Review Article

Skeletal and Dental Changes in Class II division 1 Malocclusions Treated with Splint-Type Herbst Appliances

A Systematic Review

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ABSTRACT

Objective: To evaluate skeletal and dental changes in growing individuals through lateral cephalograms obtained after the sole use of the splint-type Herbst appliances in Class II division 1 malocclusions.

Methods: Several electronic databases (Pubmed, Medline, Medline In-Process & Other Non-Indexed Citations, Cochrane Library Database, Embase, Web of Sciences, Scopus, and Lilacs) were searched with the help of a health sciences librarian. Abstracts that appeared to fulfill the initial selection criteria were selected by consensus. The original articles were then retrieved. Their references were also hand-searched for possible missing articles. Clinical trials that assessed, through lateral cephalograms, immediate skeletal and dental changes with the use of splint-type Herbst appliances without any concurrent orthodontic appliances, surgical intervention, or syndromic characteristics were considered. A comparable untreated Class II division 1 malocclusion control group was required to factor out normal growth changes.

Results: Three articles were finally selected and analyzed. An individual analysis of these articles was made and some methodological flaws were identified. The selected studies all showed statistically significant changes in the anteroposterior length of the mandible, vertical height of the ramus, lower facial height, mandibular incisor proclination, mesial movement of the lower molars, and distal movement of the upper molars. Posttreatment relapse in overjet and molar relationship was also observed.

Conclusions: Dental changes are as important as skeletal changes to attaining the final occlusal results. Long-term, prospective, double-blinded, randomized clinical trials are needed to support these conclusions.

KEY WORDS: Functional appliances; Herbst; Orthodontics; Systematic review; Dental changes; Skeletal changes

INTRODUCTION

Class II division 1 malocclusions with a mandible deficiency are prevalent in Eurocentric societies.[1] Facial esthetics play a major role in both the objective and the subjective perceptions of beauty. Therefore, improved esthetics, resulting in less convex and straighter profiles, is a treatment objective when managing such cases. The resultant amelioration in esthetics is considered a major reason why orthodontic treatment is sought in these cases.[2]

Of the multitude of functional appliances utilized to correct a Class II malocclusion, the Herbst appliance is one of the most commonly used. The Herbst appliance, because it is fixed compared to removable appliances, is particularly advantageous because patient compliance is not an issue. However, a disadvantage of the Herbst appliance is that it is prone to breakage.[3]

The original Herbst appliance consisted of banded teeth as anchorage,[4,5] but McNamara and Brudon[6] lat-

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Accepted: May 2006. Submitted: April 2006.

 DOI: 10.2319/040806-144

er proposed a splint-bonded version. The theoretical advantage of a splint version would be that the acrylic coverage would include several teeth, especially the lower incisors, potentially controlling the amount of proclination of the incisors during treatment. This has been reported as a disadvantage of the banded Herbst appliance.[7]

Few systematic reviews have been done in the field of orthodontics.[8] Even though some reviews[9,10] have analyzed the Herbst appliance's skeletal and dental effects, only one review[7] has analyzed the bonded-type Herbst appliance solely and not simultaneously with other functional appliances. To our knowledge, no systematic review has analyzed splint-type Herbst treatment effects systematically. This systematic review evaluated the skeletal and dental changes in growing individuals, as seen with lateral cephalograms, for the treatment of Class II division 1 malocclusion with the use of splint-type Herbst appliances.

MATERIALS AND METHODS

A computerized search was conducted using Medline (from 1966 to week 3 of January 2006), Medline In-Process & Other Non-Indexed Citations (up to January 30, 2006), Web of Science (from 1945 to week 2 of 2006), Lilacs (from 1982 to January 2006), Pubmed (1966 to week 3 of January 2006), Embase (from 1988 to week 4 of 2006), Scopus (up to January 30, 2006), Web of Science (from 1945 to week 4 of 2006) and all Evidence-Based Medicine review (Cochrane Database of Systematic Reviews, American College of Physicians Journal Club, Database of Abstracts of Reviews of Effects, and Cochrane Database of Trial Registration; up to January 30, 2006) databases. Terms used in this literature search were ''Herbst'' and ''functional appliances.'' The selection and the specific use of each term with its respective truncation, if applicable, inside every database search were made with the help of a librarian who specialized in health sciences database searches (Table 1).

The following inclusion criteria were utilized to select abstracts from which potential review articles would be selected:

- Human clinical trials;
- Use of Herbst appliance to treat Class II division 1 malocclusion in growing individuals;
- No syndromic patients or simultaneous surgical or orthodontic intervention;
- No individual case reports or series of cases;
- Skeletal and/or dental changes evaluated through lateral cephalograms.

