CONTINUING EDUCATION ARTICLE

The effectiveness of protraction face mask therapy: A meta-analysis

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This study examined the effectiveness of maxillary protraction with orthopedic appliances in Class III patients. A meta-analysis of relevant literature was performed to determine whether a consensus exists regarding controversial issues such as the timing of treatment and the use of adjunctive intraoral appliances. An initial search identified 440 articles relating to Class III malocclusion. Among those articles, 11 studies in English and 3 studies in foreign languages met the previously established selection criteria. Data from the selected studies were categorized by age and appliance groups for the meta-analysis. The sample sizes were comparable between the groups. The statistical synthesis of changes before and after treatment in selected cephalometric landmarks showed no distinct difference between the palatal expansion group and nonexpansion group except for 1 variable, upper incisor angulation, which increased to a greater degree in the nonexpansion group. This finding implies that more skeletal effect and less dental change are produced in the expansion appliance group. Examination of the effects of age revealed greater treatment changes in the younger group. Results indicate that protraction face mask therapy is effective in patients who are growing, but to a lesser degree in patients who are older than 10 years of age, and that protraction in combination with an initial period of expansion may provide more significant skeletal effects. Overall mean values and corresponding standard deviations for the studies selected can also be used to estimate mean treatment effects expected from the use of protraction face mask. (Am J Orthod Dentofac Orthop 1999;115:675-85.

Treatment of skeletal Class III malocclusion is most challenging, primarily because of the unpredictable and potentially unfavorable nature of growth in patients with this skeletal pattern. Typically, treatment approaches for young patients with Class III malocclusion have been directed at growth modification. This strategy often compels the orthodontist to resort to dental compensation. If this approach fails to achieve satisfying results, it leaves clinicians with only 1 choice for optimal treatment: orthognathic surgical correction. This option, however, necessitates decompensation and reversal of previous treatment. Conversely, clinicians may attempt to maintain the dentition as is, deferring definitive treatment until growth has ceased. Patients can then be treated with a combination of orthodontic and surgical therapies. Historically, clinical observation has led to the claim that the Class III skeletal relationship results primarily through over-development of the mandible. More recently, however, several authors[1,2] have reported maxillary retrusion as the most common contributing component of Class III features. In any event, with the limited ability to influence mandibular growth and the malleability of maxillary growth well established, treatment modalities for influencing mild to moderate Class III alveolar base discrepancies have shifted to a maxillary protraction paradigm.

Because of the abundant and well-documented literature, the orthopedic effect produced by posteriorly directed forces on the maxilla in Class II malocclusions has been widely used and well-received among clinicians. On the other hand, although most of the relevant studies have claimed a time-linked significant improvement from the therapy, the effectiveness of maxillary orthopedic guidance in Class III treatment has received much less attention and remains equivocal. Literature review reveals few long-term studies that deal with the effect of treatment produced by extraoral orthopedic protraction. Further, most of these studies have been conducted outside the United States. It should also be noted that articles frequently cited in the literature are case reports, mostly anecdotal in

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Table I. Description of the selected studies

Author/year	*Ethnic group*	*Sample (n)*	*Age (yr; range)*	*Treatment time (mo)*	*Appliance*	*Force magnitude & angulation (9g/°)*
Gallagher et al (1998)[13]	Caucasian	22	9.8 (5.6-13.3)	9	Slow PE	600-800 Variable
Kapust et al (1998)[12]	Caucasian	63	8.0 (4-14)	9.6	RPE	600-800 Down, forward
Ngan et al (1996)[14]	Asian	30	8.4 (5-12)	6	RPE	760 30°
Chong et al (1996)[15]	Caucasian	16	6.8 (4.6-8.3)	7.3	13 La-Li 3 RPE	460-570 30°-40°
Baik (1992, 1995)[9,16]	Asian	60	11 (8-13)	6.5	13 La-Li 47 RPE	600-1000 Down, forward
Lim & Park (1995)[11]	Asian	93	9.9 (6-14)	7.5	42 La-Li 51 RPE	700-800 20°
Battagel & Orton (1995)[17]	Caucasian	39	10.8	24	Removable fixed (Nonexpansion)	800 ?
Takada et al (1993)[10]	Asian	61	10 (6-15)	14	La-Li Edgewise (nonexpansion)	600-800 Down, forward
Ngan et al (1992)[18]	Asian	10	8.1 (7.1-10.6)	6	RPE	860-1080 45°
Mermingos et al (1990)[19]	Caucasian	12	8.1 (4.3-14.4)	13 (5-26)	Fixed La-Li	250, 350 then 500 ?
Wisth et al (1987)[20]	Caucasian	22	7.5 (5-10)	3-12	Quad helix	600 15°
Ishii et al (1985, 1987)[21,22]	Asian	63 36	10.8 (7-15) 9.8	15.8 13.2	Palatal plate (nonexpansion)	400-600 Horizontal
Cozzani (1981)[20]	Caucasian	8	10.2 (5-19)	14	4 La-Li 4 RPE	1000-2000 ?

nature and based on a limited number of subjects, although a few prospective experimental reports are available. In addition, the lack of long-term follow-up studies mitigates against claims of stability of protraction treatment. Therefore it appears as if anecdotal clinical impressions rather than scientific evidence have been the foundation for the treatment protocol of protraction therapy. This is supported by the fact that there is no consensus among clinicians as to how and when to treat nor how effective and stable the results are.

