Systematic Review Article

Predictive factors of sagittal stability after treatment of Class II malocclusions

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ABSTRACT

Objective: To determine the existence of factors permitting the prediction of sagittal stability after orthodontic treatment in patients with Angle Class II malocclusion.

Materials and Methods: PubMed, EMBASE, and the Cochrane Library were searched up to March 2015. Inclusion criteria were longitudinal studies with at least 10 subjects investigating associations between at least one factor and stability, with an average minimum follow-up period of 2 years; stability measured using posttreatment sagittal dental changes; and orthodontic treatment including removable and/or fixed appliances with or without extractions. Two reviewers independently selected and assessed the quality of the articles.

Results: The search strategy resulted in 1372 articles, of which 17 met the inclusion criteria. Large changes during treatment in molar and canine relationships were the only two factors found to be positively associated with relapse, but with limited evidence. Fourteen factors were found not to be predictive of relapse, also with limited evidence. These factors included treatment characteristics, patient pretreatment characteristics, and final posttreatment characteristics.

Conclusions: There is currently limited evidence to support the influence of factors predictive of sagittal stability following Class II malocclusion treatment. More high-quality prospective studies are needed, and functional factors possibly affecting relapse also need to be further assessed. (*Angle Orthod.* 2016;86:1033–1041.)

KEY WORDS: Angle Class II malocclusion; Stability; Relapse

INTRODUCTION

Despite the correction of a Class II malocclusion, a proportion of treated patients will end up showing signs of relapse in the years following orthodontic treatment. Uhde[1] found that changes in molar relationships following Class II treatment are always toward a Class II. Reported relapse rates following these treatments range from 20% to 52%.[2–6] Relapse, however, cannot be predicted at the individual level.[7] Moreover, relapse tendencies vary in extent and clinical significance.[8,9]

To date, investigators have studied several factors that might influence relapse. These include patient characteristics such as initial occlusal conditions, unfavorable continuing growth patterns, sex, muscular functions and habits, as well as treatment modality, changes in arch form, and posttreatment occlusion.[10–12] However, there is no consensus in the literature with regard to what factors might influence relapse, with many studies obtaining insignificant results and various reviews reaching contradictory conclusions.[7]

Therefore, the aim of this study was to investigate, using systematic review methodology, the possible factors influencing the sagittal stability of treated patients with initial Angle Class II malocclusion.

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Table 1. Eligibility Criteria, Search Terms, and Search Strategy, Modified From Srinivasan et al.[14]

Focus question	What factors are predictive of relapse in patients having undergone orthodontic treatment for Class II malocclusion?
Inclusion criteria	
	• Longitudinal studies (randomized clinical trials, prospective or retrospective studies) • Investigation of associations between at least one factor and stability • Average minimum follow-up period of 2 years • Stability measured using posttreatment sagittal dental changes, namely, changes in overjet or molar/dental relationships • Orthodontic treatment including removable appliances, fixed appliances with or without extractions
Exclusion criteria	
	• Case reports and case series (sample size, <10) • Review articles, editorials, letters, commentaries, and author replies • Studies including cleft palate; syndromic and hypodontia patients • Studies including surgical orthognathic treatment • Studies looking at stability following Class II malocclusion treatment but not using sagittal measurements
Search terms	#1((malocclusion, Angle Class II [MeSH]) OR (Angle Class II [All Fields]) OR (malocclusion [All Fields])) #2((orthodontic treatment [All Fields]) OR (orthodontic appliance [All Fields])) #3((recurrence [MeSH]) OR (relapse [All Fields]) OR (stability [All Fields]) OR (occlusal stability [All Fields]) OR (occlusal changes [All Fields]))
Search builder	#1 AND #2 AND #3

MATERIALS AND METHODS

Protocol and Registration

When planning and carrying out the present systematic review, we adhered as closely as possible to the preferred reporting items for systematic reviews and meta-analyses guidelines.[13] Methods of analysis, inclusion and exclusion criteria, and the main outcome measure were defined in advance of the study. A review protocol was not published nor was the study registered.

