation between degree of initial crowding and alignment efficiency	No blinding
Alignment efficiency of superelastic coaxial nickel-titanium vs superelastic single-stranded nickel-titanium in relieving mandibular anterior crowding: a randomized controlled prospective study	2011	Sebastian	RCT	Coaxial NiTi vs Single Strand NiTi	Power: 0.95 Alpha: 0.05	24 patients	Coaxial NiTi had a statistically significant but not clinically relevant advantage in terms of alignment efficiency ($p < 0.05$)	Nil	No blinding
Comparison between preformed and customised NiTi archwires									
Tooth and bone changes after initial anterior dental alignment using preformed vs customized nickel titanium archwires in adults: A randomized clinical trial	2018	Phermsang-Ngarm <i>et al.</i>	RCT	Preformed CuNiTi vs Customised CuNiTi	Power: 0.90 (to detect a difference of 0.8 mm using little irregularity index) Alpha: 0.05	32 patients	Customised CuNiTi resulted in more palatal movement ($p \leq 0.003$)	Customised CuNiTi led to less root resorption ($p \leq 0.007$) and less bone loss ($p \leq 0.004$)	No blinding
							Customised CuNiTi group showed more canine distal movement ($p \leq 0.049$)		

Table 5 Use of lacebacks

Title	Year	Author	Type of study	Intervention	Sample size calculation	Sample Size	Result primary outcomes	Result secondary outcomes	Limitation
A randomized clinical trial to compare the effectiveness of canine lacebacks with reference to canine tip	2002	Usmani <i>et al.</i>	RCT	Laceback vs no laceback groups	Power: 0.90 Alpha: 0.05	42 patients	Less incisor proclination when lacebacks were used ($p = 0.025$)	The use of lacebacks had no statistically significant effect on mesial molar movement ($p = 0.99$)	Attrition bias
The effectiveness of laceback ligatures: a randomized controlled clinical trial	2004	Irvine <i>et al.</i>	RCT	Laceback vs no laceback groups	Power: 0.98 Alpha: 0.05	62 patients	The use of lacebacks had no statistically significant change in incisor angulation ($p = 0.84$)	There was a significant increase in lower molar movement with the use of lacebacks (0.83 mm greater mesial movement in the experimental group) ($p < 0.05$).	

the two groups in terms of pain perception. Nordstrom *et al.* (2018) in an investigation of the efficiency of niobium-titanium-tantalum-zirconium and NiTi archwires also found comparable results between both groups, implying that niobium-titanium-tantalum-zirconium archwires may offer an alternative in patients with nickel hypersensitivity.¹⁷

Different configurations of NiTi wire

Sebastian *et al.* (2019) investigated the efficiency in alignment of mandibular anterior crowding in both extraction (40 patients) and non-extraction cases (24 patients), using coaxial NiTi archwires and single strand NiTi archwires. Co-axial forms did not demonstrate clinically relevant superiority in efficiency of alignment over the single strand NiTi archwires.¹⁸

Preformed versus customised CuNiTi wire

Phermsang-Ngarm *et al.* (2018) investigated the effect of the use of preformed CuNiTi and customised CuNiTi archwires in 32 patients.¹⁹ Preformed CuNiTi archwires were more efficient in terms of alignment, while the customised version resulted in less root resorption and bone loss. However, the overall differences were not considered to be clinically relevant.

Table 6 Space closure (contd. on page 7)

Title	Year of publication	Author(s)	Type of study	Intervention	Sample size calculation	Sample size	Results primary outcomes	Result secondary outcomes	Limitations
A randomized clinical trial to compare three methods of orthodontic space closure	2002	Dixon <i>et al.</i>	RCT	Active ligs vs powerchain vs NiTi closing coils	Power: 0.90 Alpha: 0.05	33 patients	NiTi coils closed space faster than active ligatures (p < 0.05) There was no statistical difference when comparing rate of space closure of NiTi coils to powerchain	Intermaxillary elastics did not affect the rate of space closure	No blinding
A clinical comparison between nickel titanium springs and elastomeric chains	2006	Bokas <i>et al.</i>	RCT	NiTi closing coils vs elastomeric chains Rate of canine retraction until space was closed	No sample size calculation	12 patients per intervention	The mean rate of space closure with NiTi springs was only 0.17 mm/month greater than that produced with the elastomeric chains; however, this was not a statistically significant difference (p = 0.011) The rate of space closure and molar anchorage loss using NiTi springs and elastomeric chains is similar if they are reactivated every 28 days	No difference in rate of anchorage loss between two groups	No sample size calculation No blinding
Canine and molar movement, rotation and tipping by NiTi coils versus elastomeric chains in first maxillary premolar extraction orthodontic adolescents: A randomized split-mouth study	2022	Hashemzadeh <i>et al.</i>	RCT	Elastomeric chains vs NiTi closing coils	Power: 0.90 Alpha: 0.05	22 patients per intervention	The average canine distal movement was 3.88 and 5.45 mm in elastomeric chains and NiTi coil groups, respectively (p = 0.001)	NiTi closing coils cause more canine mesiobuccal rotation (p = 0.006) NiTi coils cause more distal tipping of canines (p = 0.011) NiTi coils cause more molar mesial tipping (p = 0.028)	No blinding
A clinical investigation of force delivery systems for orthodontic space closure	2003	Nightingale <i>et al.</i>	RCT	Powerchain vs NiTi closing coils Force decay and rate space closure (1st premolars) on a 19 x 25 SS over a 15-week period	No sample size calculation	15 patients	59% of powerchains retained half their initial force at the 15-week period compared to only 46% of NiTi closing coils	No difference in space closure rates Force decay was not significantly different between powerchains and NiTi closing coil	No blinding

