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The effects of non-extraction orthodontic treatment on the vertical dimension: a comparison of a dolichofacial and a mesofacial group

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Objective: The decision regarding extraction or non-extraction orthodontic treatment for patients with different skeletal facial patterns is more commonly based on traditional concepts rather than scientific facts. The present study aimed to investigate whether dolichofacial patients responded differently compared with mesofacial patients to non-extraction orthodontic treatment with respect to vertical changes in facial height.

Methods: Twenty-eight dolichofacial patients and 29 mesofacial patients who underwent non-extraction orthodontic treatment were selected. All patients commenced treatment prior to 15 years of age and had a mean age of 12.3 years for the dolichofacial group and 12.6 years for the mesofacial group. Serial lateral cephalometric radiographs were traced by hand on acetate paper and digitised using the Rocky Mountain Orthodontics JOE 32 programme. Statistical analysis examined the recorded changes in facial axis angle, facial angle, menton-to-ANS distance and facial convexity.

Results: An increase in menton-to-ANS distance and facial angle and a decrease in facial convexity were observed in both groups to a similar extent. Interestingly, the facial axis of both groups remained constant throughout treatment and up to two years post-treatment. Both groups showed slightly increased facial axis angle beyond the original value at two years post-treatment. No statistically significant difference between the two groups was observed in the changes of any of the variables over time.

Conclusion: The results countered the traditional concept that dolichofacial patients would have an increased facial height after being subjected to non-extraction orthodontic mechanics. It appeared that long-term vertical height of the face was more dependent on genetics rather than environmental influences.

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Introduction

Balance and harmony in the facial hard and soft tissues have been the main goals of orthodontic treatment. However, there has been continuing disagreement regarding the effect of treatment on the growth of the face, particularly in the lower facial third. Rickett's superimposition of Basion-Nasion at the CC point (the centre of the cranium) illustrated that facial form remained constant throughout life in non-orthodontically treated subjects, and when serial cephalometric tracings were superimposed, it was found that unaltered facial growth exhibited a concentric pattern.[1] The facial axis angle (the angle formed by the intersection of Basion-Nasion and Pt point-gnathion line) tended to remain constant with growth and increased in length approximately 3 mm per year.[1] An earlier study by Broadbent endorsed the view that the pattern of the face was established at the completion of eruption of the deciduous dentition without marked change in the proportion of the face thereafter.[2] Nanda[3] and Zaher et al.[4] similarly felt that vertical facial patterns appeared to stabilise early in life and were often maintained, but were not immune to subsequent change as growth proceeded.

Concern has been expressed regarding possible adverse effects on facial growth as a result of orthodontic mechanics, particularly in long-face patients. In 1964, Schudy claimed that vertical dimension was most important and that extrusion of the posterior teeth (both maxillary and mandibular) during orthodontic treatment would result in rotation of the mandible downward and backward.[5] Chan[6] demonstrated that, when compared to an untreated control group, a Class II patient group treated with non-extraction orthodontics had a significantly greater increase in anterior face height during treatment. This was consistent with results reported by Chua et al.[7] who showed that non-extraction treatment in Class I and Class II patients was associated with a significant increase in the lower anterior face height. However, many subsequent studies have also highlighted that both extraction and non-extraction treatment led to an increase in the vertical dimension simply due to the inevitable extrusive nature of the applied mechanics.[8-12]

Many studies associating orthodontic treatment with facial height have evaluated extraction or non-extraction treatment in patients with either a Class I or Class II horizontal skeletal pattern. Few investigators have assessed treatment differences and the growth response of patients with different pretreatment vertical facial types. A patient was considered to have a dolichofacial skeletal pattern if the facial axis was less than 86.5 degrees, whereas a patient was considered to have a mesofacial skeletal pattern when the facial axis was between 86.5 degrees and 93.5 degrees (within one standard deviation of the norm at 90 degrees). Brachyfacial skeletal pattern was defined with facial axis greater than 93.5 degrees.

