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Scientific Section

A Cephalometric Evaluation of Patients Presenting with Persistent Digit Sucking Habits

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Abstract. *Persistent digit sucking habits are an important aetiological factor for malocclusion, and patients with persistent habits are frequently referred for orthodontic treatment. The present study investigated the effects of digit sucking habits on vertical and anteroposterior dentofacial characteristics by employing a cephalometric analysis of patients with persistent digit sucking habits compared with patients without such habits. Significant differences were seen in maxillary prognathism, relative prognathism, maxillary incisor angulation, interincisal angle, maxillary length and maxillary plane angulation. No significant differences were observed for mandibular prognathism or length, maxillary mandibular plane angle, cranial base measurements nor any measurement of facial height. The digit sucking group were also found to have a larger variation of lower incisor angulation than the controls, although no significant difference in the mean value for this variable was detected. It is concluded that persistent digit sucking may cause largely dentoalveolar change, together with some minor effects on the skeletal pattern.*

Index words: Cephalometry, Finger Sucking, Malocclusion.

Refereed Paper

Introduction

Digit sucking habits have a well established reputation, both within the orthodontic profession and among patients, for causing malocclusion. While it is easy for orthodontists and patients to recognize that a relationship between digit sucking habits and malocclusion may exist, the precise detail of such a relationship requires clarification.

Considering malocclusion in general terms, Popovich (1966) found that 61 per cent of 10-year-old finger suckers had a serious malocclusion, compared to 31 per cent of 10-year-olds without habits. Köhler and Holst (1973) found that malocclusion was significantly more common among 4-year-old children with earlier or persistent habits, compared to children who had never had such a habit. More specifically, Larsson (1987) has classified the effects of digit sucking on the occlusion in terms of vertical, anteroposterior and transverse effects. This paper will concentrate on the first two of these groupings.

When considering the effects of digit sucking on the dentofacial region, two approaches have been adopted. Most studies have concentrated on recording the characteristics of the occlusion either by direct examination or by examination of study models. The second approach, which is much less widely reported in the literature, is that of analysis of lateral cephalograms. Indeed, there have been very few comprehensive cephalometric studies of digit suckers published.

Vertical variables

An extensive cephalometric analysis of some 320 nine-year-old children in Sweden was reported by Larsson (1972). The children were grouped according to their sucking habits as either persistent digit suckers ($n = 116$), previous dummy suckers ($n = 104$) or children with no history of sucking habits ($n = 100$). A total of 15 cephalometric variables were measured. In the vertical dimension, there was no significant difference in either upper anterior face height nor total anterior face height between digit suckers and the control group of non-suckers. No significant difference was observed in the total posterior face height, measured from sella to the perpendicular intersection with the mandibular plane. However, upper posterior face height, measured from sella to the perpendicular intersection with the maxillary plane was shown to be significantly increased in the digit sucking group. Considering the angulation of the maxillary and mandibular planes to the cranial base, the mandibular plane was found to be unaffected while the maxillary plane to cranial base angle was significantly reduced. This represents a rotation of the maxillary plane upwards anteriorly and downwards posteriorly. Measurement of the vertical position of the incisal edges relative to nasion showed that the maxillary incisor was positioned in a significantly higher position in digit suckers while the mandibular incisor was unaffected.

Following up the same patients at 16 years of age Larsson (1978) revealed that following cessation of the habits, the majority of vertical cephalometric variables reverted to being similar for previous digit suckers and controls who had never sucked. However, upper anterior face height was found to be significantly reduced in

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previous digit suckers. It is interesting that the angulation of the maxillary plane relative to the cranial base, which was significantly different in the study of 9-year-old persisting suckers was no longer significantly different at 16 years of age when habits had ceased. Brenchley (1991) investigated a group of patients who had Class II division 1 malocclusions. The group was divided into those with persistent digit sucking habits at the start of orthodontic treatment, those with a history of previous sucking which had ceased and those who had never sucked. During treatment, digit suckers demonstrated a rotation of the maxillary plane, with the anterior region moving in an downwards direction and the posterior region moving in an upwards direction. Similarly, the ratio of upper anterior face height to lower anterior face height was found to increase significantly during treatment for the digit suckers than for the controls. It was concluded that digit sucking can alter the angulation of the maxillary plane and that during treatment favourable changes may occur as the habit is interrupted or ceases which assist the correction of the malocclusion. Rotation of the maxillary plane among digit suckers was also reported by Taft and Hempstead (1966), together with a significant increase in the distance between sella and pterygomaxillare.