Eligibility Criteria

Studies evaluating stability following Class II malocclusion treatment were investigated. Studies were retrieved with no restrictions based on language, publication date, or publication status. The method under evaluation was the assessment of possible factors associated with stability.

Inclusion criteria were longitudinal studies (randomized clinical trials [RCTs], prospective or retrospective studies) investigating associations between at least one factor and stability, with an average minimum follow-up period of 2 years; stability measured using posttreatment sagittal dental changes, namely changes in overjet or molar/dental relationships; and orthodontic treatment including removable or fixed appliances, with or without extractions.

Exclusion criteria were case reports or case series (sample size, <10), review articles, editorials, letters, commentaries, and author replies; studies including cleft palate, syndromic or hypodontia patients; studies including surgical orthognathic treatment; and studies looking at stability following Class II malocclusion treatment but not using sagittal measurements. As association studies do not require the use of a control group, the lack of a control group in the articles was not considered a relevant exclusion criterion.

The main outcome was the association between a defined factor and sagittal stability assessed by measuring posttreatment changes in overjet and sagittal dental relationships.

Table 2. Criteria for Grading Assessed Studies, Modified From Bondemark et al.[7]

Grade A—High Value of Evidence	Grade B—Moderate Value of Evidence	Grade C—Low Value of Evidence
All criteria should be met:	All criteria should be met:	One or more of the conditions below:
Randomized clinical study or a prospective study	Cohort study or retrospective case series with defined control or reference group	High rate of attrition (1/3 or more of subjects lost during study)
Defined diagnosis and endpoints	Defined diagnosis and endpoints	Unclear diagnosis and endpoints
Diagnostic reliability tests and reproducibility tests described	Diagnostic reliability tests and reproducibility tests described	Poorly defined patient material
Blinded outcome assessment		

Table 3. Definitions of Evidence Level

Level	Evidence	Definition
1	Strong	At least two studies assessed with level A
2	Moderate	One study with level A and at least two studies with level B
3	Limited	At least two studies with level B
4	Inconclusive	Fewer than two studies with level B

