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Linear and Angular Changes in Dento-facial Dimensions in the Third Decade

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Abstract. *The object of the study was to examine changes in dento-facial dimensions and relationships during the third decade of life, and consisted of a prospective cephalometric study. The data used consisted of 90 degree left lateral cephalometric radiographs of 21 males and 26 females at ages 18 years (T1) and 21 years (T2), and for 15 of the males and 22 of the females at 28 years (T3).*

Various dimensions representative of dento-facial morphology were measured and the changes in dimensions over time were calculated and tested for significance with the one sample t*-test.*

In general, skeletal and dental relationships remained relatively stable. Face height and jaw length dimensions increased by small amounts.

Index words: Adult facial growth.

Refereed Paper

Introduction

It is generally recognized that small changes in dentofacial dimensions and relationships occur in adult life. It has been suggested that these may be sufficient to account for post-retention changes in the occlusion and alignment of the dentition in subjects who have undergone orthodontic treatment (Sarnäs and Solow, 1980; Behrents *et al*., 1989; Bondevik, 1995).

Longitudinal studies on untreated, dentate subjects after the age of 20 years using cephalometric radiographs report an increase in anterior face height, but a measure of disagreement exists as to the nature and amount of the changes in some other dimensions, notably incisor angulations (Forsberg, 1979; Sarnäs and Solow, 1980; Behrents, 1985; Forsberg *et al*., 1991; Bishara *et al*., 1994; Bondevik, 1995).

The purpose of the present investigation was to examine the changes in some dentofacial parameters in untreated, dentate subjects during the third decade of life.

Subjects and Methods

Ninety-degree left lateral cephalometric radiographs were available for 21 males and 26 females at ages 18 (T1), and 21 (T2) years and for 15 of the males and 22 of the females at 28 years (T3).

The sample included ideal and good occlusions, and a variety of malocclusions. None had orthodontic treatment. All had intact lower arches, anterior to and including second molars, at all stages. Third molar status was variable and included congenitally missing, extracted, erupted, and impacted teeth.

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Measurements

Cephalometric landmarks (Figure 1) were traced and digitised using a GTCO 2436LM PC controlled digitizer, and the following angular and linear measurements were calculated using the Gela programme:-

- Upper incisor to maxillary plane (UI/ANS–PNS)
- Lower incisor to mandibular plane (LI/Go–Me)
- Inter-incisal angle (UI/LI)
- Maxillary/mandibular planes angle (MM)
- Upper anterior face height (UAFH)—nasion perpendicular to ANS/PNS
- Lower anterior face height (LAFH)—menton perpendicular to ANS/PNS
- Total anterior face height—UAFH + LAFH (N–Me)
- Posterior face height—articulare to gonion (Ar–Go)
- Maxillary length 1—articulare to A point (Ar–A)
- Maxillary length 2—pterygomaxillary point to A point (Ptm–A)
- Mandibular length 1—articulare to B point (Ar–B)
- Mandibular length 2—articulare to pogonion (Ar–Pog)
- Mandibular length 3—gonion to pogonion (go–Pog)

The changes in measurements from T1–T2, T2–T3, and T1–T3 were calculated. Positive values indicated an increase in height and length dimensions, the inter-incisal and maxillary/mandibular planes angle, and proclination of incisors.

All radiographs were traced twice at an interval of at least 1 month by one individual (JG). Each tracing was digitized once and the error of measurement calculated between replicate tracings. The mean value was used for the calculations.

Statistical Tests

Systematic and random measurement errors were tested between replicate measurements by means of the one

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sample *t*-test and the coefficient of reliability (Houston, 1983).

Means and standard deviations for all measurements at T1, T2, and T3 were calculated for males and females separately.

Differences in measurements at T1, and differences in the change in measurements from T1 to T2 and T2 to T3 between males and females were tested with the independent samples *t*-test.

The significance of the changes in measurements between T1 and T2, T2, and T3, and T1 and T3, and the differences between the changes in inter-maxillary lengths (Ar/A–Ar/B) were tested with the one sample *t*-test.

Significance was set at the 5 per cent level.