Use of lacebacks

Usmani *et al.* (2002), in a RCT involving 35 patients, found that the use of lacebacks had a statistically significant effect on incisor inclination with no meaningful effect on anchorage loss.²⁰ However, Irvine *et al.* (2004) found that the use of lacebacks had no tangible effect on incisor inclination or vertical positioning of incisors, with

significantly more molar mesial movement identified (Table 5).²¹

Space closure

NiTi closing coils versus elastomeric chains – rate of space closure

The efficiency of a range of space closing mechanics has been assessed in high-level primary studies. The most common

modalities tested were NiTi closing coils and elastomeric power chains. Dixon *et al.* (2002) investigated the rate of space closure between active ligatures, elastomeric power chains and NiTi closing coil in 33 patients over a four-month period.²² NiTi closing coil were superior to active ligatures but they performed similar to elastomeric chains. Bokas *et al.* (2006) corroborated these

Table 6 Space closure (cont. from page 6)

Title	Year of publication	Author(s)	Type of study	Intervention	Sample size calculation	Sample size	Results primary outcomes	Result secondary outcomes	Limitations
Nickel titanium springs versus stainless steel springs: A randomized clinical trial of two methods of space closure	2016	Norman et al.	RCT	NiTi closing coils vs SS closing coils	Power: 0.80 Alpha: 0.05	40 patients	There was a statistically significant difference in the rate of space closure favouring SS coils ($p = 0.024$) There was no statistically significant difference between the amounts of space closed when using NiTi springs versus stainless steel springs ($p = 0.76$)	No differences in breakages or distortions between spring types	No statistical blinding
Efficacy of elastic memory chains versus nickel-titanium coil springs in canine retraction: A two-center split-mouth randomized clinical trial	2017	Khanemasjedi et al.	RCT	Elastic memory chains (EMCs) vs NiTi closing coils	Power: 0.80 Alpha: 0.05	21 patients	There was a statistically significant difference favouring EMCs over NiTi closing coils, 0.22 mm advantage over three months	The rate of space closure was faster in the elastic group ($p = 0.022$)	No examiner blinding
A comparison of space closure rates between preactivated nickel-titanium and titanium-molybdenum alloy T-loops: a randomized controlled clinical trial	2012	Keng et al.	RCT	TMA T-loops vs NiTi T-loops	Power: 0.80 Alpha: 0.05	12 patients	No statistically significant difference in the rate of canine retraction or tipping between two groups ($p = 0.848$)	No statistically significant difference in the mean change in canine angulation per month following space closure	No operator blinding

Table 7 Litigation method

Title	Year of publication	Author(s)	Type of study	Intervention	Sample size calculation	Sample size	Results (primary outcomes)	Result (secondary outcomes)
Does the bracket-ligature combination affect the amount of orthodontic space closure over three months? A randomized controlled trial	2013	Wong et al.	RCT	Elastomeric O-rings vs super slick elastomeric O-rings vs self-ligating Space closure on a 0.019 x 0.025 SS archwire over a three-month period using NiTi closing coils	Power: 0.90 Alpha: 0.05	45 patients	No statistically significant difference in the amount of space closure over three months between the three groups ($p = 0.718$)	Nil

findings in an RCT of 12 patients, assessing the rate of canine retraction between NiTi closing coils and elastomeric chains.²³ Both Bokas *et al.* (2006) and Hashemzadeh *et al.* (2022) observed marginally more efficient closure with NiTi closing coils with potential deleterious effect associated with NiTi closing coils (such as canine rotation, tipping and molar tipping) being minimal and not clinically relevant (Table 6).^{23,24}

NiTi closing coils versus elastomeric chains – force decay

Nightingale *et al.* (2003), in a trial involving 22 patients, found that at the 15-week period, 59% of elastomeric power chains retained half their initial force compared to

49% of NiTi closing coils, with no associated difference in the rate space closure.²⁵ Hence, force decay rates may be similar with the two modalities, with force decay having an inconsistent effect on the rate of space closure.

NiTi closing coils versus SS closing coils – rate of space closure

Norman *et al.* (2016), in a trial of 40 patients, investigated the rate of space closure on a 19 x 25 inch SS archwire using NiTi or SS closing coils. SS closing coils were found to be associated with more efficient space closure.²⁶ Coupled with their reduced cost, this data supported the potential use of SS closing coils as an alternative to NiTi.