Anterioposterior variables

In his 1972 study, Larsson considered a number of anteroposterior variables. Maxillary incisors were significantly more proclined in digit suckers, both when measured as the angulation to the maxillary plane and when the position of the incisal edge was measured relative to the line joining the reference points of nasion and gnathion. No significant difference was observed in the lower incisor position. The skeletal relationship was noted to be altered also, with SNA increased significantly in digit suckers, whilst SNB was unaffected. When he reviewed the patients at 16 years of age, after their habits had ceased, Larsson (1978) found that while the angulation of the incisors was no longer significantly different from the controls, the value of SNA remained significantly greater. In addition, the anteroposterior length of the maxillary skeletal base was found to be increased significantly for the group with a history of digit sucking habits.

The effect of digit sucking habits on lower incisor angulation is a little less clear. Backlund (1963) reported that digit sucking causes proclination of the lower incisors as a consequence of tongue pressure. Larsson's (1972) study found a small, but not statistically significant, proclination of lower incisors. Taft and Hempstead (1966) felt that lower incisors are proclined in digit suckers, Gardiner (1956), however, found digit suckers to have retroclined lower incisors. Subtelny and Subtelny (1973) found that those children who suck and also have retroclined incisors show a greater degree of mandibular movement during the sucking process.

Willmot (1984) reported on two 14-year-old monozygous twins, one of whom had a digit sucking habit. Interestingly, the majority of measurements were similar for both girls, with only SNA being significantly greater in the digit sucker.

Methods and Materials

The present study formed part of a broader investigation into digit sucking habits among new patient referrals to the Orthodontic Department of a District General Hospital. A study group was selected from all new patients seen in the Orthodontic Department at Victoria Hospital Kirkcaldy between 1st January and 31st August 1992. Criteria for inclusion in the study group were that a digit sucking habit was persisting at the time of the consultation, the patient was 10 years or older, and that the parents consented to their child's participation in the investigation. Although no patients formally declined to participate, four patients failed to attend on two occasions for records and were excluded. The final study group was composed of 44 patients and the age and sex distribution is shown in Fig. 1.

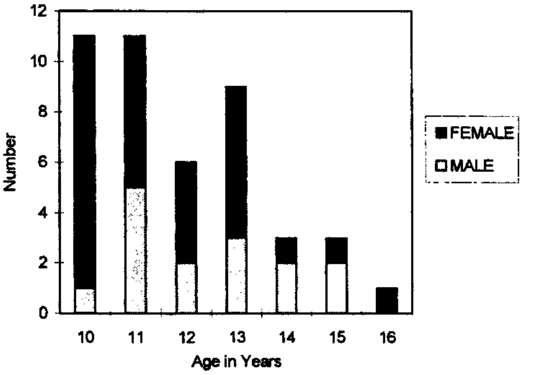

FIG. 1. Age and sex distribution of the Study and Control Groups

Each member of the Study Group was asked to demonstrate their particular digit sucking habit. Thirty-nine subjects (89 per cent) sucked their thumb with the palmar surface uppermost. Five subjects (7 per cent) sucked a finger or fingers with the palmar surface uppermost. Two subjects (4 per cent) sucked a finger or fingers with the dorsal surface uppermost. It had been hoped that analysis of the effects of different sucking methods would be possible, but in view of the numbers in the later two groups, meaningful comparison was not possible. The particular position of the digit relative to the median plane was not recorded.