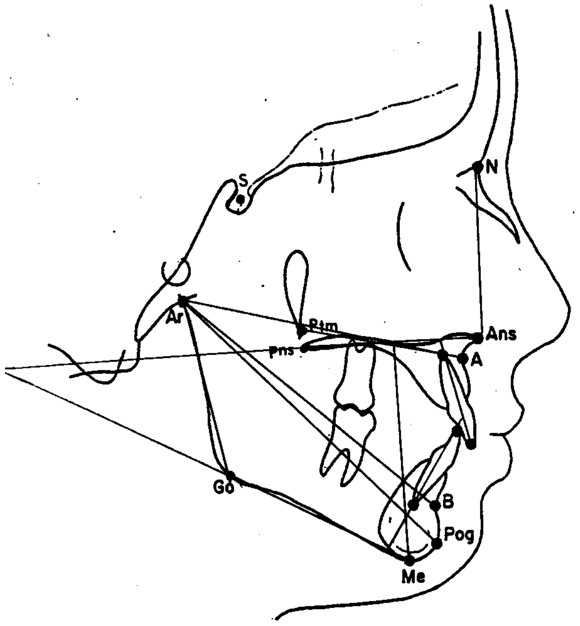

FIG. 1 Cephalometric reference points and dimensions used in the investigation.

Results

Systematic errors ranged from 0·05 to 1·2 mm or degrees. Reliability coefficients, testing for random errors, all exceeded 0·88.

At T1 (18 years) there were no significant differences in incisor inclinations between males and females. The maxillary-mandibular planes angle (ANS–PNS/Go–Me) was larger in females (5·53, $P < 0{\cdot}05$).

Anterior and posterior face height and jaw length measurements were larger in males (Table 1).

From T1 (18 years) to T2 (21 years) the lower incisors proclined by 0·77 degree in females, significantly different from a 0·54 degree retroclination in males. Changes in all other dimensions did not differ significantly between males and females (Table 2).

From T2 (21 years) to T3 (28 years) the maxillary-mandibular planes angle (ANS–PNS/Go–Me) increased by 0·84 degree in females, significantly different from a 0·20 degree decrease in males. Posterior face height increased significantly in males but not in females. None of the other dimensional changes differed between males and females (Table 3).

From T1 (18 years) to T2 (21 years) (Table 2) angular changes were non-significant except for a small, but statistically significant retroclination of the upper incisors (0·9 degree, $P < 0{\cdot}05$) in females. Upper anterior face height (N/ANS–PNS) increased by 0·21 mm ($P < 0{\cdot}05$) in males but did not change significantly in females or the pooled sample. Lower anterior face height (Me/ANS–PNS) increased significantly by approximately 0·5 mm in all groups. Total anterior face height (N/Me) increased significantly by 0·63 mm ($P < 0{\cdot}01$) in males and 0·52 mm ($P < 0{\cdot}01$) in the pooled sample, but the increase in females was non-significant. Small increases in posterior face height (Ar-Go) were non-significant in all groups. Maxillary length (Ar/A) increased significantly in males (0·71 mm, $P < 0{\cdot}01$) and the pooled sample (0·47 mm, $P < 0{\cdot}01$), but not in females. Small changes in maxillary length (Ptm/A) were non-significant in all groups. Mandibular length (Ar/B) increased significantly in males (0·43 mm, $P < 0{\cdot}05$), but not in females or the pooled sample. Ar/Pog increased

TABLE 1 *Means and standard deviations for cephalometric parameters for males (21) and females (26) at T1 (18 years), and the differences between males and females*

