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Glenoid Fossa Position in Different Facial Types: a Cephalometric Study

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Abstract. *The purpose of the present study was to analyse the position of the glenoid fossa in subjects with different sagittal and vertical skeletal features. A cephalometric study was carried out on a sample of 180 subjects (90 males and 90 females, aged 7–12 years) who were combined to form three groups (60 subjects each) according to skeletal sagittal relationships and three groups (60 subjects each) according to skeletal vertical relationships. Cephalometric analysis comprised both sagittal and vertical measurements for the assessment of the position of the glenoid fossa in relation to surrounding skeletal structures. As for sagittal measurements, TMJ position was more posterior in skeletal Class II when compared with skeletal Class III. In the vertical plane, the position of the glenoid fossa relative to basicranial structures was more caudal in low angle subjects when compared with subjects with normal or high angle vertical relationships. Both basicranial structures and the posterior nasal spine may be used as reference structures for the assessment of vertical position of the glenoid fossa in diagnosis and treatment planning.*

Index words: Cephalometrics, Glenoid Fossa, Malocclusion.

Refereed Paper

Introduction

As the relationship of the mandible to the cranial base influences both sagittal and vertical facial disharmonies, glenoid fossa position is likely to play an important role in the establishment of different craniofacial patterns. The literature provides only limited data about the diagnostic significance of the position of the temporomandibular joint in relation to other skeletal structures (Hopkin *et al*., 1968; Droel and Isaacson, 1972; Kantomaa, 1989). On the contrary, many experimental and clinical contributions have demonstrated the effects of orthopaedic/orthodontic therapies on glenoid fossa position and morphology (Stockli and Willert, 1971; Elgoyhen *et al*., 1972; Pancherz, 1979; Birkebæk *et al*., 1984; Agronin and Kokich, 1987; Woodside *et al*., 1987; Paulsen *et al*., 1995). In particular, Pancherz (1979) described the forward displacement of the articular portion of the temporal bone following Herbst therapy of Class II malocclusion. Woodside *et al.* (1987) observed similar changes in the glenoid fossa of primates whose mandibles had been forced into protrusion by means of orthodontic appliances. It should obviously be stressed that therapeutically-induced glenoid fossa displacement is partly due to concomitant physiological growth and remodelling of surrounding structures (Baumrind *et al*., 1983).

The aim of the present study was to investigate the cephalometric relationships between the glenoid fossa and other craniofacial components in subjects presenting with different sagittal and vertical skeletal characteristics.

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Subjects and Methods

A sample of 180 subjects, 90 males and 90 females, aged 7–12 years, in the mixed dentition, was selected from the files of the Department of Orthodontics of the University of Florence. The cephalometric study was carried out on the lateral films of the patients before any treatment. All cephalograms were taken by means of the same X-ray device and by a single technician. Focus-median plane distance was 152 cm and film-median plane distance was 10 cm with an enlargement of 7 per cent. An essential criterion for case selection was represented by well detectable contours of the glenoid fossa on the lateral film.

The 180 subjects comprised nine subgroups (20 subjects each, comprising 10 males and 10 females) according to sagittal and vertical parameters:

1. Skeletal sagittal relationships on the basis of the ANB values (Class I = $2° \leqslant$ ANB $\leqslant 4°$; Class II = ANB $> 4°$; Class III = ANB $< 2°$) (Ballard, 1948);
2. Skeletal vertical relationships, on the basis of the ML-NSL values (Normal = $30° \leqslant$ ML-NSL $\leqslant 40°$; low angle = ML-NSL $< 30°$; high angle = ML-NSL $> 40°$) (Schudy, 1964).

The nine subgroups were homogenous as to age and sex distribution, and they were combined to form:

1. Three groups (60 subjects each) according to *skeletal sagittal relationships* (skeletal Class I, skeletal Class II,

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skeletal Class III); each single group comprised 20 subjects with normal vertical relationships, 20 subjects with low angle vertical relationships, and 20 subjects with high angle vertical relationships.
2. Three groups (60 subjects each) according to *skeletal vertical relationships* (normal, low angle, and high angle vertical relationships); each single group consisted of 20 subjects with skeletal Class I, 20 subjects with skeletal Class II, and 20 subjects with skeletal Class III.