For comparison a control group was selected from the new patient clinics at the same Hospital. The control group was selected to match the age and sex distribution of the study group. Patients of suitable age and sex were identified from the clinic lists prior to the consultation with no knowledge of their problem and without referring to the referral letter. Following their consultation these patients were invited to act as controls in the study. The only reasons for their exclusion were if they declined (one patient), or if they had a persistent digit sucking habit at the time of consultation (one patient), or if a lateral skull radiograph had not been considered necessary for their orthodontic assessment (two patients). Since the age and sex distribution of the control group were matched to that of the study group it was necessary to stagger the collection period for members of the control group, which was from 1st March 1992 to 12th January 1993. The final control group was composed of 44 patients with the age and sex distribution shown in Fig. 1. Of the control group, 22 (50 per cent) had Class I malocclusions, 14 (32 per cent) had Class II division 1 malocclusions, five (11 per cent) had Class II division 2 malocclusions, and three (7 per cent) had Class III malocclusions.

All patients in the study and control groups had standardized cephalometric lateral skull radiographs taken. These were justified on the basis of clinical need as part of their orthodontic assessment. These films were studied for the present investigation. All films were taken using the same Siemens Orthoceph 10s Cephalostat following a standard protocol. The patients were positioned in the Cephalostat with the Frankfort plane horizontal. A millimetre rule was positioned in line with the patients mid-sagittal plane to allow a check on the uniformity of magnification. The study group had a mean magnification of 8·85 per cent, (SD 1·97). The control group had a mean magnification of 8·72 per cent (SD 2·19). A two sample *t*-test revealed no significant difference in the magnification for the study group and the control group ($P > 0{\cdot}05$).

A range of anatomical landmarks were traced onto acetate to allow identification of specific points for digitization and computer analysis. Tracing was carried out in a darkened room, with the area of the lightbox surrounding the cephalogram shielded for optimum landmark identification. Cephalograms were traced in batches of 10–15 mixed from both the study group and the control group, and no attempt was made to identify the groups of films during tracing and subsequent digitization. When all the films had been traced the tracings were then digitized and analysed using the Dentofacial Planner Cephalometric Analysis Program, Version 5.3 (Dentofacial Software Incorporated, Toronto, Canada). A total of 11 angular and eight linear variables were measured for each patient. Table 1 lists the variables and their definitions.

An evaluation of method error was undertaken by performing repeat assessments on 25 of the cephalograms, as recommended by Houston (1983). Twelve cephalograms were randomly selected from the control group and 13 from the study group. The tracing and digitization was carried out by the same examiner with a minimum interval of 2 weeks between the first and second tracing/digitization. For each variable a one-sample *t*-test was conducted to test for systematic errors and the standard deviation of the difference between first and second readings was calculated as an estimate of random errors. The results of the method error assessment are presented in Table 2. For all 19 variables the *t*-test was unable to detect any significant difference between first and second readings at the 10 per cent level. The random errors estimated by the standard deviation of the replicated measurements were considered to be within acceptable limits, and comparison with the work of Sandler (1988) would suggest that the methods used in this study were not unduly susceptible to error.

The data was statistically analysed using the Epi Info computer program, Version 5.0 (USD Incorporated, 2075 A West Park Place, Stone Mountain GA 30087, U.S.A.)

TABLE 1 *Cephalometric variables investigated*

Variable	Description
s–n–ss	Maxillary prognathism, the angle between sella, nasion, and A point
s–n–sm	Mandibular prognathism, the angle between sella, nasion, and B point
ss–n–sm	Relative prognathism, the angle between A point, nasion, and B point
ba–s–n	Cranial base angle, the angle between basion, sella, and nasion
MXP–MNP	The angle between the maxillary plane and the mandibular plane
ILs–MXP	The angle between the maxillary incisor and the maxillary plane
ILi–MNP	The angle between the mandibular incisor and the mandibular plane
ILi–ILs	The interincisal angle
ILs–SNL	The angle of the maxillary incisor relative to the anterior cranial base
MXP–SNL	The angle of the maxillary plane relative to the anterior cranial base
MNP–SNL	The angle of the mandibular plane relative to the anterior cranial base
pm–sp	Maxillary length, measured between posterior nasal spine (where the nasal floor and the posterior contour of maxilla intersect) and anterior nasal spine
cd–gn	Mandibular length, measured between condylion and gnathion
n–sp	Upper anterior face height, the vertical distance between nasion and anterior nasal spine
sp–gn	Lower anterior face height, the vertical distance between anterior nasal spine and gnathion
n–gn	Total anterior face height, the vertical distance between nasion and gnathion
s–pm	Posterior face height, measured from sella to posterior nasal spine
s–n	Anterior cranial base length, measured from sella to nasion
s–ba	Posterior cranial base length, measured from sella to basion

For each variable and for each group, the range, mean value, standard error of the mean and standard deviation were calculated. Table 3 details the results for the study group, Table 4 the results for the control group, and Table 5 the comparison of the mean values of each variable between the study group and the control group.