	Males		Females		M − F	
Variable	Mean	SD	Mean	SD	Mean	SE
UI/ANS–PNS (°)	110·66	8·64	107·68	5·54	2·98	2·22
LI/Go–Me (°)	94·90	7·14	95·96	6·49	−0·96	2·04
UI/LI (°)	134·18	12·49	130·03	11·99	4·15	3·65
ANS–PNS/Go–Me (°)	20·39	5·11	25·92	6·12	−5·53*	1·66
N/ANS–PNS (mm)	57·91	3·33	53·29	3·37	4·62***	0·10
Me/ANS–PNS (mm)	69·95	5·33	66·07	5·03	3·88*	1·55
N/Me (mm)	127·92	6·09	119·38	7·36	8·54***	1·98
Ar/Go (mm)	57·06	4·24	50·20	4·49	6·86***	1·36
Ar/A (mm)	95·92	4·56	88·40	3·27	7·52***	1·20
Ptm/A (mm)	60·36	3·24	55·19	2·28	5·17***	0·85
Ar/B (mm)	106·68	4·7	98·18	4·21	8·50***	1·34
Ar/Pog (mm)	119·61·	4·66	109·54	4·81	10·07***	1·40
Go/Pog (mm)	81·89	4·21	75·31	5·35	6·58***	1·41

*$P < 0{\cdot}05$; **$P < 0{\cdot}01$; ***$P < 0{\cdot}001$.

TABLE 2 *Changes in cephalometric parameters from T1 (18 years) to T2 (21 years) for males (21), females (26), the pooled sample (47) and the differences between males and females*

	Males		Females		Pooled		M − F	
Variable	Mean	SE	Mean	SE	Mean	SE	Mean	SE
UI/ANS–PNS (°)	0·05	0·48	−0·90*	0·44	−0·42	0·79	−0·95	1·77
LI/Go–Me (°)	−0·54	0·48	0·77	0·45	0·16	0·34	−1·31*	0·65
UI/LI (°)	0·82	0·77	0·33	0·59	0·55	0·47	0·49	0·99
ANS–PNS/Go–Me (°)	−0·32	0·36	−0·22	0·22	−0·27	0·20	−0·10	0·44
N/ANS–PNS (mm)	0·21*	0·08	−0·12	0·18	0·05	0·11	0·33	0·20
Me/ANS–PNS (mm)	0·50*	0·24	0·56**	0·17	0·53***	0·14	−0·06	0·30
N/Me (mm)	0·63**	0·20	0·42	0·22	0·52**	0·15	0·21	0·30
Ar/Go (mm)	0·57	0·45	0·36	0·38	0·46	0·29	0·21	0·60
Ar/A (mm)	0·71**	0·20	0·23	0·18	0·47**	0·14	0·48	0·27
Ptm/A (mm)	−0·21	0·36	0·28	0·23	0·07	0·21	−0·49	0·44
Ar/B (mm)	0·43*	0·18	0·05	0·23	0·24	0·15	0·38	0·30
Ar/Pog (mm)	0·77**	0·21	0·36*	0·16	0·57***	0·13	0·41	0·26
Go/Pog (mm)	0·46	0·36	−0·30	0·28	0·08	0·22	0·76	0·46

$^*P < 0{\cdot}05$; $^{**}P < 0{\cdot}01$; $^{***}P < 0{\cdot}001$.

TABLE 3 *Changes in cephalometric parameters from T2 (28 years) to T3 (21 years) for males (15), females (22), the pooled sample (37) and the differences between males and females*

	Males		Females		Pooled		M − F	
Variable	Mean	SE	Mean	SE	Mean	SE	Mean	SE
UI/ANS–PNS (°)	−0·18	0·54	0·41	0·56	−0·17	0·40	−0·59	0·78
LI/Go–Me (°)	0·42	0·44	−0·38	0·38	0·02	0·30	0·80	0·58
UI/LI (°)	−0·03	0·78	−0·84	0·67	−0·57	0·51	0·81	1·03
ANS–PNS/Go–Me (°)	−0·20	0·32	0·84*	0·30	0·32	0·24	1·04*	0·44
N/ANS–PNS (mm)	0·50*	0·19	0·45*	0·19	0·47**	0·13	0·05	0·27
Me/ANS–PNS (mm)	1·67***	0·39	1·54***	0·24	1·60***	0·21	0·13	0·46
N/Me (mm)	2·22**	0·56	2·07***	0·28	2·13***	0·28	0·15	0·63
Ar/Go (mm)	1·68**	0·45	0·17	0·47	0·92*	0·35	1·51*	0·65
Ar/A (mm)	1·22**	0·32	0·85**	0·29	1·04***	0·21	0·36	0·43
Ptm/A (mm)	0·43	0·63	0·10	0·34	0·27	0·32	0·33	0·72
Ar/B (mm)	1·53***	0·35	1·04***	0·22	1·29***	0·20	0·49	0·41
Ar/Pog (mm)	1·87***	0·33	1·42***	0·26	1·65***	0·20	0·45	0·42
Go/Pog (mm)	0·72	0·56	1·54**	0·44	1·13**	0·35	−0·82	0·71