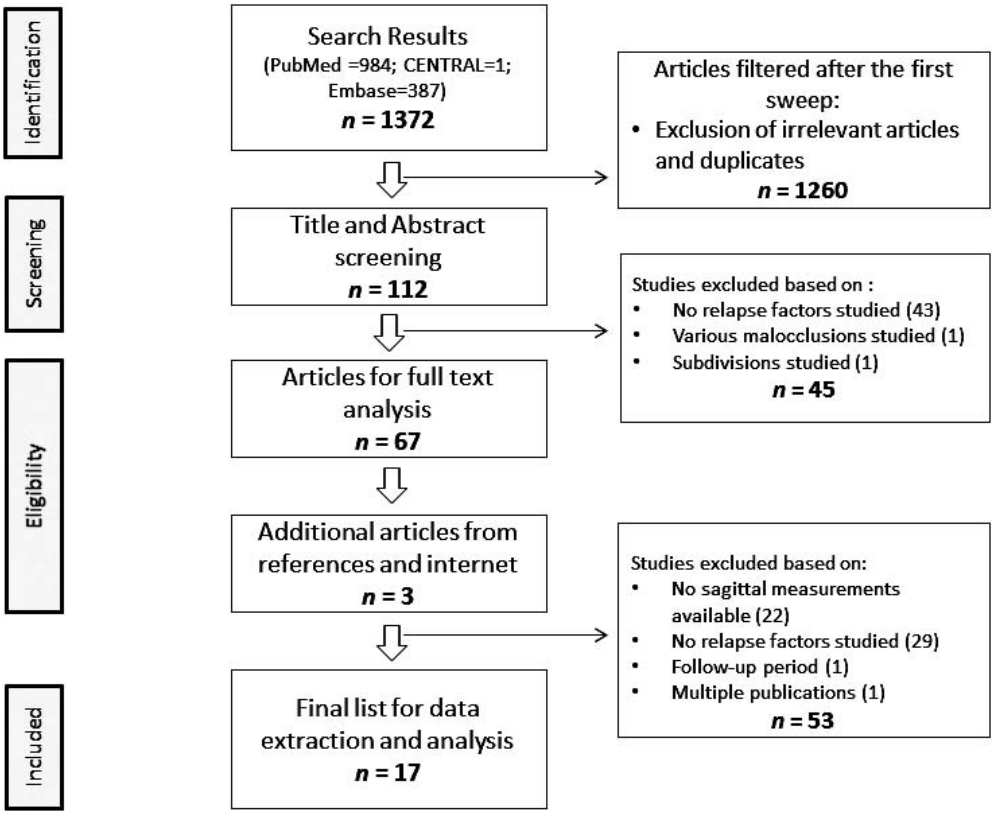

Figure 1. Flow diagram of study selection.

Information Sources and Search

Relevant studies were located by searching the following databases: PubMed, EMBASE, and the Cochrane Library. The Related Citations function in PubMed was used to retrieve further articles, as was citation tracking. The reference lists of the retrieved articles were hand searched to identify studies that might not have been included. The last search was conducted in March 2015.

The search-and-study selection was carried out independently by two reviewers. The search strategy is presented in Table 1.[14]

Study Selection

The first to be evaluated were article titles and abstracts. If eligibility could not be determined or an article was considered potentially eligible, full-text articles were retrieved. These were assessed for eligibility by applying the inclusion and exclusion criteria. Finally, eligible studies were collected for data extraction. If the two reviewers could not agree on the eligibility of a certain study, the disagreement was resolved by discussion.

Data Collection Process and Data Items

From each included study, the following information was extracted: publication data (journal, title, authors, publication date), study design, sample characteristics (sample size, age at start of treatment), details of treatment carried out, length of posttreatment follow-up, outcome used to measure stability (overjet, molar/dental relationships), and stability factors.

A quality assessment of the included studies was carried out according to the method described by Bondemark et al.[7] Using this method, studies were allocated a grading of A (high quality of evidence), B (moderate value of evidence), or C (low value of evidence) based on predetermined criteria (Table 2). In case of insufficiently precise criteria or disagreement between the two reviewers, the study was discussed until a consensus was reached.

Summary Measures and Synthesis of Results

Associations between each factor and stability were the intended main summary measure. The final level of evidence for each factor studied was determined based on the protocol proposed by Bondemark et al.[7] (Table 3), which is based on the criteria for assessing study quality from the Centre for Reviews and Disseminations in York, UK.[15]

RESULTS

Study Selection

The initial literature search resulted in a total of 1372 articles. Of these, 1260 were eliminated in an initial