Results

Measurements of prognathism

Maxillary prognathism (SNA) and relative prognathism (ANB) were both significantly increased in the digit sucking group compared with the Control Group ($P < 0{\cdot}01$). No significant difference was present for mandibular prognathism (SNB).

Incisor angulation

Maxillary incisors were found to be significantly more proclined in the digit sucking group when their angle was measured relative to both the cranial base (ILs–SNL) and to the maxillary plane (ILs–MXP). No significant differ-

TABLE 2 *Results of method error assessment, repeat measurement of 25 cephalograms. Angular measure - ments are expressed in degrees, linear measurements in millimeters*

Variable	Mean difference between first and second reading	One sample *t*-test *t*-value	*P*	Standard deviation of difference between readings
s–n–ss	0·18	0·58	>0·5	1·56
s–n–sm	0·18	1·25	>0·2	0·81
ss–n–sm	0·49	1·01	>0·3	0·70
ba–s–n	0·43	1·68	>0·1	1·28
MXP–MNP	0·01	0·03	>0·9	1·59
ILs–MXP	0·49	1·01	>0·3	2·41
ILi–MNP	0·59	1·34	>0·1	2·19
ILi–ILs	1·09	1·67	>0·1	3·26
ILs–SNL	0·76	1·52	>0·1	2·48
MXP–SNL	0·26	1·02	>0·3	1·30
MNP–SNL	0·25	1·16	>0·2	1·09
pm–sp	0·54	1·59	>0·1	1·70
cd–gn	0·45	1·00	>0·3	2·27
n–sp	0·43	1·45	>0·1	1·48
sp–gn	0·24	0·94	>0·3	1·25
n–gn	0·24	0·70	>0·4	1·71
s–pm	0·28	1·12	>0·2	1·24
s–n	0·27	1·59	>0·1	0·84
s–ba	0·50	1·32	>0·1	1·89

TABLE 3 *Results of cephalometric analysis for study group. Angular measurements are expressed in degrees, linear measurements in millimeters*

Variable	Min	Max	Mean	Standard error of mean	Standard deviation
s–n–ss	76·8	92·8	83·7	0·6	3·7
s–n–sm	70·1	87·5	78·3	0·5	3·6
ss–n–sm	0·8	9·5	5·3	0·3	2·1
ba–s–n	118·9	138·9	129·6	0·7	4·4
MXP–MNP	16·1	40·2	28·1	0·7	4·8
ILs–MXP	100·4	126·3	113·9	0·9	5·8
ILi–MNP	69·5	107·0	94·1	1·2	7·82
ILi–ILS	104·2	150·0	123·9	1·5	9·9
ILs–SNL	94·0	127·8	108·2	1·0	6·9
MXP–SNL	−1·8	11·4	5·7	0·4	2·7
MNP–SNL	22·9	43·5	33·8	0·8	5·1
pm–sp	46·7	63·1	55·0	0·6	3·7
cd–gn	99·3	134·8	115·1	1·0	6·7
n–sp	40·4	56·8	49·7	0·5	3·4
sp–gn	47·5	74·6	61·8	0·8	5·4
n–gn	92·7	127·9	111·5	1·1	7·4
s–pm	42·9	55·3	47·6	0·5	3·1
s–n	65·3	82·0	72·5	0·5	3·6
s–ba	36·6	54·9	47·3	0·6	4·0

ence was observed in the angle of the mandibular incisors relative to the mandibular plane (IL-–MNP), although the standard deviation was slightly higher in the digit sucking group, indicating a wider level of variability. The interincisal angle ILi–ILs was found to be significantly reduced in the digit sucking group ($P < 0·01$).