Traditionally, it has been accepted that extraction treatment was preferred in dolichofacial patients because overbite increased, whereas non-extraction treatment was indicated for brachyfacial patients to minimise the risk of over-closure.[13] However, this reasoning has been poorly substantiated. Recently, non-extraction treatment has become popular due to the concerns regarding temporomandibular joint disorders, narrowed smiles with dark corners, dished-in profiles and suboptimal mandibular growth following extraction orthodontic treatment.[14-16]

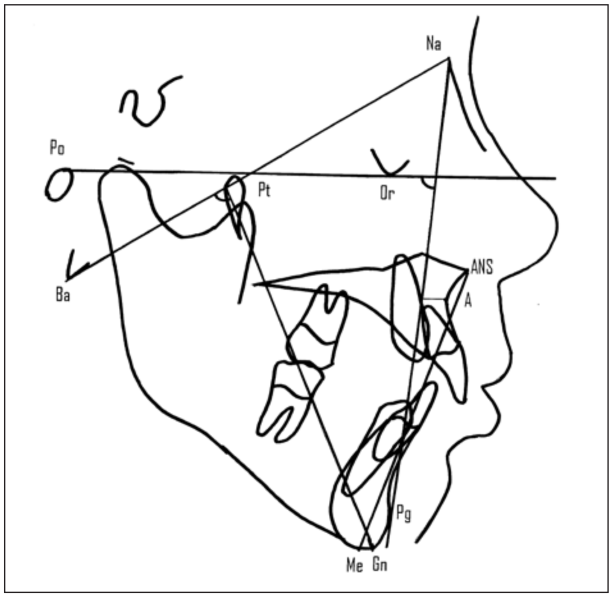

Figure 1. Reference points and measurements.
Facial axis angle: angle formed by Ba-Na and Pt-Gn
Facial angle: angle formed by Po-Or and Na-Pg
Lower face height: width formed by Me-ANS
Convexity of the face: angle formed by Na-Pt A-Pg

The purpose of the present study was to investigate the effect of non-extraction orthodontic treatment on the vertical dimension in patients of two different facial types. The null hypothesis to be tested was that there was no difference in facial height change between dolichofacial individuals compared to mesofacial individuals at the completion of treatment and two years thereafter.

Materials and methods

This retrospective study comprised two groups of treated patients, 28 with a dolichofacial skeletal pattern and 29 with a mesofacial skeletal pattern prior to treatment. Records were collected from the archived data from the Division of Graduate Orthodontics at Schulich School of Medicine and Dentistry at the University of Western Ontario. Patient treatments had been provided by the graduate students of the Division of Orthodontics. Both groups received non-extraction full fixed straight wire edgewise appliance treatment. Twelve subjects (46%) of the dolichofacial group received high pull headgear (HPHG) and six subjects (21%) of the mesofacial group received HPHG. The inclusion criteria included: 1) a patient age below 15 years at the commencement of treatment, 2) the availability of cephalometric radiographs at pretreatment (T1), post-treatment

(T2), and two years post-treatment (T3) and 3) full fixed appliance treatment without the extraction of any permanent teeth. The exclusion criteria included: 1) congenitally missing or extracted permanent teeth, with the exception of third molars, 2) orthognathic surgery patients and 3) patients with an identifiable dentofacial syndrome and/or pathology.

Lateral cephalometric radiographs were manually traced on acetate paper. The cephalometric landmarks and planes used in the present study had been previously reported by Ricketts et al.[1] The values of these measurements were digitally calculated using the Rocky Mountain Orthodontics JOE32 program and are shown in Figure 1. All radiographs were traced by the same operator. Structures appearing as bilateral images were identified by taking the average of two points. Eight random samples of the cephalometric radiographs from each group were retraced to calculate the measurement error using the error variance method. Means, standard deviations and frequency distributions of all demographic explanatory variables were computed at baseline and means and standard deviations were generated for four outcome variables (facial axis angle, facial angle, menton-ANS distance and facial convexity) at baseline, post-treatment and two years post-treatment. The JMP v7.0 statistical programme (SAS Institute Inc., Cary, NC, USA) was used to determine if there was any statistically significant difference between the dolichofacial and the mesofacial groups for each outcome variable over time using repeated measures analysis of variance. At each time point, *t*-tests were used to assess group differences in the outcome variables.