Table 4. Summary of Included Studies, in Alphabetical Order

Source	Main Inclusion Criteria		No. of Patients	Average Age at Start of Treatment (Or Range)	Average Follow-up Period	Type of Treatment	Stability Determination	Quality Assessment
Antonarakis et al. 2013[5]	Class II, 1	28	A: stable (n = 15) B: unstable (n = 13)	10.5 y ± 0.8, 10.5 ± 1.4	2.2 ± 0.9 y	Schwarz activator	M Class (↑ 25% toward II) OJ[a] ↑; 0.5 mm	B
Bock and Ruf 2013[18]	Class II, 2	37	A: early adolescent (n = 9) B: late adolescent (n = 14) C: adult (n = 14)	A: 10.6–13.4 y B: 12.9–17.9 y C: 16.1–39.9 y	2.8 y	Herbst + FA[b], Non ex	OJ or M Class	B
De Lima et al. 2013[20]	Class II	39		12.9 ± 1.2 y	6.3 ± 2.6 y	FA ± HG ± Cl II elastics, Non ex	M Class, PM1 Class, PM2 Class, C Class	B
Faltin et al. 2003[17]	Class II	23	A: early treatment (n = 13) B: late treatment (n = 10)	A: 9.6 ± 1.3 y B: 10.7 ± 1.6 y	A: 5.8 ± 2.2 y B: 6 ± 0.8 y	Bionator + FA	OJ, M Class	B
Fidler et al. 1995[9]	Class II, 1	78		11.2 ± 2.4 y	14 ± 4.6 y	LPHG + FA ± Ex 4 PM1	OJ, M Class, PM1 Class, PM2 Class, C Class	B
Hansen et al. 1991[21]	Class II, 1	40	A: pregrowth peak (n = 19) B: growth peak (n = 15) C: postgrowth peak (n = 6)	A: 12.2 ± 0.7 y B: 12.9 ± 0.6 y C: 14.2 ± 1.1 y	6.5 ± 0.6 y 5.7 ± 1.1 y 5.5 ± 1.7 y	Herbst	OJ, M Class	B
Harris et al. 1994[22]	Class II, 1	45	A: early treatment (n = 22) B: late treatment (n = 23)	A: 12 y B: 28 y	A: 5.1 ± 2.9 y B: 5 ± 1.5 y	FA + HPHG + Cl II elastics + Ex 4 PM	M correction	B
Janson et al. 2004[23]	Class II, 1	23		11.2 ± 1.5 y	5.8 ± 1.7 y	HG + activator + FA	OJ, M Class	B
Janson et al. 2009[24]	Class II	57	A: 2 PM extractions (n = 30) B: 4 PM extractions (n = 27)	A: 12.9 ± 1.5 y B: 13.7 ± 2.3 y	A: 9.3 ± 3.5 y B: 9.5 ± 4.3 y	HG + edgewise FA + Ex	OJ, M Class	B
Janson et al. 2010[25]	Class II	59	A: Non ex (n = 29) B: Ex (n = 30)	A: 12.7 ± 1.4 y B: 13.3 ± 1.5 y	A: 7.3 ± 1.6 y B: 9.6 ± 3.6 y	HG + edgewise FA ± Ex	OJ, PM, and M Class	B
Janson et al. 2012[26]	Class II, 1	60	A: Non ex (n = 30) B: Ex (n = 30)	A: 12.14 y B: 12.87 y	A: 7.15 y B: 9.25 y	HG + edgewise FA ± Ex	OJ, M Class, C Class	B
Luppanapornlarp and Johnston Jr 1993[19]	Class II	62	A: Ex (n = 33) B: Non ex (n = 29)	A: 12.9 y B: 13.1 y	A: 15.4 y B: 15.3 y	Edgewise FA ± Ex	OJ, M Correction	C
Pancherz and Anehus-Pancherz 1993[3]	Class II	45	A: stable (n = 36) B: unstable (n = 9)	12.4 ± 1.1 y	5.9 ± 1.2 y	Herbst + FA ± Ex	½ M cusp toward Cl II	C
Pancherz and Anehus-Pancherz 1994[4]	Class II, 1	69	A: stable (n = 49) B: unstable (n = 20)	A: 12.7 ± 1.2 y B: 12.2 ± 1.1 y	5–10 y	Herbst	OJ ↑ > 1 mm ½ M cusp toward Cl II	B
Pancherz 1991[2]	Class II	29	A: stable (n = 14) B: unstable (n = 15)	A: 12.2 ± 0.7 y B: 12.3 ± 1.3 y	5–10 y	Herbst + FA ± Ex	OJ ↑ > 1 mm ½ M cusp toward Cl II	B