Maxillary and mandibular lengths

The maxillary length measured from the anterior to the posterior nasal spines was found to be significantly increased in the digit sucking group. There was no such significant difference in the length of the mandible.

Cranial base measurements

Anterior cranial base length, posterior cranial base length and the cranial base angle were all found to differ very little between the study group and the control group, and the differences were not statistically significant.

Vertical height measurements

Upper posterior face height was measured as the true distance between sella and the posterior nasal spine. Although the mean value for the study group was 1·1 mm greater than for the control group, this was not found to be statistically significant ($P = 0·09$). Anterior face height

TABLE 4 *Results of cephalometric analysis for control group. Angular measurements are expressed in degrees, linear measurements in millimeters*

Variable	Min	Max	Mean	Standard error of mean	Standard deviation
s–n–ss	73·1	88·3	80·9	0·6	3·9
s–n–sm	69·5	86·8	77·3	0·6	4·1
ss–n–sm	−3·7	10·0	3·6	0·4	2·5
ba–s–n	117·1	140·8	129·7	0·7	4·6
MXP–MNP	14·7	51·6	27·6	0·9	6·1
ILs–MXP	77·2	122·5	106·2	1·4	9·1
ILi–MNP	78·4	110·5	93·8	1·0	6·9
ILi–ILS	103·8	171·1	133·2	2·3	15·0
ILs–SNL	71·8	114·9	98·8	1·4	9·2
MXP–SNL	0·1	15·5	7·4	0·5	3·5
MNP–SNL	23·5	50·3	34·3	0·8	5·0
pm–sp	44·8	58·4	52·4	0·5	3·2
cd–gn	97·4	124·2	113·9	0·1	6·6
n–sp	43·6	59·3	50·1	0·5	3·3
sp–gn	52·8	76·4	61·9	0·9	6·0
n–gn	99·5	135·7	112·0	1·1	7·5
s–pm	41·7	52·9	46·5	0·4	3·0
s–n	65·9	81·1	71·5	0·6	3·8
s–ba	38·2	53·3	47·3	0·5	3·1

TABLE 5 Comparison of the mean values of each variable between the study group and the control group. Angular measurements are expressed in degrees, linear measurements in millimeters

Variable	Study group mean	Control group mean	Difference between means	*t* value	*P* value
s–n–ss	83·7	80·9	2·8	3·4	<0·01
s–n–sm	78·3	77·3	1·0	1·2	N/S
ss–n–sm	5·3	3·6	1·7	3·5	<0·01
ba–s–n	129·6	129·7	−0·1	0·1	N/S
MXP–MNP	28·1	27·6	0·5	0·4	N/S
ILs–MXP	113·9	106·2	7·7	4·7	<0·01
ILi–MNP	94·1	93·8	0·3	0·2	N/S
ILi–ILs	123·9	133·2	−9·3	3·4	<0·01
ILs–SNL	108·2	98·8	9·4	5·4	<0·01
MXP–SNL	5·7	7·4	−1·7	2·5	<0·05
MNP–SNL	33·8	34·3	−0·5	0·4	N/S
pm–sp	55·0	52·4	2·6	3·6	<0·01
cd–gn	115·1	113·9	1·2	0·9	N/S
n–sp	49·7	50·1	−0·4	0·7	N/S
sp–gn	61·8	61·9	−0·1	0·1	N/S
n–gn	111·5	112·0	−0·5	0·4	N/S
s–pm	47·6	46·5	1·1	1·7	N/S
s–n	72·5	71·5	1·0	1·3	N/S
s–ba	47·3	47·3	0·0	<0·0	N/S

was measured by using three vertical distances, rather than true distance. The Frankfort plane was used as a reference line for orientation of the films. Mean values for upper anterior face height, lower anterior face height and total anterior face height were all found to have very small differences, none of which achieved statistical significance.

In summary, six of the variables were found to have differences between digit suckers and non digit suckers which were significant at the 1 per cent level, these being s–n–ss (SNA), ss–n–sm (ANB), ILs–MXP, ILi–ILs, ILs–SNL, and pm–sp. One variable was significantly different at the 5 per cent level, MXP–SNL. The remaining variables were not found to be significantly different between the groups.