$^*P < 0{\cdot}05$; $^{**}P < 0{\cdot}01$; $^{***}P < 0{\cdot}001$.

significantly in all groups. Mandibular body length (Go/Pog) did not change significantly in any group.

From T2 to T3 (Table 3) the incisor angulations did not change significantly in any of the groups. The maxillary/mandibular planes angle (ANS–PNS/Go–Me) increased significantly in females (0·84 degree, $P < 0{\cdot}05$). Anterior face height, upper (N/ANS–PNS), lower (Me/ANS–PNS) and total (N/Me) increased significantly in all groups. Posterior face height (Ar/Go) increased significantly in males (1·68 mm. $P < 0{\cdot}01$) and the pooled sample (0·92 mm, $P < 0{\cdot}05$), but not in females. Maxillary length (Ar/A) increased significantly in all groups. the changes in Ptm/A were non-significant. Mandibular length (Ar/B and Ar/Pog) increased significantly in all groups. Mandibular body length (Go/Pog) increased significantly in females and the pooled sample but non-significantly in males.

The cumulative changes from T1 to T3 are shown in Table 4. The differences between the changes in inter-maxillary lengths (Ar/A–Ar/B) were non-significant (Table 5).

Discussion

The cephalometric analysis in the present investigation showed that, at T1 (18 years) skeletal and dental relationships expressed by the angular measurements were similar between males and females with the exception of the maxillary/mandibular planes angle (ANS–PNS/Go–Me) which was lower than average in females. It was not surprising to find that face height and jaw length dimensions were larger in males.

The inclination of both upper and lower incisors did not change significantly between 18 and 28 years with the exception of the maxillary incisors in females which retroclined on average by 0·9 degree in the earlier part of the observation period between 18 and 21 years. Bondevik (1995) reported retroclination of maxillary incisors of 1·44 degrees in females in the later age group between 22 and 33 years, although Sarnäs and Solow (1980) found no significant change in incisor inclinations between 21 and 26 years.

TABLE 4 *Changes in cephalometric parameters from T1 (18 years) to T3 (28 years) for males (15), females (22), the pooled sample (37)*

Variable	Males		Females		Pooled	
	Mean	SE	Mean	SE	Mean	SE
UI/ANS–PNS (°)	0·22	0·65	−0·66	0·59	−0·30	0·44
LI/Go–Me (°)	−0·07	0·71	0·48	0·53	0·21	0·42
UI/LI (°)	0·20	1·19	−0·52	0·75	−0·16	0·65
ANS–PNS/Go–Me (°)	−0·35	0·46	0·74*	0·29	0·18	0·27
N/ANS–PNS (mm)	0·68*	0·19	0·45*	0·13	0·57***	0·11
Me/ANS–PNS (mm)	2·07***	0·46	2·16***	0·31	2·12***	0·26
N/Me (mm)	2·77***	0·58	2·60***	0·34	2·67***	0·30
Ar/Go (mm)	1·85***	0·35	0·36	0·47	1·11**	0·34
Ar/A (mm)	1·92***	0·34	0·94**	0·31	1·43***	0·24
Ptm/A (mm)	0·10	0·50	0·26	0·30	0·18	0·27
Ar/B (mm)	1·93***	0·41	0·95*	0·32	1·44***	0·26
Ar/Pog (mm)	2·62***	0·34	1·77***	0·29	2·20***	0·23
Go/Pog (mm)	1·20*	0·45	1·66***	0·43	1·43***	0·31

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

TABLE 5 *Differences between the changes in inter-maxillary jaw length Ar/A – Ar/B*

	Males		Females		M + F	
	Mean (mm)	SE	Mean (mm)	SE	Mean (mm)	SE
T1–T2	0·28	0·27	0·18	0·29	0·23	0·21
T2–T3	−0·31	0·47	−0·24	0·36	−0·25	0·29
T1–T3	−0·01	0·53	−0·01	0·45	−0·01	0·35

During the earlier period, between approximately 13 and 18–20 years several studies have shown a tendency for the incisors to upright (Björk and Palling, 1954; Siatowski, 1974; Persson *et al*., 1989; Love *et al*., 1990; Foley and Mamandras, 1992) although Sinclair and Little (1985) found no significant change in incisor inclination between 10 and 20 years.