Table 4. Continued

Source	Main Inclusion Criteria		No. of Patients	Average Age at Start of Treatment (Or Range)	Average Follow-up Period	Type of Treatment	Stability Determination	Quality Assessment
Paquette et al. 1992[27]	Class II, 1	63	A: Ex (n = 33) B: Non ex (n = 30)	A: 12.5 y B: 12.6 y	14.5 y	Edgewise FA ± Ex	OJ, M Correction	C
Wood 1983[28]	Class II, 1	60	A: retention (n = 30) B: no retention (n = 30)	A: 11.9 y B: 11.8 y	A: 3.1 y B: 2.9 y	Any Class II, 1 treatment	OJ	B

[a] OJ indicates overjet; M, molar; PM1, first premolar; PM2, second premolar; C, canine.
[b] FA indicates fixed appliance; Ex, extraction; Non ex, non extraction; HG, head gear; LPHG, low-pull head gear; HPHG, high-pull head gear.

sweep for irrelevance and duplicates. A further 45 articles were excluded after evaluating titles and abstracts; 67 were thus selected for full text examination. Three additional studies were identified by searching the reference lists of relevant articles. Fifty-two studies did not meet the predefined eligibility criteria. One further study was excluded[16] due to multiple publications by the same team based on an identical data sample in a parallel publication.[9] Only the study investigating the most relapse factors was included. A final total of 17 studies were thus included in the present systematic review. The systematic study selection is presented in the form of a flow diagram (Figure 1).

Study Characteristics (Table 4)

Methods. All 17 studies finally selected were retrospective and published in English. The age at the start of orthodontic treatment ranged from 8.3[17] to 39.9 years.[18] The average length of posttreatment follow-up varied between 2.2[5] and 15.4 years.[19]

Subjects. The included studies involved a total of 817 subjects. The main inclusion criteria varied between studies. Nine studies included only Angle Class II division 1 patients, one study included only Angle Class II division 2 patients, while the remaining seven studies included Angle Class II patients regardless of overjet.

Intervention. The included studies had varying types of intervention, including a range of dentofacial orthopedic appliances (ie, activators, Herbst, headgear) and fixed appliances. Only 2 of the 17 studies did not include using orthopedic appliances, the treatment consisting only of fixed appliances with or without extractions.

Quality Assessment

Of the 17 included studies, none was graded as providing high value of evidence (grade A), 14 were graded as having moderate value of evidence (grade B), and three were graded as having a low value of evidence (grade C). The reason for assigning grade C in most of these studies was the high rate of (participant) attrition.

Results of Individual Studies (Table 5)

Outcomes: (1). The primary outcomes assessed varied for the 17 studies. Twelve studies primarily assessed the influence of different types of orthodontic treatment on stability (functional or fixed appliances with or without extractions), while five of the studies primarily assessed the influence of patient characteristics on stability (skeletal maturity or age at the beginning of treatment; bite force). (2) The secondary outcomes assessed also varied for the different studies. These included initial or final dental or cephalometric measures, as well as changes in these measures during treatment.

Synthesis of Results (Table 6)

Because of the heterogeneity in interventions and reported outcomes within the included studies, a meta-analysis could not be performed. A qualitative evaluation and data synthesis were thus carried out in lieu of statistical methods of combining the evidence.

The level of evidence for each factor studied was determined based on the protocol proposed by Bondemark et al.,[7] described previously (Table 3). The evidence level protocol was not applied to factors assessed in only one of the studies, as their evidence level was logically inconclusive. For factors having both evidence for and against their effect, same-level studies canceled each other out. Using this protocol, we obtained the results presented in Table 6.

