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How long does treatment with fixed orthodontic appliances last? A systematic review

Aliki Tsihlaki,^a Siew Yee Chin,^b Nikolaos Pandis,^c and Padhraig S. Fleming^d

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Introduction: There is little agreement on the expected duration of a course of orthodontic treatment; however, a consensus appears to have emerged that fixed appliance treatment is overly lengthy. This has spawned numerous novel approaches directed at reducing the duration of treatment, occasionally with an acceptance that occlusal outcomes may be compromised. The aim of this study was to determine the mean duration and the number of visits required for comprehensive orthodontic treatment involving fixed appliances. **Methods:** Multiple electronic databases were searched with no language restrictions, authors were contacted as required, and reference lists of potentially relevant studies were screened. Randomized controlled trials and nonrandomized prospective studies concerning fixed appliance treatment with treatment duration as an outcome measure were included. Data extraction and quality assessment were performed independently and in duplicate. **Results:** Twenty-five studies were included after screening: 20 randomized controlled trials and 5 controlled clinical trials. Twenty-two studies were eligible for meta-analysis after quality assessment. The mean treatment duration derived from the 22 included studies involving 1089 participants was 19.9 months (95% confidence interval, 19.58, 20.22 months). Sensitivity analyses were carried out including 3 additional studies, resulting in average duration of treatment of 20.02 months (95% confidence interval, 19.71, 20.32 months) based on data from 1211 participants. The mean number of required visits derived from 5 studies was 17.81 (95% confidence interval, 15.47, 20.15 visits). **Conclusions:** Based on prospective studies carried out in university settings, comprehensive orthodontic treatment on average requires less than 2 years to complete. (Am J Orthod Dentofacial Orthop 2016; ■:■-■)

It is accepted that comprehensive orthodontic treatment is lengthy; the time frame is largely dictated by the biologic principles underpinning optimal tooth movement.^{1,2} There has been a lack of clarity concerning the typical duration of treatment. In a previous review that included observational studies, the authors were unable to arrive at an overall estimate of treatment duration.³ In spite of this lack of

a clear yardstick, there has been a seemingly relentless drive among orthodontists and general dentists to reduce the duration of orthodontic treatment. Modern adjuncts directed at hastening treatment include newer technologies and novel surgical procedures, but some clinicians also resort to eschewing integral treatment phases in an effort to reduce treatment times.^{4,5}

Excessive treatment duration has been linked to a greater susceptibility to iatrogenic consequences of appliance therapy, primarily root resorption and plaque-induced conditions, including demineralization.⁶ Moreover, patient compliance and oral health-related quality of life may be impaired by longer treatment, particularly in adults.⁷ Shorter treatment times may, therefore, theoretically offer advantages to both treatment providers and patients, although shorter treatment is not without significant potential disadvantages.

For providers of care, there may be financial incentives in delivering more efficient treatment, most likely associated with fewer visits and shorter chairside times.⁸ However, potential financial gain may be tempered by the necessity for prolonged and diligent retention associated with the placement of teeth in inherently unstable

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positions with limited torque expression when the objectives of treatment are confined to the alignment of anterior teeth in isolation.⁵

Novel approaches, involving various degrees of financial outlay and theoretical risk, have included expensive vibratory appliances⁹ and adjunctive surgical procedures to expedite tooth movement.¹⁰ Both, however, appear to be largely unproven; a randomized trial failed to identify an increase in the rate of orthodontic alignment in conjunction with a well-marketed, nonsurgical adjunct involving vibratory stimulation.¹¹ Moreover, a recent Cochrane review highlighted a lack of evidence to support the use of surgical adjuncts at this stage, with only 4 clinical trials incorporating a total of just 57 patients.¹² Furthermore, patient perceptions of surgically assisted orthodontics are not all favorable, especially when given the alternative of other noninvasive techniques.¹³

It is therefore increasingly important that there is an appreciation of the expected length of orthodontic treatment before routinely embarking on treatment involving compromised objectives or adjunctive procedures, particularly with the lack of evidence underpinning these approaches. The aim of our review was to determine the duration of orthodontic treatment with fixed appliances.

MATERIAL AND METHODS

The protocol for this systematic review was registered on PROSPERO international prospective register of systematic reviews (www.crd.york.ac.uk/prospero; protocol, 1 CRD42014014983). The following inclusion and exclusion criteria were used.