Results

The demographic characteristics of the study groups are presented in Table I. The groups were well balanced at baseline for gender distribution, age and race. The mean age was 12.3 ± 1.3 years for the dolichofacial group and 12.6 ± 1.3 years for the mesofacial group. The mean treatment times were very similar at 2.6 ± 0.7 years and 2.6 ± 0.9 years for the dolichofacial and the mesofacial group, respectively. Statistical analysis of the four outcome measures revealed pretreatment differences in facial axis angle, facial angle, menton-to-ANS distance and facial convexity between the dolichofacial and the mesofacial groups (Table II). Statistical significance ($p \leq 0.05$) of the observed differences between the facial types was maintained for each of the outcome measures at pretreatment, post-treatment and the two-year post-treatment assessment periods. Over the course of treatment and for two years post-treatment, the facial angle increased as the convexity decreased in both groups at essentially the same rate (Figures 2 and 3). Menton-to-ANS distance increased modestly in both facial patterns and the amount was almost identical for both groups (Figure 4). The facial axis remained relatively constant as it initially decreased during treatment and returned slightly beyond its original value in both facial types (Figure 5). Reproducibility of all measurements was calculated using the error variance method, which yielded a high intra-class correlation coefficient. The values ranged from 0.85 to 0.98 with a value of 1 accepted as a perfect correlation.

To further assess the validity of the result, two suspected outliers in the dolichofacial group were identified and removed. Table II shows that, after outlier removal, the mean values of the facial axis remained almost the same but the standard deviation reduced significantly (Table II and Figure 6).

Also, to eliminate the effects of HPHG, a separate analysis was conducted in which subjects who received HPHG were removed from both groups. Without HPHG intervention, the dolichofacial group showed a continuous increase in facial axis angle throughout the study period (Figure 7). There was no statistically significant difference in the changes observed between the two facial patterns for any of the four outcome variables over time. All outcome measures behaved similarly in both groups.

Discussion

Conventional wisdom accepted that non-extraction treatment was appropriate for brachyfacial patients while extraction treatment was desirable for dolichofacial patients. These theoretical approaches were based on the assumption that the extraction of premolars allowed molars to move mesially, decreasing the 'wedge-effect' and reducing the vertical dimension. Therefore, extractions would be a favourable treatment plan for dolichofacial patients, but detrimental to brachyfacial patients who already had reduced vertical dimension. However, a critical review of the literature has shown inconsistent results regarding changes in the vertical dimension with various orthodontic mechanics. Many studies have focused attention

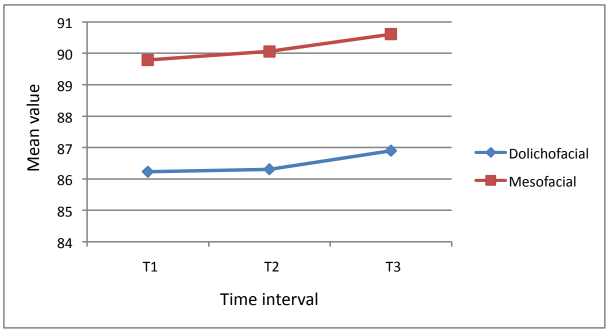

Figure 2. Change in mean facial angle over time. The facial angle increased at a similar rate for both groups as the mandible grew forward.