Due to the lack of high quality evidence studies included, the factors studied either had only a limited level of evidence or the studies were inconclusive as to their effect on relapse. The only two factors found to be predictive of relapse, with limited evidence, were large changes in molar and canine relationships during

Table 5. Summary of Results for the Included Studies, in Alphabetical Order

Source	Factors Predictive of Relapse	Factors Not Predictive of Relapse
Antonarakis et al. 2013[5]	Lower bite force Larger gonial angle	Initial or final M relationships Initial or final OJ Initial OB, SNA[a], SNB, ANB, maxillary plane, mandibular plane, intermaxillary plane, maxillary incisor inclination, mandibular incisor inclination Pre-ttt [b] or post-ttt chronological age Length of ttt Length of follow-up Pre-ttt or post-ttt height or change in height during ttt or post-ttt
Bock and Ruf 2013[18]		Skeletal maturity (pre-ttt hand-wrist radiograph)
De Lima et al. 2013[20]	Initial C relationships Postretention time	Initial M relationships Initial PM1 or PM2 relationships Length of ttt Retention time
Faltin et al. 2003[17]		Skeletal maturity (based on cervical vertebral maturation)
Fidler et al. 1995[9]	Change in M relationships during ttt Change in C relationships during ttt Change in PM relationships during ttt	Change in OJ during ttt Ex vs Non ex
Hansen et al. 1991[21]		Growth period (based on height changes)
Harris et al. 1994[22]		Pre-ttt chronological age
Janson et al. 2004[23]	Initial OJ Change in OJ during ttt Change in M relationships during ttt	Initial M relationships Initial ANB angle Initial Wits appraisal Length of follow-up
Janson et al. 2009[24]	Change in OJ during ttt Change in C relationships during ttt Change in M relationships during ttt 2 vs 4 PM Ex	
Janson et al. 2010[25]		Change in OJ during ttt 2 PM Ex vs Non ex
Janson et al. 2012[26]	Change in OJ during ttt Change in C relationships during ttt Change in M relationships during ttt 2 PM Ex vs Non ex	
Luppanapornlarp and Johnston Jr 1993[19]		Ex or Non ex (clear cut-cases)
Pancherz and Anehus-Pancherz 1993[3]		Growth period (based on height changes) Partial vs total anchorage of Herbst Retention presence 2nd or 3rd molars present
Pancherz and Anehus-Pancherz 1994[4]		Initial, final or changes during ttt of NAPog (soft tissues), N-Nasal Tip-Pog (soft tissues), Upper lip to E-line, Lower lip to E-line
Pancherz 1991[2]		Initial, final, or changes during ttt of OJ, M relationships, OB, SNA, SNB, ANB, maxillary plane, mandibular plane, intermaxillary plane, occlusal plane, maxillary incisor inclination, mandibular incisor inclination
Paquette et al. 1992[27]		Ex vs Non ex (borderline cases)
Wood 1983[28]	Retention presence Initial OJ Final OB Final interincisal angle	

[a] Cephalometric measurements: S, sella; N, nasion; A, subspinale; B, supramentale; Ar, articulare; Gn, gnathion; Pog, pogonion; E-line, nasal tip-chin (soft tissue).

[b] Ttt indicates treatment; Ex, extraction; Non ex, non extraction; C, canine; M, molar; OJ, overjet; OB, overbite; PM, premolar; PM1, first premolar; PM2, second premolar.

treatment. Fourteen factors were found to be not predictive of relapse, with, again, only limited evidence. These factors included treatment characteristics (treatment timing, length of treatment, retention time, and length of follow-up) as well as patient pretreatment characteristics (molar relationships, overbite; SNA, SNB, and ANB angles; maxillary, mandibular, and intermaxillary plane angles; incisor inclination), and final posttreatment characteristics (overjet, molar relationships).