1. Study design. Randomized and prospective non-randomized studies carried out in primary or secondary care or in the community were to be included. Studies with short follow-up periods not including the duration of orthodontic treatment and retrospective studies were excluded.
2. Participants. Patients of any age with complete-arch, fixed, bonded orthodontic appliances followed until the end of treatment were to be included. Patients with craniofacial syndromes and cleft lip or palate were excluded.
3. Interventions and comparators. Any treatment intervention involving comprehensive, complete-arch, fixed orthodontic appliances without adjunctive use of removable or functional appliances was included. Patients undergoing treatment involving fixed appliances with surgical interventions including surgical exposure of ectopic teeth were excluded. Interceptive orthodontic interventions

were also excluded. Since this was an epidemiologic review, no between-group comparisons were planned.

4. Outcome measures. These were the duration of orthodontic treatment (months) from appliance placement to removal and the number of visits.

Search strategy for identification of studies

Comprehensive electronic database searches were undertaken without language restrictions as follows: MEDLINE via OVID (to November 2014, [Appendix](#)), the Cochrane Oral Health Group's Trials Register (November 2014), and the Cochrane Central Register of Controlled Trials (CENTRAL, the Cochrane Library Issue 3, 2014). Unpublished literature was accessed electronically through ClinicalTrials.gov (www.clinicaltrials.gov) and the National Research Register (www.controlled-trials.com) using the term *orthodontic*. In addition, efforts were made to obtain conference proceedings and abstracts, with authors contacted to identify unpublished or ongoing clinical trials. Reference lists of included studies were screened for additional relevant research.

Assessment of relevance, validity, and data extraction

Data were extracted independently and in duplicate by 2 authors (A.T., S.Y.C.) using prepiloted data extraction forms. The investigators were not blinded to the authors or the results of the research, and any disagreements were resolved by discussion with a third author (P.S.F.). The following information was recorded where available: (1) year of publication and study setting; (2) participants: sample size, age, and sex; (3) type of intervention; (4) type of control; and (5) outcomes: treatment duration (including means and standard deviations in months, where available) and number of visits (means).

Authors were contacted to clarify data as required, including information on treatment duration.

The quality of the eligible trials was assessed independently and in duplicate by 2 authors (A.T., S.Y.C.), and any disagreements were resolved by discussion with a third reviewer (P.S.F.). The Cochrane Collaboration's risk of bias tool was used to assess risk of bias for randomized controlled trials (RCTs),¹⁴ and the Newcastle-Ottawa scale was used for the nonrandomized studies.¹⁵ The following domains were assessed as being at low, high, or unclear risk of bias for the RCTs: sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias) and outcome assessors (detection bias), incomplete outcome data addressed