Cephalometric analysis (Fig. 1)

Sagittal measurements.
ANB°: antero-posterior jaw discrepancy (grouping variable).
T-Fs′: linear distance from point T to the projection of point Fs on SBL (point Fs′). Point T is the most superior point of the anterior wall of sella turcica (Viazis, 1991); SBL (Stable Basicranial Line) is a line passing through point T and tangent to the lamina cribrosa of the ethmoid bone (Tollaro *et al.*, 1995a, 1995b); point Fs (Fossa summit) is the point on the superior margin of the glenoid fossa where a line parallel to SBL lies tangent to the superior curvature.
T-Ar′: linear distance from point T to the projection of point Ar on SBL (point Ar′).

Vertical measurements
ML-NSL°: the inclination of the mandibular line to the nasion-sella line (grouping variable).
Fs-Fs′: the linear distance from point Fs to point Fs′.
Ar-Ar′: the linear distance from point Ar to point Ar′.
SBL-Go: linear distance from SBL to point gonion.
SBL-PNS: linear distance from SBL to the posterior nasal spine.
TangFs-PNS: linear distance from the line tangent to Fs (and parallel to SBL) to the posterior nasal spine.
TangAr-PNS: linear distance from a line passing through point Ar (and parallel to SBL) to the posterior nasal spine.

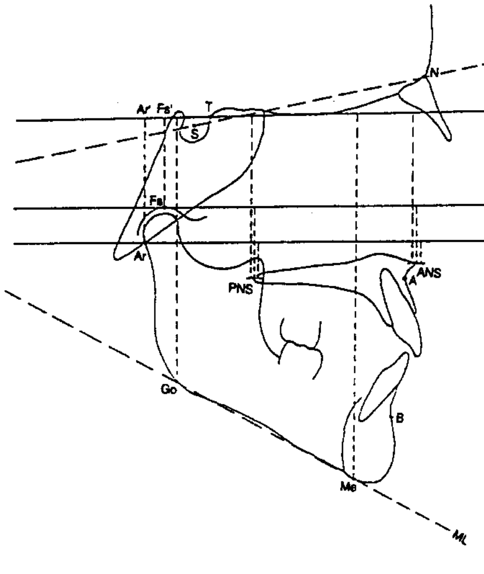

FIG. 1. Cephalometric measurements.

SBL-Me: linear distance from SBL to point menton.
SBL-ANS: linear distance from SBL to the anterior nasal spine.
TangFs-ANS: linear distance from the line tangent to Fs (and parallel to SBL) to the anterior nasal spine.
TangAr-ANS: linear distance from a line passing through point Ar and parallel to SBL to the anterior nasal spine.

Computer-assisted analysis of lateral cephalograms of the 180 subjects was carried out by means of a digitizer (Numonics 2210, Numonics, Lansdale, Pennsylvania, USA) and of a software (Viewbox 1.8, copy D. Halazonetis, 1993, portion copyright Microsoft Corp., Halazonetis, 1994). Each landmark was digitized three times to reduce method error, as the average location of each cephalometric point was computed and used.

Data analysis

The comparisons among the *three different groups according to sagittal relationships* and among the *three different groups according to vertical relationships* were performed by means of Kruskal-Wallis one-way analysis by ranks (Statgraphics®, 1987). Secondly, Mann-Whitney U-test was applied to those variables showing significant differences in Kruskal-Wallis analysis (Statgraphics®, 1987). Bonferroni's correction was applied to the level of significance in order to avoid statistical errors of type I due to multiple comparisons (P , 0.025 for Kruskal-Wallis analysis and P , 0.008 for Mann-Whitney U-test).

Results

The descriptive statistics and the results of Kruskal-Wallis test are shown in Tables 1 and 2. The results of Mann-Whitney U-test are reported in Table 3.