It is often noted in the medical literature that clinicians repeat the trials of the same treatment protocols in similar patients to establish a standard of care, but definitive conclusions from any 1 trial are rare, especially when the studies are based on inadequate sample size.[3,4] Meta-analysis provides a method of equating and eventually comparing results of several independent studies on a specific topic. It is a technique that permits analysis and comparison of research data from diverse sources.[5-8] Therefore to determine whether the literature provides support for a consensus concerning the efficacy of protraction face mask therapy, a meta-analysis of relevant literature was performed.

The primary purposes of this study were to evaluate the effectiveness of maxillary protraction with orthopedic appliances in Class III patients and to compare and contrast the range of improvement with respect to various treatment modalities to assess the relevance of proposed key elements of protraction therapy. Because the number of subjects in individual studies is rela-

tively low, meta-analysis was used to increase sample size and provide stronger statistical support for conclusions drawn concerning the use of protraction face mask in Class III treatment.

METHODS

A meta-analysis of selected literature was carried out. Meta-analysis is the application of statistical procedures to collections of findings from individual studies for the purpose of integrating them, using results from existing studies to reveal patterns of underlying relations. The survey of extant literature relating to this subject began with a *MEDLINE* (US National Library of Medicine) search using the subject headings *orthodontics* and *Class III malocclusion*. From this search, articles dated 1996 or earlier were identified. Abstracts and summaries of these articles were reviewed to select those papers in which an extraoral protraction device was used. To minimize the chance of omitting any relevant literature, the first step of the screening procedure was performed again. In addition to the computer search, the reference list for each selected article was examined to identify the articles that were not retrieved by the *MEDLINE* search. Because a much higher prevalence of Class III malocclusion is reported in the Asian population, an effort was made to locate the literature published in foreign journals (Chinese, Japanese, and Korean). To minimize inclusion of poor-quality studies, only refereed journals were examined. A total of 440 articles was identified in this process.

The following election criteria were established for inclusion of an article in this study: complete description of extraoral and intraoral appliances used in the study; age of the patients; duration of treatment; and cephalometric measurements of treatment outcome, including changes in SNA, SNB, ANB, mandibular plane, palatal plane, or point A. If these data or mean values and standard deviations for each variable were not provided, the article was eliminated from consideration.

From the selected literature, common cephalometric variables representing the treatment effect were tabulated. These variables were then subsequently combined to produce mean values and standard deviations after meta-analytical procedures. After the cephalometric data and the study protocol were assembled, the studies were sorted for statistical analysis according to the type of appliance used and age of the patients at the time of treatment. For each variable, the combined mean value and standard deviation were calculated for comparison.

Studies were divided by age, with the age of 10 years as the cut-off point. Therefore only the data from 4 studies[9-12] were included to form the 2 groups. The remaining studies had ranges in age including both the younger and older groups. Age 10 years was used as the cut-off age, because it was near the average age reported and is generally considered the beginning of pubertal growth.

RESULTS

Literature Search Results

Through the computerized literature search, review of reference lists, and communication with researchers and editors, 440 articles were identified as relating to Class III malocclusion. After the elimination of the studies not directly relevant to Class III treatment with the protraction face mask, 76 articles in English and 45 articles in foreign languages remained. Among the 121 potentially useful studies, only 18 articles (15 English, 3 foreign) presented reasonably acceptable cephalometric quantitation and a comprehensive description of the treatment protocol. However, several articles were noted to be based on data derived from the same treatment groups. Thus a representative article was selected from each of those groups, and the others were eliminated, resulting in a total of 14 articles. In all, 11 English language studies and 3 foreign language studies met the criteria established for inclusion. The studies are listed and described briefly in Table I.

Summary Graphs of Reported Cephalometric Data

Fig 1 summarizes the cephalometric changes after protraction face mask therapy as reported in selected articles containing cephalometric data and comprehensive descriptions of the treatment protocol. The common measurements presented in the studies were determined to be change in SNA, SNB, ANB, Wits,[24,25] mandibular plane, palatal plane, upper and lower incisor angulation, and point A. These selected variables represent the skeletal and dental changes occurring during the treatment in sagittal and vertical dimensions. Means and corresponding standard deviations were plotted for each variable for those studies that provided these data. These figures graphically demonstrate the trends and variability of treatment effects reported in the selected studies. Despite the discrepancies in the treatment protocol and experimental design between the studies, definite trends were noted in variables, representing the changes occurring during the treatment with protraction face mask: SNA, Wits, ANB, mandibular plane angle, upper incisor angle increase, SNB, with the exception of 2 studies, and lower incisor angulation decreases and point A moves forward.