Discussion

The present study investigated vertical and antero-posterior cephalometric differences between new referrals with digit sucking habits and those without such habits. A number of significant differences were observed which can reasonably be attributed to the persistent digit sucking. ‘A’ point tended to be more anteriorly positioned in the digit suckers, and this may be expected with one considers the lever effect of a thumb of finger creating an anteriorly directed force on the maxillary alveolar process and incisors. A criticism of the use of ‘A’ point in the measurement of maxillary prognathism is that the landmark is influenced by the degree of proclination of the maxillary incisors. The digit suckers in this study were found to have significantly proclined maxillary incisors, and this certainly will have contributed to the observed Class II skeletal base tendency. Persistent digit suckers are more likely to present with Class II skeletal base relationships, which result from increased maxillary prognathism and maxillary incisor proclination. As was mentioned in the introduction, there is some disagreement about the effect of digit sucking on the mandibular incisors. The present study was unable to detect any significant difference in the lower incisor angulation of digit suckers. This finding is in agreement with Larsson (1972). However, there was an increased standard deviation among the digit suckers for this parameter, which may indicate that there are some cases with more retroclined incisors whilst others have more proclined incisors than usual. The study group was not large enough to allow breakdown into subgroups with different patterns of digit sucking, but it seems likely that the effect of habits on the lower incisors will depend on exactly how the digit is positioned and the action of the tongue during the sucking process. The position of the digit relative to the median plane was not recorded in this study, and it remains possible that this factor could influence the lower incisor angulation. The interincisal angle showed an expected reduction which can be attributed to the proclination of the maxillary incisors.

Only one of the linear variables was significantly altered in the digit suckers, this being maxillary length. This would suggest that forward growth is encouraged by the light long-term force generated during the habit.

Of particular interest is the observation that the maxillary plane angle was altered to a significant degree, with the anterior region rotating upwards and the posterior region rotating downwards. The presence of the rotation as indicated by the angle MXP–SNL was confirmed by the observation that the upper posterior face height s–pm was larger in the digit suckers and the anterior face height n–sp was smaller in the digit suckers. These two variables did not achieve statistical significance, but when considered alongside the significant maxillary plane angle change they support the view that rotation had occurred. These results are consistent with those of Larsson (1972). While it is reasonable to assume that the presence of the digit may offer some resistance to the downward growth of the anterior maxilla, the effect on the posterior end of the maxillary plane is a little harder to explain. It is possible that the downward, displacement of the mandible which occurs during digit sucking may result in a stretching of the palatoglossus muscles and overlying mucosa, thus generating a downward force on the posterior edge of the maxillary complex. Furthermore, the generation of suction at the posterior region of the oral cavity during the sucking process may be of importance.

As well as finding some important significant differences between digit suckers and non-suckers, this study found a number of interesting similarities. All of the cranial base measurements were similar between the two groups. This is not expected since digit sucking habits are remote to the cranial base and would not be expected to have an effect. However, these parameters offer support to the validity of the control group.

When considering the vertical height measurements, it has already been mentioned that the changes in upper anterior face height and upper posterior face height appear to be part of an overall rotation of the maxillary plane. However, neither the lower anterior face height nor the total anterior face height demonstrated differences between the groups of statistical significance. This would suggest that digit suckers who develop anterior open bite do so largely through dentoalveolar modification rather than by any substantial skeletal change. The observation that the maxillary-mandibular plane angle was similar in both the anomaly and control groups would support this view.

Conclusions

Persistent digit sucking habits among new patients attending a Hospital Orthodontic Department were found to be associated with:

(1) increased maxillary prognathism;
(2) increased relative prognathism;
(3) increased maxillary incisor proclination;
(4) reduced interincisal angle;
(5) increased maxillary anteroposterior length;
(6) rotation of the maxillary plane downwards posteriorly and upwards anteriorly.

These variables were significantly different from the control group at the 1 per cent level, except for rotation of the maxillary plane which was significant at the 5 per cent level.

No significant associations were observed between persistent digit sucking habits and mandibular prognathism, cranial base measurements, maxillary-mandibular plane angle, nor any face height measurement.

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