Because it was considered unlikely that all or most of the abstracts would provide enough information regarding the use of control groups in their studies, no attempts were made at this stage to identify studies that did not use adequate control groups to factor out growth changes. Meeting abstracts were employed to trace whether an article was indeed published from their data, although meeting abstracts were not selected.

The selection process was done independently by every author. Their results were then compared and discussed to resolve any discrepancies. The exception to the aforementioned statement is the Lilacs database. Because of language limitations, only one author evaluated Lilacs. All abstracts that seemed to meet the initial inclusion criteria were selected. Those abstracts that did not provide enough information to determine their suitability to the inclusion criteria were selected so that the final decision would be made with the complete article.

The articles ultimately selected, with selection made only after the complete article had been read, were chosen with the following additional inclusion criteria:

- A comparable nontreated Class II division 1 control group to factor growth changes;
- Only splint-type Herbst appliances used;
- Only linear or angular measurements.

The actual articles chosen from the selected article abstracts were then independently evaluated by every author. A unanimous consensus was reached regarding which articles fulfilled the final selection criteria to be included in the systematic review. Articles that did not factor out growth with the use of a control sample were rejected at this stage. Craniofacial growth was deemed an extremely important issue to factor out. This was required to make an accurate assessment of the amount of true magnitude of the changes. Failure to account for and consider craniofacial growth changes could result in a potential overestimation of the amount of change attained. Although measurement error is needed for a correct interpretation of the clinical significance of the findings, it was not considered a reason to reject an article, but was considered in the interpretation of the data.

Considering that more methodologically sound studies may provide more reliable conclusions, a methodological scoring process was developed to identify which selected studies were stronger methodologically (Table 2). No attempt was made to imply that this evaluation tool has been properly validated. Previous reports[11,12] have shown that there is no sound evidence about the validity of the use of quality assessment of clinical trials, and they recommend that researchers individually examine the influence of key components of methodological quality.

The reference lists of the retrieved articles were also

Table 1. Search Results from Different Electronic Databases[a]

Database	Keywords	Results	Selected	% of Total Selected Abstracts (3)[b]
PubMed	(1) Herbst (2) Orthod* (3) 1 and 2	180	2	66.6
Medline	(1) herbst. mp. [mp = title, original title, abstract, name of substance word, subject heading word] (2) orthod$.mp. [mp = title, original title, abstract, name of substance word, subject heading word] (3) 1 and 2	176	2	66.6
Medline In-Process and Other Non-Indexed Citations	(1) herbst.mp. [mp = title, original title, abstract, name of substance word, subject heading word] (2) orthod$.mp. [mp = title, original title, abstract, name of substance word, subject heading word] (3) 1 and 2	3	0	0
Embase	(1) herbst.mp. [mp = title, abstract, subject heading, heading word, drug trade name, original title, device manufacturer, drug manufacturer name] (2) orthod$.mp. [mp = title, abstract, subject heading, heading word, drug trade name, original title, device manufacturer, drug manufacturer name] (3) 1 and 2	7	0	0
All EBM reviews (Cochrane Database of Systematic Reviews, ACP Journal Club, DARE, and CCTR)	(1) herbst.mp. [mp = ti, ab, tx, kw, ct, ot, sh, hw] (2) orthod$.mp. [mp = ti, ab, tx, kw, ct, ot, sh, hw] (3) 1 and 2	19	1	33.3
Web of Science	TS = (Herbst AND ortho$)	42	0	0
Hand search	Reference list from selected articles	1	1	33.3

[a] EBM indicates Evidence-Based Medicine; ACP, American College of Physicians; DARE, Database of Abstracts of Reviews of Effects; and CCTR, Cochrane Database of Trial Registration.

[b] Percentages do not add up to 100% because the same reference could be found in several databases.

hand-searched for additional relevant publications that may have been missed in the database searches. In cases in which additional information was required for discussion or statistical analysis, and was not specifically given in the article, contact with the authors was sought in order to obtain the required information.

RESULTS

The search results and the final number of abstracts selected according to the initial selection criteria from the various databases are provided in Table 1. From the abstracts reviewed initially, 21 studies met the initial inclusion criteria, but upon review and after reading the articles, only three articles met the final selection criteria (14%). From the initial 21 abstracts, five studies[13–17] were rejected because they included control groups that were not all Class II division 1 cases, 12 articles[18–29] were rejected because of their use of the banded-type Herbst appliance, one article[30] was excluded because it was not a controlled trial, and one because no control group was reported.[21] As seen in Table 3, some articles were rejected for more than one reason. A flow diagram of the literature search may be found in Table 4. A methodological scoring process was developed to identify which of the studies finally selected[31–33] were stronger methodologically (Table 5).