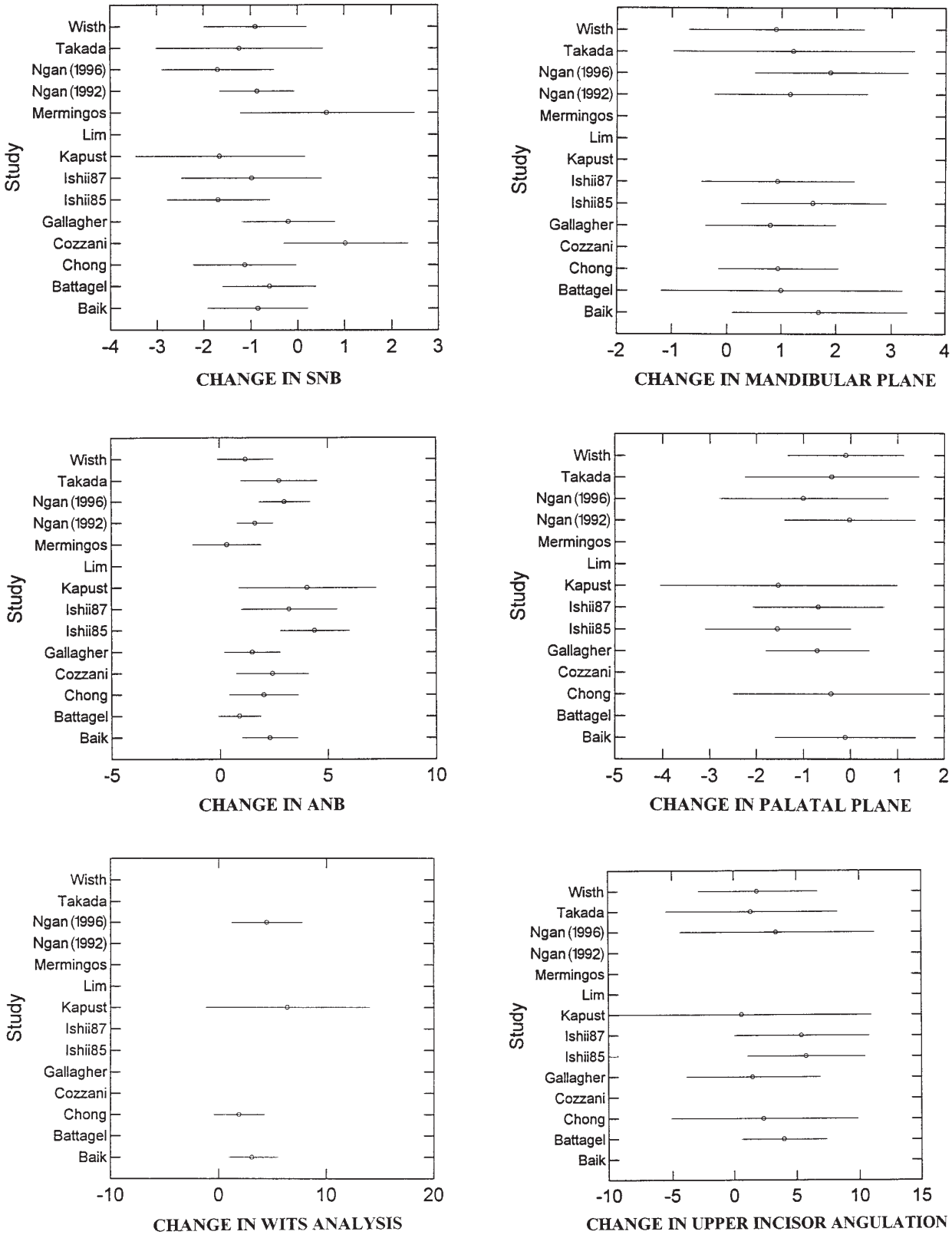

Fig 1. Graphic representation of means and standard deviations of cephalometric treatment changes.