Table 6. Evidence Level of Studied Factors

Factor Studied	Factor Predictive of Relapse	Not a Factor Predictive of Relapse	Final Level of Evidence
OJ[a]:			
A: initial OJ	A: 2 level B studies	A: 2 level B studies	A: 4 = inconclusive
B: change in OJ during ttt[b]	B: 3 level B studies	B: 3 level B studies	B: 4 = inconclusive
C: final OJ		C: 3 level B studies	C: 3 = limited
Molar class:			
A: initial M relationships		A: 4 level B studies	A: 3 = limited
B: change in M relationships during ttt	B: 4 level B studies	B: 1 level B study	B: 3 = limited
C: final M relationships		C: 2 level B studies	C: 3 = limited
Canine relationships:			
A: initial C relationships	A: 1 level B study		A: 4 = inconclusive
B: change in C relationships during ttt	B: 3 level B studies		B: 3 = limited
OB:			
A: initial OB		A: 3 level B studies	A: 3 = limited
B: change in OB during ttt		B: 1 level B studies	B: 4 = inconclusive
C: final OB	C: 1 level B study	C: 1 level B study	C: 4 = inconclusive
SNA[c] and SNB:			
A: initial SNA/SNB		A: 2 level B studies	A: 3 = limited
B: change in SNA/SNB during ttt		B: 1 level B study	B: 4 = inconclusive
C: final SNA/SNB		C: 1 level B study	C: 4 = inconclusive
ANB:			
A: large initial ANB		A: 3 level B studies	A: 3 = limited
B: change in ANB during ttt		B: 1 level B study	B: 4 = inconclusive
C: final ANB		C: 1 level B study	C: 4 = inconclusive
Mandibular plane:			
A: initial mandibular plane angle		A: 2 level B studies	A: 3 = limited
B: large changes in mandibular plane		B: 1 level B study	B: 4 = inconclusive
C: final mandibular plane		C: 1 level B study	C: 4 = inconclusive
Maxillary plane:			
A: initial maxillary plane angle		A: 2 level B studies	A: 3 = limited
B: change in maxillary plane during ttt		B: 1 level B study	B: 4 = inconclusive
C: final maxillary plane angle		C: 1 level B study	C: 4 = inconclusive
Intermaxillary plane:			
A: initial intermaxillary plane angle		A: 2 level B studies	A: 3 = limited
B: change in intermaxillary plane during ttt		B: 1 level B study	B: 4 = inconclusive
C: final intermaxillary plane angle		C: 1 level B study	C: 4 = inconclusive
Maxillary & mandibular incisor inclination:			
A: initial inclination		A: 2 level B studies	A: 3 = limited
B: change in inclination during ttt		B: 1 level B study	B: 4 = inconclusive
C: final inclination	C: 1 level B study	C: 1 level B study	C: 4 = inconclusive
Treatment timing: (age, height, skeletal maturity)		5 level B studies 1 level C study	3 = limited
Length of treatment		2 level B studies	3 = limited
Extraction vs nonextraction treatment	1 level B study	2 level B studies 2 level C studies	4 = inconclusive
Retention time		2 level B studies	3 = limited
Length of follow-up		2 level B studies	3 = limited

[a] OJ indicates overjet; OB, overbite; M, molar.
[b] Ttt indicates treatment.
[c] Cephalometric measurements: S indicates sella; N, nasion; A, subspinale; B, supramentale.

DISCUSSION

Summary of Evidence

To date, based on the currently available evidence, the implication of the studied factors is not strong enough to permit drawing convincing conclusions. The only factors that could be considered positive predictors of relapse following treatment for Class II malocclusion are large changes in molar and canine relationships during treatment, but only limited evidence supports these factors. Patient characteristics proposed to increase the risk of relapse are more severe pretreatment dental sagittal relationships (large overjet, canines and molars in a full-cusp Class II relationship) as well as large treatment changes. Either these factors were deemed inconclusive in the present

study or limited evidence pointed toward the lack of an effect on relapse, except for the changes in canine and molar relationships.