Siatowski (1974) claimed that incisor uprighting was sufficient to account for the increase in lower arch crowding, which commonly occurs in untreated subjects between 13 and 18 years. Increases in crowding averaging approximately 2·00 mm and ranging up to 6·0 mm have been reported during this period of more active growth (Richardson, 1979; Sampson *et al*., 1893).

The relative stability of the incisor relationships in the present investigation is consistent with the minor changes in lower arch alignment reported in the same material (Richardson and Gormley, 1998). Between 18 and 28 years the increase in lower arch crowding averaged only 0·3 mm in males and 0·4 mm in females.

The maxillary/mandibular planes angle did not change significantly in males, but increased, indicating slight backward rotation of the mandible, by 0·84 degree in females between 21 and 28 years. Sarnäs and Solow (1980), Bishara *et al.* (1994) and Bondevik (1995) all reported no significant change in the maxillary/mandibular planes angle in samples of minimum age 21 years, although half of the females in Bondevik's (1995) sample showed backward rotation.

Total anterior face height (N/Me) increased on average by 2·7 mm in the pooled sample from T1–T3 with no significant difference between males and females. Most of the change (2·1 mm) occurred between T2 and T3 which is perhaps surprising since it might be expected that the change would diminish with age. It is, however, not dissimilar to the 1·5 mm increase reported by Sarnäs and Solow (1980) between 21 and 26 years, but larger than those of Forsberg (1979) who found increases of 0·4 and 0·6 mm between 24–29 years and 24–34 years, respectively. According to Sarnäs and Solow (1980), Fosberg's (1979) figures suggest that the major part of the anterior face height increase in the third decade takes place in the first half of the decade. The present findings, together with those of Bondevik (1995) who reported a 1·0-mm increase in anterior face height between 22 and 33 years, and Bishara *et al.* (1994) who found a 1·9-mm increase between 25 and 46 years refute this statement. Apparently, anterior face height increase continues well into the fourth decade. In all the above studies, including the present one and in those on earlier age groups from 14 to 20 years (Love *et al.*, 1990; Foley and Mamandras, 1992) most of the anterior face height increase occurred in the lower face from ANS–PNS/Me. This, together with the relative stability of the maxillary/mandibular planes angle in males, suggests that the increase in anterior face height is probably largely due to continued tooth eruption. In females the slight increase in the maxillary/mandibular planes angle may contribute to the increase in anterior face height.

In females the posterior face height from Ar-Go did not increase significantly throughout the study in contrast to the anterior face height. This would account for the slight increase in the maxillary/mandibular planes angle. In males the posterior face height increased by almost as much as the anterior face height.

Bishara *et al*. (1994) measuring posterior face height in the same way (from Ar to Go) found that anterior and posterior face heights increased by the same amount in females with no significant change in the mandibular planes angle from 25 to 46 years.

Length dimensions of both jaws increased in both sexes. The increases in Ar/A and Ar/B were not significantly different (Table 5) indicating that there was no change in antero-posterior jaw relationships which is consistent with the relative stability of the incisor relationships. During the earlier teenage years Björk and Palling (1954) found that growth of the mandible exceeds that of the maxilla resulting in straightening of the profile and retroclination of the lower incisors which may be one of the reasons for the increase in lower arch crowding at that time.

Larger changes were found in Ar–Pog and Go–Pog probably due to increased chin prominence.

Slightly smaller jaw length increases were noted by Sarnäs and Solow (1980) between 21 and 26 years, Bishara *et al*. (1994) between 25 and 46 years and by Bondevik (1995) between 22 and 33 years.