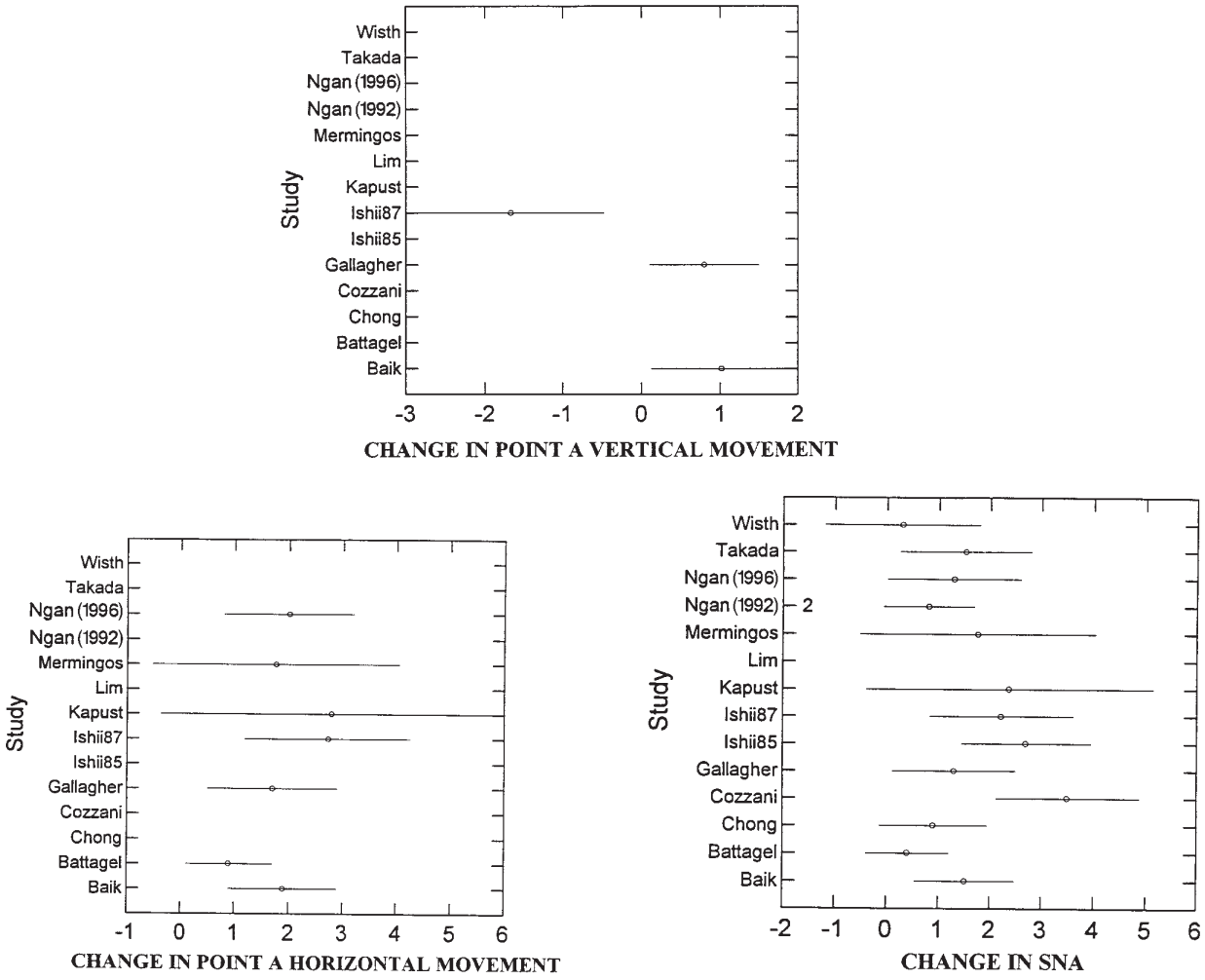

Fig 1. continued.

Appliance Group: Expansion Versus Nonexpansion

Table II summarizes mean values of the 2 appliance groups and shows negligible differences, except for 1 variable, upper incisor angulation. Upper incisor angulation demonstrates greater proclination in the nonexpansion groups (mean difference, 2.81°).

Younger Group Versus Older Group

Table III summarizes the combined mean values and standard deviations of the 2 age groups. The comparison showed a trend that all values of the younger group were larger than the older group, implying greater treatment effects in the younger aged group.

Combined Estimates

Table IV shows means and standard deviations of all variables as presented in the individual studies. Combined estimates of means and standard deviations are shown. The combined values reflect the treatment effect of the protraction face mask: increase in SNA, ANB, Wits, mandibular plane, upper incisor angulation, and decrease in SNB, palatal plane, and lower incisor angulation, with advancement of point A.

DISCUSSION

Many issues related to maxillary protraction remain controversial. Yet there is no extensive literature review that attempts to synthesize and analyze previously reported work. This analysis provides an overview of reported results, providing insight into protraction treatment and hopefully aiding in the design of future research. During the process of screening studies for this meta-analysis, it was noted that both the quantity of publications on this subject and the quality of the

Table II. Means and standard deviations for the expansion and nonexpansion groups and the difference between the 2 groups

	Ap	*Age*	*E*	*N*	*F*	*T*	*SNA*	*SD*	*SNB*	*SD*	*ANB*
Expansion (group 1)											
Gallagher	1	9.8	2	22	700	9.0	1.3	1.2	–0.2	1.0	1.5
Kapust	1	8.0	2	63	700	9.6	2.4	2.8	–1.7	1.8	4.0
Ngan (1996)	1	8.4	1	30	760	6.0	1.3	1.3	–1.7	1.2	3.0
Baik	1	11.0	1	48	800	6.5	1.7	1.0	–0.9	1.1	2.5
Lim	1	9.9	1	51	750	7.5	1.7		–1.5		3.2
Ngan (1992)	1	8.1	2	10	960	6.0	0.8	0.9	–0.9	0.8	1.6
Wisth	1	7.5	2	22	600	7.5	0.3	1.5	–0.9	1.1	1.2
TOTAL (group 1)				246			246	195	246	195	246
MEAN (group 1)	1	9.2			740	7.7	1.6	1.9	–1.3	1.4	2.9
Nonexpansion (group 2)											
Chong	2	6.8	2	16	515	7.3	0.9	1.0	–1.1	1.1	2.0
Baik	2	9.4	1	12	800	6.6	1.0	0.8	–0.7	0.9	1.7
Battagel	2	10.8	2	39	800	12.0	0.4	0.8	–0.6	1.0	0.9
Lim	2	9.9	1	42	750	7.5	2.0		–1.5		3.6
Takada	2	10.0	1	61	700	14.0	1.5	1.3	–1.2	1.8	2.8
Merming	2	8.1	2	12	500	13.0	1.8	2.3	0.6	1.9	0.3
Ishii (1987)	2	10.7	1	63	500	15.8	2.2	1.4	–1.0	1.5	3.2
Ishii (1985)	2	9.8	1	36	500	13.2	2.7	1.3	–1.7	1.1	4.4
TOTAL (group 2)				281			281	239	281	239	281
MEAN (group 2)	2	9.9			640	12.3	1.7	1.3	–1.2	1.4	2.7
DIFFERENCE							0.09		0.10		0.11