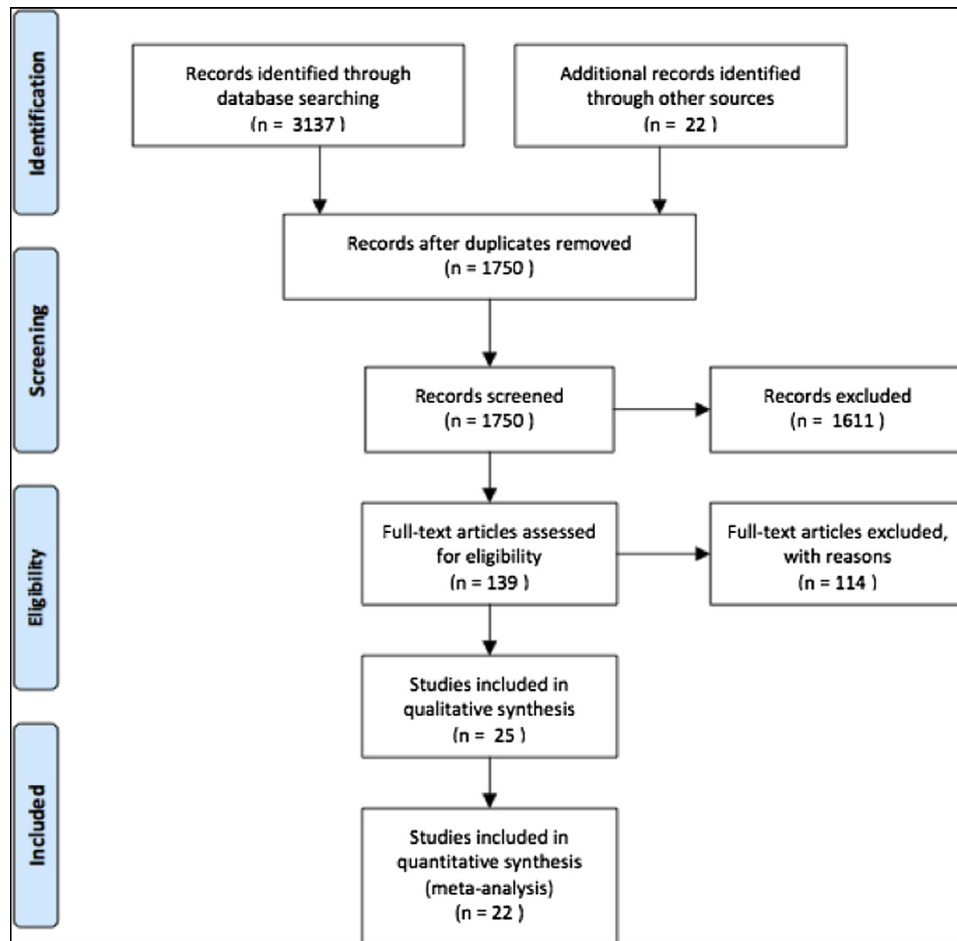


Fig 1. PRISMA flowchart of article identification and selection.

(attrition bias), selective outcome reporting (reporting bias), and other biases. An overall assessment of risk of bias (high, unclear, low) was made for each included trial. Studies with at least 1 criterion considered to be at high risk of bias were considered to be at high risk of bias overall and excluded from the primary analysis. The nonrandomized studies were judged on 3 broad perspectives consisting of 8 domains: selection of the study groups, comparability of the groups, and ascertainment of the outcome of interest. A star system was used in which high-quality studies could receive a maximum of 9 stars. A rating of 5 stars or fewer signified low quality. Studies at high risk of bias and low quality were excluded from the primary meta-analysis.

Statistical analysis

Clinical heterogeneity of the included studies was analyzed by reviewing the treatment interventions and protocol, including participants and settings, appliance designs, and use of extractions or additional procedures.

Statistical heterogeneity was assessed based on a graphic display of the estimated treatment durations in conjunction with 95% confidence intervals. A weighted estimate of treatment duration was calculated from the included studies. Sensitivity analyses were planned at the outset to address studies at higher risk of bias and other potential sources of heterogeneity including overriding effects of large studies and differences in outcomes related to specific treatments (eg, extraction vs nonextraction), study setting (primary or secondary care), or patient groups (adults over 18 years vs adolescents). Meta-analyses and sensitivity analyses were undertaken with Stata software (StataCorp, College Station, Tex) using *metan* and *metareg* commands.

RESULTS

The search returned 1728 studies after removal of duplicates. All abstracts were reviewed, and 139 potentially relevant articles were retrieved in full. Additional screening of reference lists returned another 22 articles

Table. Characteristics of the included studies (N = 25)