NiTi T-Loops versus SS T-loops – rate of space closure

Keng *et al.* (2012) investigated the efficiency of space closure and potential deleterious effect with beta titanium and NiTi T-loops. No difference regarding either the rate of space closure or concerning deleterious effects was observed.²⁷

Ligation method

Wong *et al.* (2013) investigated the method of ligation using two different types of elastomeric O-rings and self-ligation in 45 patients (Table 7). The rate of space closure on a 0.019 x 0.025 inch SS wire over three months using NiTi coils was measured periodically. No effect of the method of ligation on the rate of space closure was found.²⁸

Discussion

The present article provides an update on the scientific evidence underpinning the use of the pre-adjusted edgewise appliance and related mechanics, augmenting a previous report published in 2007.³ A noteworthy increase in the volume of high-quality prospective research was obtained with, for example, no prior prospective research concerning either the mechanics used for overbite reduction or in relation to the selection of the optimal archwire sequence.^{4,5,6} This increased volume of literature underpinning the use of fixed appliances mirrors the orthodontic literature more widely, although concerns in relation to the quality of reporting continue to exist.²⁹ Notwithstanding this, further evidence concerning the use of certain mechanics, for example, lacebacks, has not emerged. This likely relates to the consistency among the pre-existing studies,^{20,21} suggesting that further research is not necessarily required in order to validate the findings, although replication of previous clinical trials may be regarded as helpful in order to mitigate against the risk of inadequate power associated with single studies.³⁰

Since 2007, there have been numerous mechanical improvements, particularly in relation to fixed appliance auxiliaries, with elastomeric materials used for space closure an example. A number of new primary studies concerning the choice of mechanic on the rate of space closure have been conducted, with no consistent pattern being observed.^{23,24,31} A number of the more recent studies have involved comparison of proprietary brackets with alternative systems, with self-ligating and customised systems being compared to conventional brackets. This research on marketed products is of value, with much of it highlighting little distinction between newer marketed products and less heralded systems.³² It would therefore be helpful if independent clinical research concerning marketed products is instituted earlier in the development pathway in order to better inform end users concerning the related advantages and limitations.

This review was confined to the selection of attachments and mechanics associated with labial fixed appliance systems. We also did not include anchorage management techniques. Moreover, while the focus of this review was on the evidence underpinning pre-adjusted edgewise labial appliances, aligner therapy has seen considerable

growth in recent years.³³ While aligners offer aesthetic advantage and may be associated with lower pain experience over the initial three-month period,³⁴ the ability to produce more predictable correction of complex tooth movements, including rotational control, has been questioned.^{1,2} Using the American Board of Orthodontics Objective Grading System, patients treated with Invisalign were also shown to have deficient scoring in respect of buccolingual inclinations and occlusal contacts compared to those treated with fixed appliances.³⁵ Other related limitations have also been demonstrated on the basis of observational research.^{1,36,37}

A lack of distinction associated with a range of interventions, including the selection of archwires, was observed. This may well reflect a lack of difference or indeed statistical power within the primary studies. However, it is also conceivable that the chief discriminator is the operator and handling of archwires, rather than the selection of the specific wire. As such, the importance of optimal education and the practical application of knowledge cannot be overstated. Equally, it is also important to note that significant variability in relation to the choice of outcome measures, as well as the timing of data collection, exists.³⁸ A potential solution is the creation and wider adoption of a core outcome set within orthodontic research to better inform trial design, maximising the yield from research and minimising associated waste of scarce resource.^{39,40}

Conclusion

In recent years, there has been a large increase in the amount of high-quality evidence for pre-adjusted edgewise mechanics. In particular, there is a wealth of evidence to support the selection of fixed appliance attachments, archwires and auxiliaries, including lacebacks and space closing mechanics. This information can be used to routinely make informed decisions in the selection and manipulation of fixed appliances during daily practice.

Ethics declaration

The authors declare no conflicts of interest.

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Data available upon request.

Author contributions

Padhraig S. Fleming and Nicky Mandall designed this study. Aliya Hasan and Mohamed Hania undertook the fieldwork. Aliya Hasan and Padhraig S. Fleming analysed the data and produced the initial draft of the manuscript. All authors contributed to redrafting of the manuscript and are accountable for this work, with Padhraig S. Fleming approving the final version.

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Appendix 1 A list of search terms used

Levelling the curve of Spee:

- Level curve of Spee
- Overbite reduction
- Levelling of teeth
- Orthodontics AND levelling curve of Spee

Archwire sequence:

- Pre-adjusted edgewise
- Archwires
- Archwire sequence
- Initial aligning archwires
- Orthodontics AND archwires

Customisation of appliances:

- Bracket variations in orthodontics
- Self-ligating brackets
- 0.022 inch slot system
- 0.018 inch slot system
- Pre adjusted edgewise slot size
- Roth AND MBT

Lacebacks:

- Laceback(s)
- Canine ligatures
- Canine tieback

Space closure:

- Closing coils
- Closing chains
- NiTi coils
- SS coils
- Elastomeric chains
- Closing loops
- E-chains

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