Ap, Appliance (1, expansion; 2, nonexpansion); *E*, ethnic group (1, Asian; 2, Caucasian); *N*, sample; *F*, force magnitude;*T*, treatment duration in months.

research in terms of sample size and experimental design have improved markedly in recent years.

The selected studies were divided into different age and appliance groups because the timing of the treatment and expansion regimen have been the predominant controversies. Gender differences were not examined in the meta-analysis because most of the studies found no significant differences in treatment responses between male and female patients and did not report the data in sex-specific groups.

Subject and study treatment outcomes are commonly annualized[10,12,17] to examine the effects of various treatment parameters. Although it seems logical to adjust the time units so the outcome of each individual can be weighed equally, 1 limitation of this technique is that treatment outcome is not necessarily proportional to treatment duration. For this reason, this analysis does not annualize the data.

Meta-analysis has been recommended for use in reviewing the results of a research domain in quantitative terms, with the objective of identifying significant relationships between study features and outcomes.[16] In this study, precautions were taken not to overly emphasize the role of quantitative statistical analysis in synthesizing the reported results, as recommended by Thomson and Pocock.[26] Thus a conservative statistical synthesis was applied to provide a clearer descriptive overview of the literature, rather than drawing inferential conclusions.[5-8,27]

Treatment Effects

Several observations can be made considering the consistent findings across reports surveyed for this study. The treatment effects of the protraction face mask therapy are a combination of skeletal and dental changes of the maxilla and mandible. The maxilla moves downward and forward with a slight upward movement in the anterior and downward movement in the posterior palatal plane as the result of protraction force; at the same time posterior teeth extrude somewhat. As a consequence, downward and backward rotation of the mandible improves the maxillomandibular skeletal relationship in the sagittal dimension but results in an increase in lower anterior facial height. This rotation is a major contributing factor in establishing an anterior overjet improvement. A force exerted by the chincup has been speculated to help in redirecting the mandibular downward and backward growth. Upper incisor labial inclination increased, although lower incisor inclination decreased. It is postulated that upper incisor proclination is due to mesial dental movement, and lower incisor uprighting occurs as the result of pressure by the chincup and soft tissue.

SD	Wits	SD	MP	SD	PP	SD	L1	SD	UI	SD	Ahor	SD
1.3			0.8	1.2	–0.7	1.1	–2.5	3.2	1.5	5.4	1.7	1.2
3.2	6.4	7.6			–1.5	2.5	–5.5	14.3	0.6	10.3	2.8	3.2
1.2	4.5	3.3	1.9	1.4	–1.0	1.8	–5.2	5.6	3.4	7.8	2.0	1.2
1.3	3.2	2.3	1.6	1.5	0.0	1.5					2.0	0.9
	4.8		2.8				–1.2		0.5		2.9	
0.8			1.2	1.4	0.0	1.4						
1.3			0.9	1.6	–0.1	1.2	–2.0	5.0	1.9	2.8		
195	192	141	183	132	195	195	188	137	188	137	214	163
2.1	4.9	5.5	1.8	1.4	–0.8	1.9	–3.5	10.3	1.3	8.3	2.4	2.2
1.6	1.9	2.4	0.9	1.1	–0.4	2.1	–1.7	5.5	2.4	7.5		
1.2	2.7	1.7	2.0	1.9	–0.4	1.7					1.4	1.2
1.0			1.0	2.2			–2.5	3.0	4.0	3.4	0.9	0.8
	5.6		1.7				–2.0		3.7		2.6	
1.8			1.2	2.2	–0.4	1.9	0.2	4.4	1.4	7.0		
1.6											1.8	2.3
2.2			0.9	1.4	–0.7	1.4	–4.9	2.9	5.4	5.4	2.7	1.5
1.6			1.6	1.3	–1.6	1.6	–3.1	3.6	5.8	4.7		
239	70	28	269	227	188	188	257	215	257	215	168	126
1.7	4.2	2.1	1.3	1.8	–0.7	1.7	–2.4	3.8	4.1	5.7	2.1	1.4
	0.68		0.52		0.04		1.14		2.81		0.31	

Expansion Versus Nonexpansion

There were only 2 individual studies in the reviewed literature that compared the treatment results between the 2 different intraoral appliances: rapid palatal expander and labio-lingual wire.[11,16] Both studies claimed that statistically more forward movement of point A was achieved in their expansion groups, but the angular change was very similar in the expansion group and the nonexpansion group.