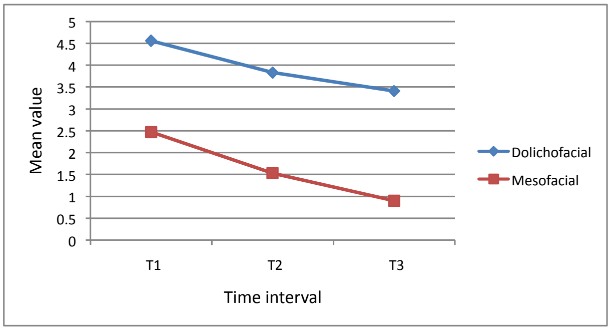

Figure 3. Change in mean convexity overtime. The convexity of both groups decreased at a similar rate. This was consistent with an increase in facial angle observed in both groups over time as the mandible grew forward.

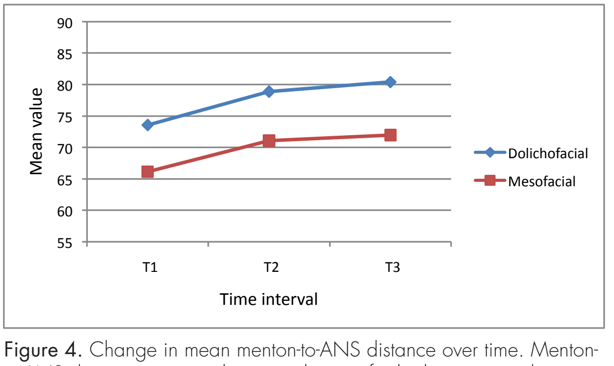

Figure 4. Change in mean menton-to-ANS distance over time. Menton-to-ANS distance increased at a similar rate for both groups, indicating a similar amount of increase in lower face height.

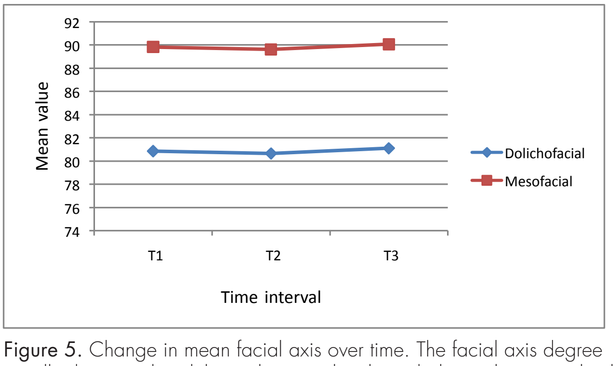

Figure 5. Change in mean facial axis over time. The facial axis degree initially decreased and then subsequently rebounded past the original value.

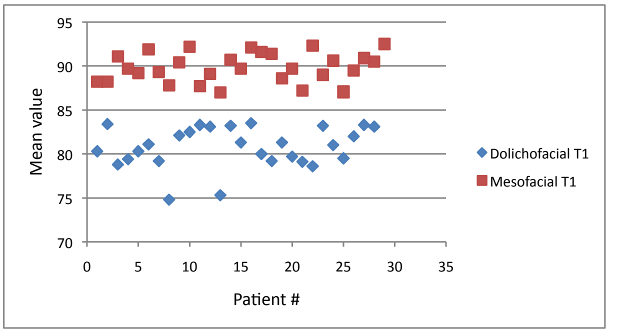

Figure 6. Scatterplot of facial axis distribution. Two outliers from the dolichofacial group were identified.