Study	Design	Participants	Intervention/comparison	Extraction (yes/no)	Adults/young people (< 18 y)
Al Maaitah, 2013 ¹⁶	RCT split mouth	N = 34: 204 brackets SEP and 204 brackets conventional etch. Each group split in ≤17 y and >17 y. Overall mean age, 18.7 y; range, 12-26 y; sex, 13 M, 21 F	SEP vs conventional etch	No	Both
Banks, ¹⁷ 2000	CCT	N = 94: 49 fluoride-releasing modules (782 teeth) and 45 nonfluoride-releasing modules (740 teeth). Overall mean age, 16 y	Fluoride-releasing modules vs nonfluoride-releasing modules	No	Both
Borsos, ¹⁸ 2012	CCT	N = 30: 15 palatal implant (PI) and 15 transpalatal arch (TPA). Overall mean age, 14.22 ± 1.37 y	PI vs TPA	Yes	Young
Cattaneo, ¹⁹ 2011	RCT	N = 41: 20 active ligation In-Ovation R and 21 passive ligation Damon 3 MX	In-Ovation R (active) vs Damon 3 MX (passive) self-ligation	No	Both
DiBiase, ²⁰ 2011	RCT	N = 48: 27 Damon 3 and 21 Synthesis. Overall mean age, 16.2 y; sex, 32 M, 30 F initially	Damon 3 self-ligation vs Synthesis conventional ligation	Yes	Both
Fleming, ²¹ 2010	RCT	N = 54: 28 SmartClip self-ligation and 26 Victory conventional ligation. Mean overall age, 15.81 ± 2.58 y; sex, 18 M, 36 F	SmartClip self-ligation vs Victory conventional ligation	Yes	Both
Germec, ²² 2008	RCT	N = 26: 13 extraction and 13 nonextraction	Extraction vs air rotor stripping	Yes	Both
Genatschke, ²³ 2001	RCT (feasibly study)	N = 33: 18 chlorhexidine varnish (CHX) and 15 placebo varnish. Median overall age, 15 y; range, 11-18 y	CHX varnish vs placebo varnish group	Unclear	Both
Jiang, ²⁴ 2013	RCT	N = 95: 48 acidulated phosphate fluoride (APF) and 47 placebo	1.23% APF vs placebo	Unclear	Young
Johansson, ²⁵ 2012	RCT	N = 90: 44 Time 2 self ligation (SL) and 46 Gemini conventional edgewise (CE). Overall age range, 11.7-18.2 y	Time2 SL vs Gemini CE	No	Both
Jung, ²⁶ 2013	CCT	N = 66: 34 orthodontic mini-implant (OMI) with intreproximal stripping (IPS) and 32 second premolar extraction. Overall age range, 17-44 y	OMI + IPR vs extraction	Yes	Adults
Liu, ²⁷ 2009	RCT	N = 34: 17 mini-implant and 17 TPA. Sex, 6 M, 28 F	Mini-implant vs TPA	Yes	Both
Ma, ²⁸ 2008	RCT	N = 30: 15 mini-implant and 15 headgear (HG). Overall age range, 18-22 y; sex, 16 M, 14 F	Mini-implant vs HG	Yes	Adults
Magnius, ²⁹ 2014	RCT split mouth	N = 46 (836 teeth): 416 teeth pumice and 416 teeth prophylaxis paste. Overall mean age, 14.1 ± 1.4 y; sex, 17 M, 29 F	Oil-free pumice vs prophylaxis paste	Yes	Young
Manning, ³⁰ 2006	RCT	N = 34: 17 (299 bonds) SEP and 17 (298 bonds) Transbond conventional adhesive	SEP vs conventional adhesive (Transbond)	Yes	Young
Miller, ³¹ 1996	RCT	N = 17: 9 GIC and 8 composite bracket adhesive	GIC vs resin adhesive	Unclear	Young
Millett, ³² 1999	CCT split mouth	N = 40 (240 brackets): 120 brackets GIC and 120 resin. Overall mean age, 13.4 ± 2 y; sex, 17 M, 23 F	GIC vs resin adhesive	Unclear	Young
Millett, ³³ 2000	CCT split mouth	N = 45 (426 brackets): 213 compomer and 213 resin adhesive. Overall median age, 14.4 y, range, 13.7-15.5 y; sex, 13 M, 32 F	Compomer vs resin adhesive	No	Young
Norevall, ³⁴ 1996	RCT split mouth	N = 60: 30 machine cut grooves bracket base and 30 mesh foil bracket base; 492 teeth Aquacem (GIC) and 493 Unite (resin). Overall mean age, 13.56 ± 1.57 y; sex, 21 M, 39 F	GIC vs acrylic resin	Yes	Young
Polat, ³⁵ 2008	RCT	N = 20: 10 In-Ovation SL and 10 conventional preadusted edgewise (CPAE)	SL vs CPAE	No	Young
Reukers, ³⁶ 1998	RCT	N = 61: 32 fully programmed appliance (FPA) and 29 partly programmed appliance (PPA). Overall mean age, 12.4 ± 1.2 y	FPA SWA (0.022-in slot) vs PPA (0.018-in slot) conventional edgewise	Yes	Young

Table. Continued

Study	Design	Participants	Intervention/comparison	Extraction (yes/no)	Adults/young people (<18 y)
Sandler, ³⁷ 2008	RCT	N = 51: 26 palatal implant (PI) and 25 headgear (HG). Overall mean age, 15.2 y; range, 12-39 y; sex, 13 M, 38 F	PI vs HG	Yes	Young
Sandler, ³⁸ 2014	RCT	N = 71 0.22 TADs, 26 Nance, and 23 HG. Overall mean age, 14.22 ± 1.46 y	TADs vs Nance palatal arch vs HG	Yes	Young
Van der Veen, ³⁹ 2010	RCT split mouth	N = 28: 14 buccal appliances maxilla with lingual mandible and 14 lingual appliances maxilla with buccal appliances mandible. Overall mean age, 15.3 ± 1.2 y	Buccal vs lingual appliances	Unclear	Both
Xu, ⁴⁰ 2010	RCT	N = 63: 32 en-masse retraction and 31 2-step retraction. Sex, 24 M, 39 F	En-masse retraction vs 2-step retraction	Unclear	Young

SEP, Self-etching primer; M, male; F, female; SWA, straightwire appliance; TADs, temporary anchorage devices.