In this analysis, the combined sample sizes for the expansion and nonexpansion groups were 246 and 281, respectively. The estimated mean ages were comparable; however, the mean magnitude of forces used was higher in the expansion group, and the treatment duration was longer in the nonexpansion group. The comparison of the mean values between the 2 groups showed remarkable similarity in overall measurements except for 1 variable, upper incisor angulation. Upper incisors showed greater proclination in the nonexpansion group (2.81°).

Several conclusions can be drawn from this comparison. First, although the results of protraction are similar, the average duration was much higher in the nonexpansion group. Thus the same degree of improvement was obtained within a shorter period of time with the expansion appliance. It can therefore be suggested that the use of an expansion appliance enhances the protraction effect in terms of time with less dental effect. Regarding the nature of treatment effects, more skeletal effect and less dental change are produced with the expansion appliance, although more dental change is produced with the nonexpansion appliance. Flaring of the upper incisors may be limited because of the space created by the expansion appliance. Second, it could be further speculated that the result may be different if an acrylic palate is added to the expansion appliance to enhance the anchorage, as suggested by Haas.[28] None of the studies used the expansion appliance with an acrylic palatal pad.

Effects of Age

In an attempt to evaluate the influence of age on the treatment effects, the selected studies were divided into 2 groups: younger (4-10 years) and older (10-15 years). The combined sample sizes for the younger and older groups were 115 and 150, respectively. Estimated mean force level and duration of treatment time were comparable between the 2 groups. The intraoral appliances used in the 2 groups did not exhibit any distinct difference, showing fairly equal distribution between the 2 groups. Thus it could be assumed that data of either group were minimally affected, if at all, by these confounding variables. Under this assumption, the comparison revealed a trend that all mean values of the

Table III. Means and standard deviations for the younger and older age groups and the difference between the 2 groups

	Ap	*Age*	*E*	*N*	*F*	*T*	*SNA*	*SD*	*SNB*	*SD*	*ANB*
Younger aged group (4-10 yrs)											
Kapust	1	4-7	2	15	700	8.6	3.7	2.7	-1.2	1.6	4.9
Kapust	1	7-10	2	32	700	9.4	2.0	2.6	-2.1	1.9	4.1
Baik	1	8-10	1	11	800	6.5	1.6	1.0	-0.7	0.7	2.3
Lim	1,2	6-8	1	14	750	7.7	2.5		-1.4		3.9
Lim	1,2	8-10	1	23	750	8.2	2.2		-1.5		2.7
Takada	2	6-10	1	20	700	13.0	1.5	1.2	-2.1	2.1	3.6
TOTAL (group 1)		4-10		115			115	78	115	78	115
MEAN (group 1)					725	9.2	2.2	2.1	-1.6	1.7	3.8
Older aged group (10-15 yrs)											
Kapust	1	0-14	2	16	700	9.8	1.9	3.3	-1.2	1.7	3.0
Biak	1	0-12	1	22	800	6.5	1.7	0.8	-1.1	0.9	2.8
Biak	1	2-13	1	15	800	6.5	1.7	0.8	-0.7	0.9	2.1
Lim	1,2	0-12	1	39	750	7.5	1.7		-1.5		3.2
Lim	1,2	2-14	1	17	750	6.9	1.5		-1.6		3.1
Takada	2	0-12	1	22	700	12.0	2.0	1.5	-1.2	2.1	3.3
Takada	2	2-15	1	19	700	17.0	0.9	1.1	-0.4	0.9	1.3
TOTAL (group 2)		0-15		150			150	94	150	94	150
MEAN (group 2)					743	9.2	1.6	1.6	-1.2	1.4	2.8
DIFFERENCE							0.6		0.5		1.0

Ap, Appliance (1, expansion; 2, nonexpansion); *E*, ethnic group (1, Asian; 2, Caucasian); *N*, sample; *F*, force magnitude; *T*, treatment duration in mon
Ap, Appliance (1, expansion; 2, nonexpansion); *E*, ethnic group (1, Asian; 2, Caucasian); *N*, sample; *F*, force magnitude;
T, treatment duration in months.