Regarding cranial base changes, no selected study reported significant changes except with regard to the cranial base angle (1°), and this change is not likely clinically significant.[33] No changes in the facial growth axis were reported, but a decrease in the facial profile was found (3°).[33] Significant changes in the vertical dimensions were reported for the posterior (1.4 to 2.5 mm)[31,33] and lower anterior facial heights (1.2 to 3 mm).[31,33]

Significant decreases in the intermaxillary discrepancy were found (−1.5 to −2.1° and −4.2 to −4.9 mm).[31,33] Also, significant decreases for the overjet

Table 2. Methodological Score for the Clinical Trials

I. Study Design (11√)
- A. Objective—objective clearly formultated (√)
- B. Population—described (√)
- C. Selection criteria—clearly described (√); adequate (√)
- D. Sample size—considered adequate (√); estimated before collection of data (√)
- E. Baseline characteristics—baseline characteristics (√); similar between groups (√)
- F. Timing—prospective (√); long-term follow-up (√)
- G. Randomization—stated (√)

II. Study Measurements (4√)
- H. Measurement method—appropriate to the objective (√)
- I. Blind measurement—blinding of examiner (√); blinding of statistician (√)
- J. Reliability—described (√)

III. Statistical Analysis (5√)
- K. Dropouts—included in data analysis (√)
- L. Statistical analysis—appropriate for data (√)
- M. Confounders—included in analysis (√)
- N. Statistical significance level—*P* value stated (√); confidence intervals (√)

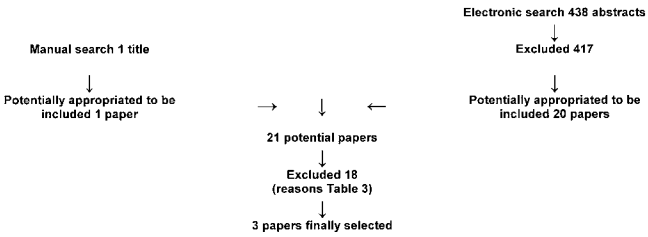
Maximum number of √s = 20

Table 3. Articles Selected but Later Excluded and Reasons for Exclusion[a]

Pancherz[18]	Banded type used
Pancherz[19]	Banded type used
Pancherz[20]	Banded type used
Hagg and Pancherz[21]	Banded type used. No control group
Pancherz and Littmann[22]	Banded type used
Pancherz and Littmann[23]	Banded type used
Pancherz[30]	Not a controlled trial
Pancherz and Stickel[24]	Banded type used. Only TMJ changes evaluated
Valant and Sinclair[13]	Control group were not all class II div 1 cases
Schiavoni[14]	Control group were not all class II div 1 cases. Repeated sample from Schiavoni et al[16]
Hansen and Pancherz[15]	Control group were not all class II div 1 cases
Kucukkeles and Sandalli[25]	Banded type used
Schiavoni et al[16]	Control group were not all class II div 1 cases
Lai and McNamara[17]	Control group were not all class II div 1 cases
Pancherz et al[26]	Banded type used. Only TMJ changes evaluated
Croft et al[27]	Banded type used
Manfredi et al[28]	Banded type used
Pancherz and Fischer[29]	Banded type used. Only TMJ changes evaluated

[a] TMJ indicates temporomandibular joint.

Table 4. Flow Diagram of the Literature Search



(−4.6 to 5.6 mm)[31,32] and overbite (−2.5 mm)[31] were reported.

Some significant changes in the maxillary anteroposterior position were reported, but these are not likely clinically significant (<1 mm).[31,33] No significant changes were reported for the upper incisors. The upper molars were significantly more retruded (1.5 to 5.4 mm),[31,33] slightly intruded (−0.9 mm),[33] and retroclined (5.6°)[31] after treatment.

A significant increase in the mandibular protrusion was found (1.2 to 2.9°).[31,33] No significant changes for the mandibular plane inclination,[31,33] gonial angle,[31–33] or condylar position[31] were reported. Mandibular dimensions were shown to be significantly increased (0.7 to 2.7 mm).[31–33] In general, mandibular incisors were protruded (1.5 to 4 mm),[31–33] proclined (3.2 to 4.5°),[33] and extruded (5.3°)[31] after treatment. The mandibular molars were also protruded (0.8 to 3.6 mm)[31–33] but not proclined or clinically significantly extruded.

DISCUSSION

The present systematic review was performed to systematically retrieve and analyze the skeletal and dentoalveolar changes that take place in growing individuals who have Class II division 1 malocclusions and were treated with splint-type Herbst appliance therapy.