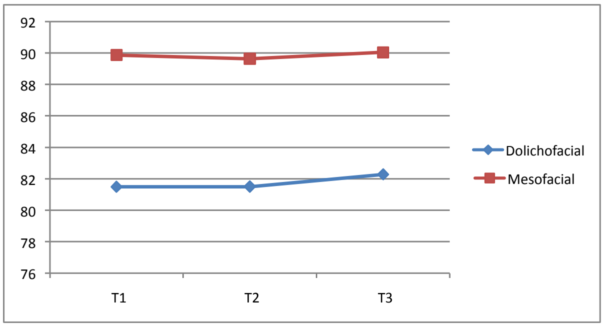

Figure 7. Change in mean facial axis over time. Patients who received HPHG were removed from the analysis to minimise the confounding effect. The mean values and trend remained very similar to that shown in Figure 5.

on a comparison of the two facial type extremes (dolichofacial and brachyfacial) but no study has compared dolichofacial to a normal mesofacial facial type. The present study therefore focused on the changes in vertical dimension of dolichofacial patients compared to a normal mesofacial growth pattern in response to non-extraction orthodontic treatment. Our results showed that, after controlling for age and facial type, no statistically significant changes were evident in vertical dimension. The results of the present study failed to reject the null hypothesis that there was no difference in the change in facial axis angle, facial angle, menton-to-ANS distance and facial convexity measures in the dolichofacial patients compared with the mesofacial patients when subjected to similar non-extraction orthodontic treatment. The mesofacial and the dolichofacial patients displayed similar decreases in convexity and increases in facial angle as the mandible expectedly grew in both groups. The comparable increase in the menton-to-ANS distance in the two groups also demonstrated a similar change in lower face height. Interestingly, both groups revealed a similar decrease in the facial axis angle, indicating that there was a slight backward

Table I. Demographic characteristics of facial type groups at pretreatment.

	Dolichofacial	Mesofacial
Sex	11 Males 17 Females	12 Males 17 Females
Mean age	12.3 yrs ± 1.3	12.6 yrs ± 1.3
Race	24 Caucasian 1 Chinese 0 Latin 3 Mixed heritage	24 Caucasian 0 Chinese 4 Latin 1 Mixed heritage

Table II. Means ± standard deviations of outcome measures by time period and facial type.

Time	Outcome measure	Dolichofacial group (N = 28)	Mesofacial group (N = 29)	Statistical significance (*p* value)
Pretreatment (T1)	Facial axis angle	80.85 ± 2.32 81.21 ± 1.71* 81.49 ± 1.59#	89.83 ± 1.68 89.87 ± 1.73#	< 0.0001
	Facial angle	86.23 ± 2.86	89.79 ± 2.91	< 0.0001
	Convexity	4.56 ± 2.21	2.47 ± 1.87	< 0.0002
	Menton-ANS	73.56 ± 4.31	66.14 ± 4.44	< 0.0001
Post-treatment (T2)	Facial axis angle	80.65 ± 2.95 81.18 ± 1.89* 81.51 ± 1.89#	89.62 ± 2.66 89.63 ± 2.61#	< 0.0001
	Facial angle	86.31 ± 3.24	90.06 ± 2.64	< 0.0001
	Convexity	3.83 ± 2.46	1.53 ± 2.15	< 0.0002
	Menton-ANS	78.88 ± 4.91	71.08 ± 5.85	< 0.0001
Two-years post-treatment (T3)	Facial axis angle	81.10 ± 3.27 81.47 ± 2.54* 82.28 ± 2.19#	90.06 ± 2.70 90.04 ± 2.70#	< 0.0001
	Facial angle	86.90 ± 3.40	90.61 ± 2.62	< 0.0001
	Convexity	3.41 ± 2.88	0.90 ± 2.18	< 0.0005
	Menton-ANS	80.40 ± 5.11	71.96 ± 6.06	< 0.0001

* after outliers were removed
\# after subjects who received HPHG were removed

rotation of the mandible in both treatment groups, probably in response to the extrusive nature of non-extraction mechanics. Both groups demonstrated a favourable increase of the facial axis during the two years post-treatment. The results were consistent with previous studies that had been conducted to investigate the effect of orthodontic treatment on the vertical dimension of the face. Klapper et al.[13] showed that there was no statistically significant difference in the facial axis angle change between the dolichofacial and the brachyfacial patients regardless of the facial type or treatment plan. It was concluded that treatment mechanics had more effect on upper molar position than facial types, and that there was a positive correlation between the amount of distalisation of the upper molars and the lengthening of the face. In addition, Kim et al.[10] demonstrated that the vertical dimension of patients with Class I malocclusion and hyperdivergent facial type did not decrease, regardless of maxillary and mandibular first premolar or second premolar extractions.