Table IV. Means and standard deviations for all variables for individual and combined studies

	Ap	*Age*	*E*	*N*	*F*	*T*	*SNA*	*SD*	*SNB*	*SD*	*ANB*
Gallagher	1	9.83	2	22	700	9.0	1.3	1.2	-0.2	1.0	1.5
Kapust	1	8.0	2	63	700	9.6	2.4	2.8	-1.7	1.8	4.0
Ngan (1996)	1	8.4	1	30	760	6.0	1.3	1.3	-1.7	1.2	3.0
Chong	2	6.8	2	16	515	7.3	0.9	1.0	-1.1	1.1	2.0
Baik	1,2	10.7	1	60	800	6.5	1.5	1.0	-0.9	1.1	2.3
Battagel	2	10.8	2	39	800	24.0	0.4	0.8	-0.6	1.0	0.9
Lim	1,2	9.9	1	93	750	7.5	1.8		-1.5		3.4
Takada	2	10.0	1	61	700	14.0	1.5	1.3	-1.2	1.8	2.8
Ngan (1992)	1	8.1	2	10	960	6.0	0.8	0.9	-0.9	0.8	1.6
Mermingos	2	8.1	2	12	500	13.0	1.8	2.3	0.6	1.9	0.3
Wisth	1	7.5	2	22	600	7.5	0.3	1.5	-0.9	1.1	1.2
Ishii (1987)	2	10.7	1	63	500	15.8	2.2	1.4	-1.0	1.5	3.2
Ishii (1985)	2	9.8	1	36	500	13.2	2.7	1.3	-1.7	1.1	4.4
Cozzani	1,2	10.2	2	8	1500	13.5	3.5	1.4	1.0	1.3	2.4
TOTAL				535			535	442	535	442	535
MEAN							1.7	1.6	-1.2	1.4	2.8

Ap, Appliance (1, expansion; 2, nonexpansion); *E*, ethnic group (1, Asian; 2, Caucasian); *N*, sample; *F*, force magnitude; *T*, treatment duration in months.

younger group were greater than the older group, implying greater treatment effects in the younger group. However, the magnitude of the differences was not substantial: SNA, 0.6°; SNB, 0.5°; ANB, 1.0°; Wits, 1.3 mm; mandibular plane, 0.3°; palatal plane, 0.7°; lower incisor, 3.0°; upper incisor, 0.9°; and point A, 0.5 mm. It was also noted that standard deviations for all the variables in the younger group were higher than the older group, implying greater variation in the outcome of treatment in the younger group.

Many authors[10,12,23,29-33] claimed that treatment

SD	*Wits*	*SD*	*MP*	*SD*	*PP*	*SD*	*L1*	*SD*	*UI*	*SD*	*Ahor*	*SD*
3.5	6.2	3.8			-2.5	2.7	-9.2	16.3	-0.7	16.3	3.9	2.3
3.2	7.3	9.6			-1.5	2.4	-4.7	25.7	1.5	8.4	2.3	3.2
0.9	2.8	1.8	1.6	1.6	1.0	1.3					2.0	1.2
	4.2		1.5				1.5		6.2		2.9	
	5.6		2.0				-4.0		2.0		2.5	
1.9			1.9	2.6	-0.3	2.2	-1.5	5.0				
78	95	58	68	31	78	78	104	67	84	47	95	58
2.7	5.7	7.5	1.8	2.3	-1.0	1.9	-3.7	13.1	2.0	11.4	2.7	2.7
2.9	4.5	3.2			-0.7	2.4	-3.7	5.1	1.0	7.7	2.8	3.7
1.2	3.6	2.2	1.8	1.3	-0.1	1.5					2.2	0.9
1.2	3.0	2.8	1.4	1.8	-0.2	1.6					1.8	0.8
	5.1		2.0				-1.5		1.5		2.1	
	5.4		1.8				-1.6		1.2		1.9	
1.9			1.6	2.5	-0.8	1.7	1.4	4.7	1.8	7.6		
1.5			0.1	1.2	-0.1	1.6	-0.6	3.2	0.9	6.2		
94	109	53	134	78	94	94	113	57	113	57	109	53
1.8	4.5	2.7	1.5	1.8	-0.4	1.8	-0.7	4.4	1.2	7.2	2.1	2.1
	1.3		0.3		0.7		3.0		0.9		0.5	

SD	*Wits*	*SD*	*MP*	*SD*	*PP*	*SD*	*L1*	*SD*	*UI*	*SD*	*Ahor*	*SD*
1.3			0.8	1.2	-0.7	1.1	-2.5	3.2	1.5	5.4	1.7	1.2
3.2	6.4	7.6			-1.5	2.5	-5.5	14.3	0.6	10.3	2.8	3.2
1.2	4.5	3.3	1.9	1.4	-1.0	1.8	-5.2	5.6	3.4	7.8	2.0	1.2
1.6	1.9	2.4	0.9	1.1	-0.4	2.1	-1.7	5.5	2.4	7.5		
1.3	3.1	2.2	1.7	1.6	-0.1	1.5					1.9	1.0
1.0			1.0	2.2			-2.5	3.0	4.0	3.4	0.9	0.8
	5.2		2.3				-1.6		2.0		2.8	
1.8			1.2	2.2	-0.4	1.9	0.2	4.4	1.4	6.9		
0.8			1.2	1.4	0.0	1.4						
1.6											1.8	2.3
1.3			0.9	1.6	-0.1	1.2	-2.0	5.0	1.9	4.8		
2.2			0.9	1.4	-0.7	1.4	-4.9	3.7	5.4	5.4	2.7	1.5
1.6			1.6	1.3	-1.6	1.6	-3.1	4.0	5.8	4.7		
1.7												
442	262	169	460	367	421	421	445	352	445	352	382	289
1.9	4.7	5.0	1.5	1.7	-0.8	1.7	-2.9	7.2	2.8	6.9	2.3	1.9

should be started as early as possible to produce a more significant response from protraction therapy. Results of this study also demonstrate that treatment changes in the younger group were larger than those in the older group. However, the magnitude of the difference between the 2 groups was not substantial. Further comparison of estimated changes between the older group and the total combined group revealed negligible differences. Therefore it was concluded from the data that protraction face mask therapy is still effective but to a lesser degree in growing patients older than 10 years of age.