Study	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Al Maaitah 2013	+	?	+	?	?	+	+
Cattaneo 2011	+	?	?	+	+	+	+
DiBiase 2011	+	?	+	?	+	+	+
Fleming 2010	+	+	+	?	+	+	+
Germec 2008	-	-	?	?	+	+	+
Jenatschke 2001	?	?	?	?	+	+	+
Jiang 2013	+	+	+	+	+	+	+
Johansson 2012	+	?	+	+	+	+	+
Liu 2009	+	?	+	?	?	+	+
Ma 2008	+	?	+	?	?	?	+
Magnus 2014	+	?	?	+	?	+	+
Manning 2006	+	?	+	?	+	+	+
Miller 1996	?	?	+	?	+	+	+
Norevall 1996	?	?	?	?	?	+	?
Polat 2008	?	?	+	?	?	+	+
Reukers 1998	+	+	+	?	+	+	+
Sandler 2008	+	+	+	?	+	+	+
Sandler 2014	+	+	+	?	+	+	+
Van der Veen 2010	+	?	+	?	+	+	+
Xu 2010	+	?	+	?	+	+	+

Fig 2. Risk of bias for each RCT (n = 20). Low risk of bias (green); unclear risk of bias (yellow); high risk of bias (red).

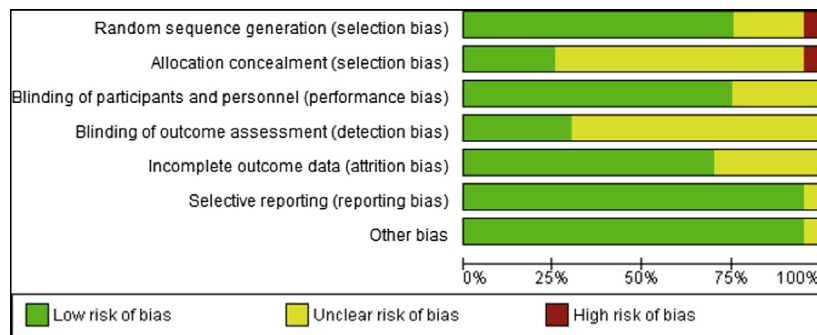


Fig 3. Overall risk of bias score for the specific domains.

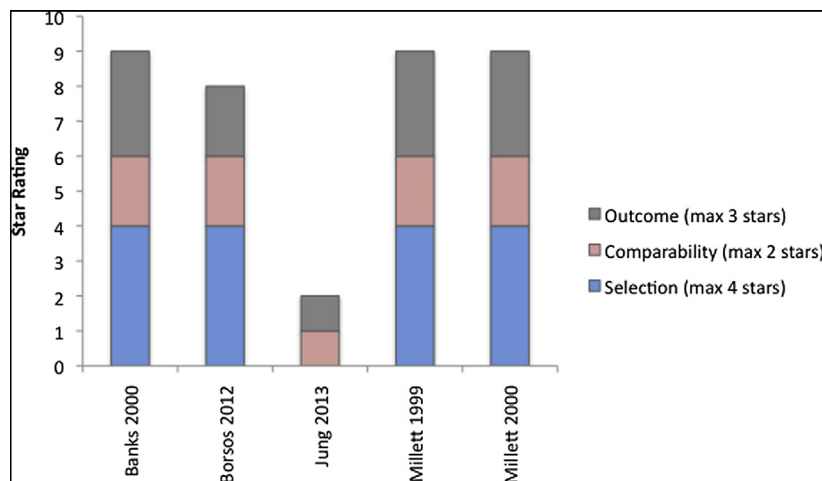


Fig 4. Newcastle-Ottawa scores for included nonrandomized studies (n = 5).

for review. After a detailed assessment, which included contacting the relevant authors for further clarification of data relating to treatment duration, 114 studies were excluded (Appendix), and 25 remained (Fig 1; Table¹⁶⁻⁴⁰). Twenty studies were RCTs, and 5 were controlled clinical trials (CCTs). All included studies were carried out in a university or hospital setting. Among the primary studies, other primary outcomes of interest other than estimates of overall treatment duration, included bracket failure rates, prevalence of decalcification, and occlusal outcomes.