There is only limited evidence that the following factors had any effect on relapse. None was found to be a factor in predicting relapse. Treatment timing was found to have no relationship with relapse, implying that treatment carried out during the postpubertal period has the same chance of relapsing as treatment carried out before or after the pubertal growth spurt. Length of treatment was also found to have no association with relapse, thus both short and long treatments were prone to a similar extent of relapse. Pretreatment overbite showed no effect on relapse, with deepbite patients exhibiting the same relapse as patients with normal or diminished overbite. Similarly, pretreatment incisor inclination showed no effect on relapse, meaning that patients with proclined incisors were no more prone to relapse than were those having retroclined incisors. Pretreatment sagittal and vertical skeletal variables also demonstrated no effect on relapse. Other factors such as extraction evinced no conclusive evidence with regard to their effect on relapse.

Limitations

This systematic review enables us to obtain more evidence of the effect of each factor affecting relapse following Class II treatment than does any single study. However, as with many studies of this nature that deal with different studies and therefore different research methodologies, several limitations prevent the statistical pooling of data using meta-analysis.

A primary limitation to the current study derives from the quantity and quality of studies available. With objective eligibility criteria, less than 20% of the studies passing the preliminary screening could be included, therefore leaving many assessed factors aside. The present systematic review identified only a limited number of studies, with a maximum of six studies investigating any one particular factor influencing Class II treatment stability. Moreover, among the included studies, none was considered the highest level of evidence, implying a lack of good quality prospective trials. Furthermore, each of the individual studies included relatively small sample sizes with a high rate of attrition in several of the studies. This was taken into consideration when assessing the results.

Another limitation is the lack of control groups in the studies included. As mentioned before, the use of control groups is not strictly necessary when carrying out association studies and therefore not considered an exclusion criteria. The fact that some studies included both successful and unsuccessful treatments could also be considered a limitation, as this increases the heterogeneity of the results. This was not considered a necessary exclusion criterion, as the final overjet and dental relationships were factors evaluated in the studies. Another criterion is the 2-year minimum follow-up period, which can be seen as limited for a follow-up study. The choice of this minimum follow-up time was made to enable the inclusion of a larger number of articles. Moreover, the length of follow-up was included as one of the factors possibly affecting stability. The broad age range can also be considered, as it could reflect a heterogeneous collection of studies. Nevertheless, this is a necessary characteristic for studies assessing the effect of age on relapse. This was taken into account in the quality assessment of the studies, and therefore in our results.

A particular difficulty experienced during the gathering of results from the various articles was the heterogeneity in defining relapse and the ways of evaluating it. The results of the different studies are therefore sometimes difficult to compare objectively. Evaluating the quantity of relapse in the different studies was beyond the scope of this systematic review, as only the presence or absence of relapse was of interest in analyzing the influencing factors.

Excluded Factors Possibly Influencing Sagittal Stability

Other factors possibly affecting sagittal relapse after Class II treatment may not have been uncovered in the present systematic review. This is due mainly to two problems, the first being that studies assessing these factors may not have met eligibility criteria and the second being that sufficient studies assessing a given factor were unavailable. Factors that have been insufficiently studied and for which evidence cannot, to date, enable us to draw conclusions but could affect relapse, include skeletal characteristics such as the gonial angle[5]; soft tissue values such as lip position[4]; and functional factors such as bite force,[5] tongue thrust, and orbicularis oris, mentalis, and anterior suprahyoid muscle activity.[29,30]

To obtain better evidence of the effect of certain factors on relapse, more high-quality prospective studies are needed. RCTs with adequate sample sizes, homogenous patient samples, transparent definitions of relapse, and robust methodology need to be conducted to enable researchers to conduct meta-analyses and therefore produce objective, quantifiable results in the future.

CONCLUSIONS

- Large changes in canine and molar relationships during Class II malocclusion treatment were the only factors found to be predictably associated with relapse, but with limited evidence.
- There is limited evidence to confirm that treatment timing, length of treatment, retention time, length of follow-up, initial molar relationships and overbite, initial sagittal and vertical skeletal variables, incisor inclination, and posttreatment overjet and molar relationships are not factors that can predict sagittal stability following Class II malocclusion treatment.

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