Utility of Protraction Therapy

Table IV shows the variability in results obtained among different studies. The reported increase in ANB angle ranged from 0.9° to 4.39°, with a mean value of 2.79° across all studies. This is well over expected growth changes for 1 year. Variability exists not only among the individual subjects in a study but also among the groups of subjects in different studies. Further, this mean was generated from studies that used all permutations of treatment: time, appliance, expansion protocol, force level, and force vector. Therefore the variability in approach should be taken into consideration when interpreting the estimates of means of the combined studies. It is interesting that, regardless of approach, a positive effect was observed. Even more change may be feasible on a routine basis when optimal conditions are applied uniformly rather than being masked or diluted by pooling data from such diverse treatment protocols. When the conditions for protraction therapy are studied further and when each factor contributing to the amount of protraction (eg, types of intraoral appliance, timing of treatment, force duration, magnitude, direction, and sites of application) is determined, it is likely that the mean effectiveness of protraction treatment will be increased beyond the 2.79° change shown in this study. In addition, good patient compliance, favorable growth potential, and an appropriate biologic response will further enhance the treatment result.

Study Limitations

Clinical significance of treatment variation was not alluded to in this study because the clinician must consider a multitude of factors, such as severity, patient compliance, and growth potential, in making a decision to use protraction therapy. An ethnic maturation differential may well exist and must also be taken into consideration. Ideally, the combined treatment outcome should be compared with a matched control group. However, various growth studies in the literature report that, on the average, the angle of maxillary prognathism, SNA, remains almost constant throughout growth.[34-37] According to Mitani and Fukazawa,[38] the growth rate and pattern were similar during the prepubertal growth period for the normal group and the skeletal Class III group of children aged from 7 to 10 years. Thus it could be suggested that the lack of data from a combined control group in this meta-analysis should not influence the results, especially when comparing groups.

One of the major limitations was the lack of standardization of the design of various studies and the necessity to use all studies that met the inclusion criteria. Meta-analysis is highly limited by the manner in which authors of primary studies conducted the research and reported their findings. Meta-analysis of existing literature cannot supplant a randomized controlled clinical trial. Unless studies being combined are designed in such a way to evaluate only a specific variable, with other factors being controlled, it would be difficult to accurately determine the effect of the different appliances or the timing of the treatment. Because it was observed in this study that treatment variables such as forces and appliances used and treatment duration were relatively evenly distributed when dividing into separate groups, it was assumed that the effects of other confounding variables were decreased as the sample size and power increased by combining the data. Thus it was possible to observe the range of variability among the reported findings of the same variables in a more global aspect, which could not be detected by looking only at 1 study. Meta-analysis should be considered an alternative that provides valuable information based on the entirety of evidence in the published literature.

For a more objective and comprehensive understanding of the literature regarding the protraction face mask therapy, several other aspects (such as the reliability of cephalometric assessment, nature of control groups, and posttreatment changes) should be considered. Most of the literature relies on the cephalometric measurements that involve the landmark point A. The reliability of the use of point A should be carefully examined. Point A is not an easy landmark to locate with repeated accuracy, especially in the presence of the erupting permanent incisor. This landmark has also been shown to be greatly influenced by the position of the upper incisor.[39-41] Thus it might be more accurate if constructed landmarks were used in conjunction with anatomic landmarks such as Tindlund[42] and Tindlund et al[43] proposed.

In evaluating treatment outcome, one must also take into consideration the presence of centric relation to maximum intercuspation discrepancy before treatment. Estimates of the treatment changes for cephalometric parameters (such as SNB, ANB, Wits, mandibular plane, and overjet) should be interpreted with caution because the amount and direction of mandibular functional shift affects both sagittal and vertical dimensions. Therefore the direction and amount of mandibular functional shift should be recorded if a cephalometric record is taken in maximum intercuspation, to provide better knowledge in diagnosing the severity of the problem or in evaluating the true effect of the appliance.

The data do not truly represent the maximum potential effect of the appliance because the need for the maxillary advancement in each individual is determined by the severity of the pretreatment problem and is limited by the degree of the downward and backward repositioning of the mandible, which contributes to the establishment of the positive overjet. This is a difficult issue to resolve when retrospective studies are conducted and evaluated. Carefully conducted prospective research with comprehensive records and an accurate assessment of initial severity would be of value in the determination of the true effect of the appliance.

CONCLUSIONS

No distinct differences were present between the palatal expansion group and the nonexpansion group except for upper incisor angulation, which showed greater proclination in the nonexpansion group. Protracted face mask therapy is effective in patients who are growing but to a lesser degree in patients who are older than 10 years of age.

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