The generation of a random number sequence was considered adequate in 15 trials, with only 1 study considered at high risk of bias (Figs 2 and 3). Five studies were judged to have adequate allocation concealment, with allocation concealment not clearly reported in most studies. Blinding of the clinicians and patients to the intervention was not possible in many studies because of the nature of the research. Blinding of outcome assessors was possible; however, this was

clearly undertaken in only 6 studies and was unclear in the remaining 14 RCTs. Overall, most of the included RCTs were deemed to be at low or unclear risk of bias. With regard to the CCTs, 4 studies were judged to be of good quality using the Newcastle-Ottawa scale (8-9 stars). One CCT was deemed to be of low quality (Fig 4).

The mean treatment duration derived from the 22 included studies involving 1089 participants was 19.9 months (95% confidence interval [CI], 19.58, 20.22 months) (Fig 5). Sensitivity analyses were carried out, including 3 additional studies; 1 study reported the duration of treatment with medians and ranges, and 2 studies were deemed to be of low quality overall. The resulting average duration of treatment based on the data from 1211 participants was 20.02 months (95% CI, 19.71, 20.3 months; Fig 6), indicating a similar result. In terms of visits required, this was reported in only 5 RCTs. The mean number of required visits was 17.81 (95% CI, 15.47, 20.15 visits; Appendix).

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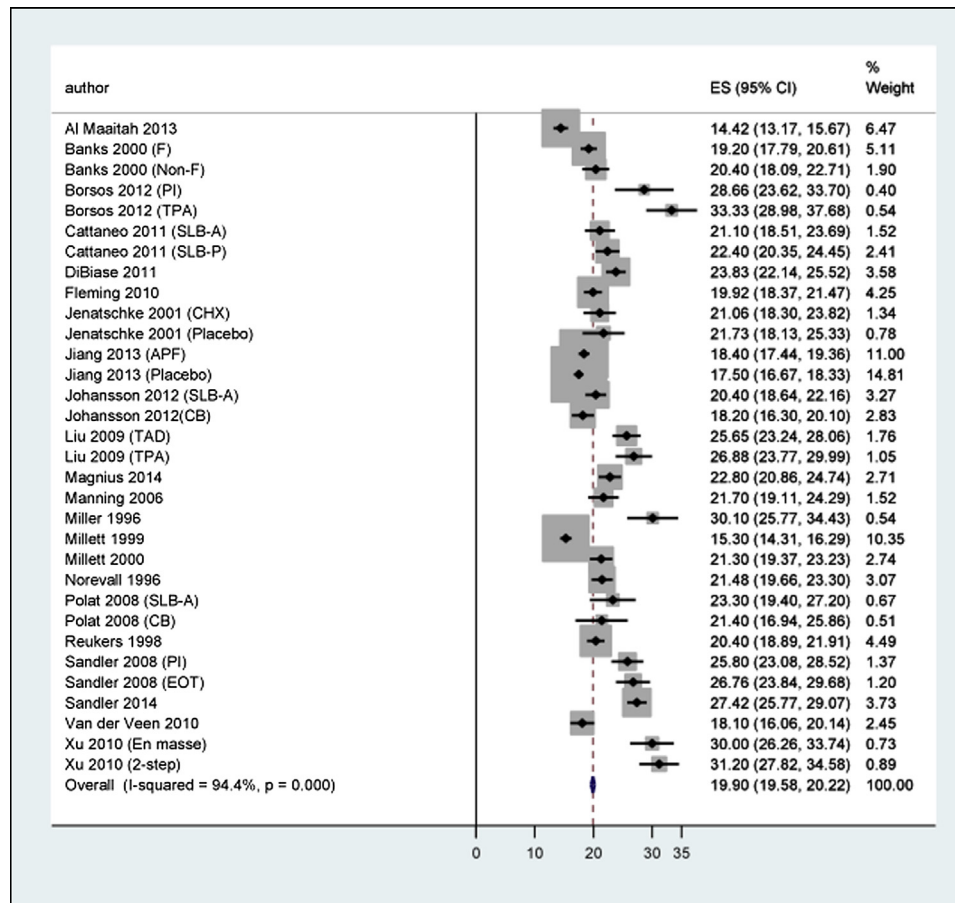


Fig 5. Forest plot for treatment duration excluding studies with low quality. *ES*, Effect size (mean difference).