A difficulty encountered in this systematic review is that generally each article used different variables and reference points in its cephalometric analysis. Seventy-five different dental and skeletal cephalometric points (seven for cranial base, seven for facial proportion and growth direction, 31 for mandibular measurements, 23 for maxillary measurements, and seven for intermaxillary relationships) were used in the three selected studies. This situation impeded the possibility of doing a meta-analysis to combine the results of the selected studies.

For the abovementioned reason, in our Results section, only a trend with a range of change values has been reported. The studies in general did agree in di-

Table 5. Methodological Scores of Selected Articles[a]

Articles	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Total No. of Checks	% of the Total
Sidhu et al[31]	√	√	√≠	√−	√√	√−	−	√	−−	−	−	√	−	≠−	9	45
Franchi et al[32]	√	√	√√	√−	√√	−≠	−	√	−−	−	−	√	√	≠−	11	55
Ursi et al[33]	√	√	√√	√−	√√	−−	−	√	−−	−	−	√	−	≠−	9.5	47.5

[a] A–N indicate methodological criteria given in Table 2; √, sastisfactorily fulfilled the methodological criterion (1 check point); ≠, partially fulfilled the methodological criterion (0.5 check points); and −, did not fulfill the methodological criterion (0 check points).

rection and some in the magnitude of their findings regarding skeletal and dentoalveolar change. An interesting situation was identified in one of the studies.[31] That study reported nonsignificant results even though the magnitude of its reported difference was larger than that found in the other two studies,[32,33] which stated that their smaller differences were significant. A possible explanation is the smaller sample size and lower methodological score of the former study.[31] This was subjectively taken into account when summarizing the findings in the results.

The studies selected showed that use of the splint-type Herbst appliance resulted in increased anteroposterior length of the mandible, increased vertical height of the ramus, increase in lower facial height, mandibular incisor proclination, mesial movement of lower molars, and distal movement of upper molars. No changes were reported for the upper incisors. Similar trends were identified in most of the excluded studies[13–23,25,27–29] in the second stage of the search and selection process.

Two of the selected studies reported relapse in treated patients during the posttreatment observation period. The cause of relapse is not certain, though unstable occlusion and abnormal swallow have been indicated[31] as well as mesial drift of the upper molars.[32]

There are a number of flaws that were also noted in the selected articles and in general with studies that deal with splint-type Herbst appliances. First, control and treatment groups have to be homogenous with respect to race, gender distribution, age at different observation times, type of malocclusion and craniofacial pattern at the time of first observation, and observation period and stage of skeletal maturity.[32] Though the articles selected considered several of these aspects when choosing their subjects, the information compiled from the three selected studies cannot possibly account for all of the combinations of the above variables. Therefore, more research is needed to produce a larger body of literature that would cover skeletal and dentoalveolar changes caused by splint-type Herbst therapy in a variety of different populations at a variety of different treatment times. For example, only one of the studies[32] considered skeletal maturity in its analyses.

Secondly, another flaw noted during the course of compiling this systematic review was the limited number of studies fulfilling our selection criteria, indicating that the vast majority of published studies have inherent design flaws in the conduct and reporting of their scientific investigations, along with small sample sizes upon which results are based. Five nonselected studies used a control group that included patients that were not Class II. It has been suggested that control groups and treated groups should be homogenous regarding malocclusion type and craniofacial pattern.[32] There is controversy in this regard.[34] It has been reported[35,36] that longitudinal growth characteristics are in general similar in nontreated Class II and Class I malocclusions, with some specific linear and angular measurements that would follow a different pattern. A limitation found in these studies is that their samples were classified as Class II as per their occlusal characteristics[35] or were not properly defined,[36] ie, not defined according to their initial basal bone characteristics, which are more likely to influence the nontreated skeletal changes.

The following systematic review conclusions should be considered with caution because only a secondary level of evidence was found. Methodologically sound long-term prospective blinded randomized clinical trials are needed to support the conclusions.

CONCLUSIONS

- The studies selected all showed that use of the splint-type Herbst appliance in treating adolescents with Class II division I malocclusion resulted in increased anteroposterior length of the mandible, increased vertical height of the ramus, increase in lower facial height, mandibular incisor proclination, mesial movement of lower molars, and distal movement of upper molars.
- The magnitudes of the reported differences were significant in several cases, but were not likely clinically significant. It is the combination of several small changes in different skeletal and dental areas that produces the overall reported positive change.

ACKNOWLEDGMENT

Special thanks to Linda Seale for her professional assistance in the database search.

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