To further validate the current findings, treatment mechanics were taken into consideration. To date, there has been no evidence to suggest that functional appliance therapy could cause significant forward mandibular rotation in subjects who presented with dolichofacial growth pattern prior to treatment.[17,18] Two studies which assessed the use of transpalatal arches (TPA) found that the vertical control of the molars was no different from control groups treated in a similar fashion without a TPA.[19,20] Subjective and anecdotal findings have been reported regarding the clinical impact of high-pull headgear (HPHG) in controlling the extrusion of upper molars and in preventing an increase in vertical dimension. However, these findings have not been substantiated by clinical studies.[21-23] In the present study, twelve subjects (46%) of the dolichofacial group received HPHG and six subjects (21%) of the mesofacial group received HPHG. After subjects who received HPHG were removed from the statistical analysis, the same values were observed (Table II and Figure 7). Without HPHG intervention, the dolichofacial group showed an increase in facial axis angle throughout the entire study period. It is possible that HPHG, when not combined with TPA, allowed buccal tipping of the crowns of the upper molars. The accompanying extrusion of the mesiolingual cusp of the upper first molars may cause a backward rotation of the mandible. Therefore, it may be advisable to always combine TPA with HPHG.

In comparison with other studies, meaningful results were provided by the two-year post-treatment data. Evidence from the present study indicated that by two years post-treatment, the vertical dimension had not been influenced by orthodontic mechanics for either facial type. It was likely more strongly determined by genetics. As predicted by Ricketts, the facial axis remained constant throughout growth, even in orthodontically-treated patients.[24] The vertical dimensions of the facial skeleton have been previously shown to be under greater genetic control than the horizontal dimensions.[25] This was supported Zaher et al.[4] who noted that post-treatment changes in the cranial base, maxilla, mandible and maxillary-mandibular relationships were not significantly different between the various facial types.

It is concluded from the present study that the concern of a permanent adverse effect of orthodontic treatment on the vertical dimension of the dolichofacial patients is unjustified. Dolichofacial patients did not exhibit increased long-term lengthening of facial height compared with the mesofacial patients. The present study drew attention to the fallacy of conventional wisdom and the underestimation of the genetic component of vertical growth of patients. Orthodontic mechanics may create short-term change to the vertical dimension of the face, but it is suggested that long-term changes in vertical dimension are determined by the patient’s vertical growth pattern and muscle characteristics. These observations are further supported by Sharp et al.[26] who also found that orthodontic treatment had no long lasting effect on the vertical height of the molars and the face of 11-year-old girls following 12 years of post-treatment review, despite the differences in subject selection criteria.

Although the present study provided valuable insight, there were known limitations. Due to the strict inclusion criteria, the sample size was small. A retrospective study, based on a cephalometric analysis, landmark identification and measurement variation may create study error, and it is well known that many of the anatomical points used in the study undergo remodelling during growth. The chosen landmarks were readily identifiable by the single operator and repeated analysis showed consistency in measurement. The results may therefore form the basis of a larger prospective study of carefully screened experimental groups with similar initial characteristics and treatment mechanics provided by a single operator. In addition, a control group would help to provide a more compelling comparison of the influence of orthodontic treatments and genetics on the facial growth pattern.

Conclusions

The present study showed that facial height was not altered two years post-treatment in either mesofacial or dolichofacial patients who received non-extraction orthodontic treatment.

Facial height therefore appeared to be under the influence of genetics rather than treatment mechanics at the two-year post-treatment period. An evaluation and consideration of the influence of genetics on skeletal growth and development is suggested in the development of orthodontic treatment plans.

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