DISCUSSION

On the basis of this systematic review, it appears that an average course of comprehensive orthodontic treatment with fixed appliances requires considerably less than 2 years (19.9 months). However, a wide range of treatment durations (14–33 months) were reported in the studies. This variation may relate to baseline and treatment-related differences among the studies, although important potential confounders were minimized by omitting studies involving adjunctive appliances, additional treatment phases, and combined orthodontic–surgical treatment. Clearly, the most significant arbiter of treatment duration appears to be the treating clinician, particularly his or her treatment planning decisions, standards, and finishing practices. This finding has previously been highlighted in retrospective studies investigating the potential impact of self-ligating brackets, which reported marked differences in treatment duration, ranging from 15.8 to 31 months with conventional brackets.^{41,42}

It is traditionally accepted that treatment with preadjusted edgewise appliances involves multiple phases, comprising initial alignment and leveling, overbite reduction, overjet reduction, space closure, and finishing and detailing of the occlusion. Therefore, average treatment durations of about 2 years appear reasonable. However, although these treatment phases may be considered as distinct entities, there is often considerable overlap between them, and mechanics including the use of fixed Class II correctors and fixed anterior biteplanes are becoming more accepted mechanisms of streamlining treatment without resorting to compromised objectives.^{43,44} Nevertheless, prospective research on the implications of the latter approaches in terms of overall treatment duration is lacking.

The present drive toward reducing orthodontic treatment duration may reflect an increasing awareness of cosmetic dental procedures and a growing uptake of orthodontic treatment by adults.⁴⁵ Although social judgments may be less influential for children receiving

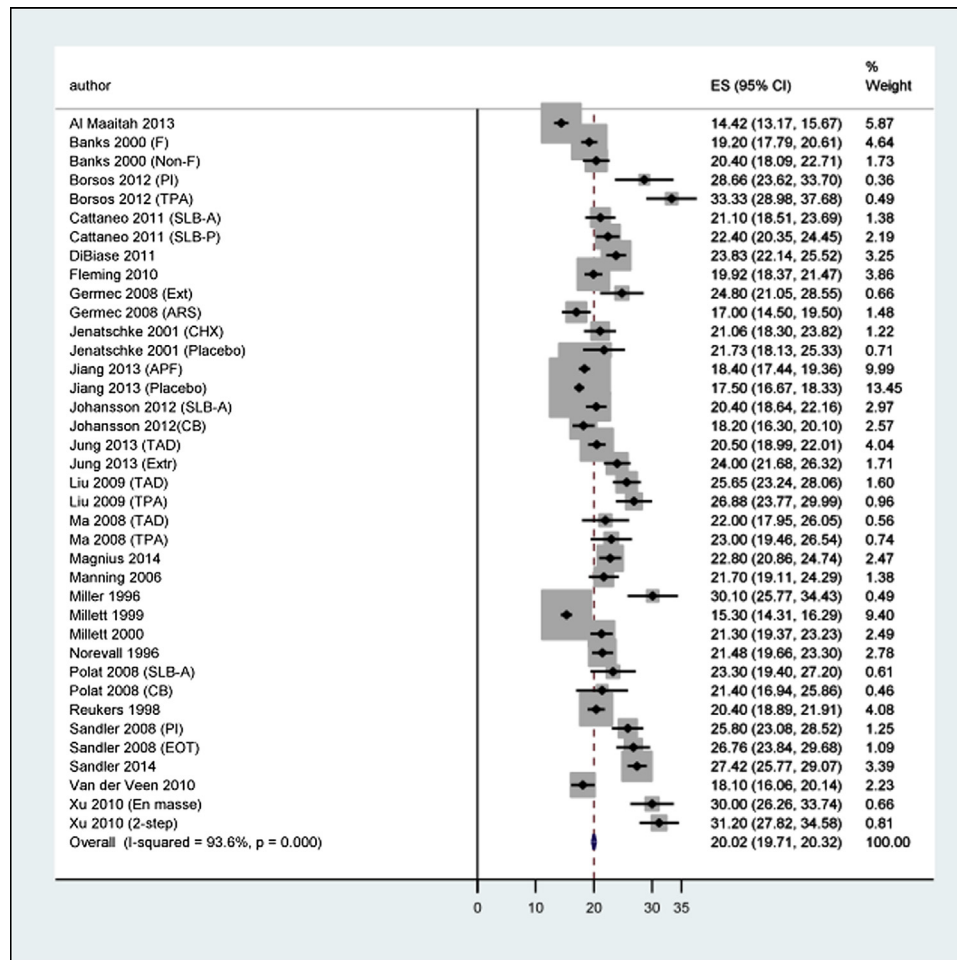


Fig 6. Forest plot for treatment duration including high- and low-quality studies. *ES*, Effect size (mean difference).