Conclusions

The present findings indicate that, in general, skeletal and dental arch relationships tend to remain relatively constant, while face height and jaw length dimensions continue to increase throughout the third decade of life. Such changes are unlikely to have much influence on lower arch crowding in untreated subjects, as confirmed by the relative stability of lower arch alignment in this material reported elsewhere (Richardson and Gormley, 1997).

The clinical significance of these findings relates to postretention changes in orthodontically treated subjects, often attributed to late growth (Sarnäs and Solow, 1980; Behrents *et al*., 1989; Bondevik, 1995). The nature and extent of the changes in the present untreated sample suggest that growth is unlikely to be a major cause of post-retention changes after the age of 20 years. It should be pointed out that these observations are based on average figures and do not preclude the possibility of changes in incisor inclination leading to lower incisor crowding in individual subjects, treated or untreated.

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References

Behrents, R. G. (1985)
Growth in the ageing cranio-facial skeleton, Monograph 17, Craniofacial Growth Series,
Center for Human Growth and Development, University of Michigan, Ann Arbor.

Behrents, R. G., Harris, E. F., Vaden, J. L., Williams, R. A. and Kemp, D. H. (1989)
Relapse of orthodontic treatment results: growth as an etiologic factor,
Journal of the Charles H Tweed Foundation, **17,** 65–80.

Bishara, S. E., Treder, J. E. and Jakobsen, J. R. (1994)
Facial and dental changes in adulthood,
American Journal of Orthodontics and Dentofacial Orthopedics, **106,** 175–186.

Björk, A. and Palling, M. (1954)
Adolescent age changes in saggital jaw relation, alveolar prognathy and incisal inclination,
Acta Odontologica Scandinavica, **12,** 201–232.

Bondevik, O. (1995)
Growth changes in the cranial base and the face: a longitudinal cephalometric study of linear and angular changes in adult Norwegians,
European Journal of Orthodontics, **17,** 525–532.

Foley, T. F. and Mamandras, A. H. (1992)
Facial growth in females 14 to 20 years of age,
American Journal of Orthodontics and Dentofacial Orthopedics, **101,** 248–254.

Forsberg, C-M. (1979)
Facial morphology and ageing: a longitudinal cephalometric investigation in young adults,
European Journal of Orthodontics, **1,** 15–23.

Forsberg, C-M., Eliasson, S. and Westergren, H. (1991)
Face height and tooth eruption in adults—a 20-year follow-up investigation,
European Journal of Orthodontics, **13,** 249–254.

Houston, W. J. B. (1983)
The analysis of errors in orthodontic measurements,
American Journal of Orthodontics, **83,** 382–390.

Love, R. J., Murray, J. M. and Mamandras, A. H. (1990)
Facial growth in males 16 to 20 years of age,
American Journal of Orthodontics and Dentofacial Orthopedics, **97,** 200–206.

Persson, M., Persson, E. C. and Skagius, S. (1989)
Long-term spontaneous changes following removal of all first premolars in Class 1 cases with crowding,
European Journal of Orthodontics, **11,** 271–282.

Richardson, M. E. (1979)
Late lower arch crowding: facial growth or forward drift?
European Journal of Orthodontics, **1,** 219–225.

Richardson, M. E. and Gormley, J. S. (1998)
Lower arch crowding in the third decade,
European Journal of Orthodontics **20**, 597–607.

Sampson, W. J., Richards, L. C. and Leighton, B. C. (1983)
Third molar eruption patterns and mandibular dental arch crowding,
Australian Orthodontic Journal, **8,** 10–20.

Sarnäs, K-V. and Solow, B. (1980)
Early adult changes in the skeletal and soft tissue profile,
European Journal of Orthodontics, **2,** 1–12.

Siatkowski, R. E. (1974)
Incisor uprighting: Mechanism for late secondary crowding in the anterior segments of the dental arches,
American Journal of Orthodontics, **66,** 398–410.

Sinclair, P. M. and Little, R. M. (1985)
Dentofacial maturation of untreated normals,
American Journal of Orthodontics, **88,** 146–156.