treatment, their impact on adults is more significant.⁴⁶ This issue is compounded by an acceptance that biologic processes underpinning tooth movement are innately slower in adults. This set of circumstances has spawned the concept of short-term orthodontics, an approach that is undertaken either as a stand-alone procedure or to facilitate further minimally invasive cosmetic dentistry. Commonly, short-term orthodontics involves a truncated orthodontic treatment focusing on alignment of the anterior teeth, with a trade-off between shorter treatment and less complete occlusal correction.⁵ On the contrary, traditional orthodontic approaches seek to obtain ideal esthetic and functional results and maximize long-term stability. While a perfect occlusal outcome is often elusive in orthodontics,⁴⁷ its achievement is contingent on adequate expression of tip and torque, combined with careful treatment planning and mechanics.⁴⁸ Realizing these objectives is necessarily slow, with complete torque expression particularly

time-consuming. Conversely, with short-term orthodontic treatment, a compromised result is often premeditated. Therefore, patients must be aware of the objectives and limitations of each option before embarking on treatment.^{8,49} If the expected treatment duration is a barrier to undertaking comprehensive treatment, on the basis of this review, it appears reasonable to suggest that comprehensive correction should not normally take much longer than 20 months.

Treatment duration can be influenced by a variety of factors. In particular, the severity of the malocclusion, extraction-based treatment, multidisciplinary treatment involving hypodontia or orthognathic surgery, and alignment of impacted teeth allied to operator experience and patient compliance may all be influential.^{3,50} We had hoped to consider the effects of extractions and age in this review, but because we included studies largely involving both a combination of extraction and nonextraction patients with broad age

ranges, and because individual patient data were not available, this was not possible. It does, however, seem reasonable to assume that these variable would have some effect and for patients to be advised accordingly.

While the pooled estimate of treatment duration is most likely representative, it remains unclear as to what an acceptable threshold for treatment duration may be for either children or adults. It is likely that this figure fluctuates among patients. However, assuming that most adolescent patients are willing to undergo treatment for the average expected period of 20 months, it certainly appears that undertaking either compromised treatment or a blanket prescription of as yet unproven adjunctive nonsurgical or surgical procedures cannot at this stage be advocated.⁴ There may, however, be specific indications for these approaches and greater potential applications among adult patients, although it would appear important that patients should be apprised of the relative indications for adjunctive procedures and the limited evidence to underpin them.^{10,11}

All included studies were undertaken in either a hospital or a university setting. Many of these patients may have been treated by trainees under supervision and had more complex malocclusions.⁵¹ It is therefore possible that the mean values obtained may constitute a slight overestimate of the overall duration of comprehensive orthodontic treatment. We had initially planned to assess the potential impact of treatment setting on the duration of treatment; however, because practice settings were not represented, this proved to be impossible.

As this review was carried out to gather epidemiologic data, rather than to undertake a comparative effectiveness review, a decision was made to include prospective studies in isolation. Consequently, potentially biased data from retrospective studies, whereby patients might have been selected on the basis of achieving a better, more efficient outcome, were omitted.⁵² A further methodologic complication was related to the fact that treatment duration was derived from some clinical trials in which the primary outcome was unrelated, with, for example, bracket failure or development of demineralization being common main outcomes. Consequently, bias inherent in these primary studies may not necessarily have directly affected estimates of treatment duration. The Cochrane risk of bias tool, however, was used to gauge bias associated with these studies to estimate inherent bias and study quality. Moreover, the Newcastle–Ottawa scale was used in the nonrandomized studies; a lack of uniformity in terms of the selection of quality assessment tools in systematic reviews is widely acknowledged.⁵³

Overall, this meta-analysis involved many primary studies compared with similar reviews, with a median

of 4 studies per meta-analysis recently shown in orthodontics.⁵⁴ This may be because treatment duration seems to be commonly used as an important outcome measure in orthodontic trials. There is little consensus regarding the most influential orthodontic outcomes with an undue emphasis on clinician-centered and cephalometric outcomes.⁵⁵ Clearly, however, treatment time does appear to be a key consideration for orthodontists and patients, particularly adults.

CONCLUSIONS

On the basis of this review, it is reasonable to assume that the average duration of comprehensive orthodontic treatment is less than 2 years. If alternative approaches to reduce the treatment time are undertaken, it would be sensible that these interventions or alternatives are chosen with an awareness of this yardstick.

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.ajodo.2015.09.020>.

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