The comparisons among the *three groups according to the sagittal relationships* revealed significantly smaller distances T-Fs′ and T-Ar′ in skeletal Class II when compared with skeletal Class III.

Statistically significant differences among the *three groups according to the vertical relationships* were found by means of Kruskal-Wallis analysis for Fs-Fs′, Ar-Ar′, TangFs-PNS, TangAr-PNS, SBL-Me, SBL-ANS, TangCo-ANS, TangAr-ANS. Mann-Whitney test assessed significant differences among all three 'vertical' groups for SBL-Go, TangFs-PNS, SBL-Me, and for TangFs-ANS, whereas significant differences were found between normal and low angle groups, and between low and high angle groups for Fs-Fs′, between normal and high angle groups, and between low and high angle groups for TangAr-PNS, SBL-ANS, TangAr-ANS, and between low and high angle groups only for Ar-Ar′.

Discussion

Sagittal measurements

Significant differences for sagittal measurements were found only in the comparison between groups belonging to different skeletal Classes: TMJ position (horizontal distances from point T to Ar′ and to Fs′) is more

TABLE 1 *Descriptive statistics and Kruskal-Wallis one-way analysis by ranks for the three groups selected according to skeletal sagittal relationships*

	Groups according to skeletal sagittal relationships															
	Skeletal class I				$n = 60$	Skeletal class II				$n = 60$	Skeletal class III				$n = 60$	Kruskal-Wallis
	Mean	S.D.	Median	Max	Min	Mean	S.D.	Median	Max	Min	Mean	S.D.	Median	Max	Min	p
Age	9·20	1·40	9·00	12·00	7·00	9·15	1·30	9·00	12·00	7·00	9·13	1·48	9·00	12·00	7·00	0·9701
ANB (°)	3·11	0·59	3·00	4·00	2·00	6·52	1·35	6·50	9·00	4·50	−0·69	1·95	0·00	1·90	−7·00	0·0000*
T-Fs′ (mm)	1·81	0·33	1·80	2·50	0·80	1·89	0·26	1·90	2·60	1·20	1·75	0·33	1·70	2·70	1·10	0·0246*
T-Ar′ (mm)	2·02	0·42	2·00	2·080	0·04	2·08	0·28	2·00	2·80	1·40	1·94	0·32	1·90	2·90	1·40	0·0232*
ML-NSL (°)	34·89	8·40	35·95	52·00	17·00	35·55	7·77	35·80	50·00	21·00	35·57	7·70	35·00	51·00	23·00	0·8803
Fs-Fs′ (mm)	1·98	0·38	1·95	2·70	1·20	2·03	0·28	2·00	2·50	1·20	2·01	0·32	2·00	2·70	1·30	0·7083
Ar-Ar′ (mm)	2·90	0·38	2·85	3·70	2·10	2·94	0·28	2·90	3·60	2·30	2·86	0·35	2·80	3·70	2·10	0·3757
SBL-Go (mm)	7·09	0·63	7·00	8·80	6·00	7·00	0·49	6·95	8·30	6·10	6·85	0·55	6·90	8·00	5·90	0·1685
SBL-PNS (mm)	4·20	0·36	4·20	5·10	3·30	4·21	0·34	4·20	5·10	3·00	4·13	0·34	4·10	5·10	3·20	0·4295
TangGs-PNS (mm)	2·20	0·33	2·30	2·90	1·40	2·19	0·31	2·20	3·00	1·50	2·11	0·34	2·10	3·00	1·40	0·1479
Tang-Ar-PNS (mm)	1·28	0·29	1·30	1·90	0·70	1·30	0·25	1·30	1·90	0·70	1·29	0·29	1·30	2·00	0·90	0·9061
SBL-Me (mm)	10·17	0·84	10·20	12·60	7·50	10·22	0·72	10·10	12·30	8·90	10·14	0·74	10·05	12·20	8·50	0·9336
SBL-ANS (mm)	4·30	0·44	4·35	5·30	3·30	4·40	0·50	4·40	5·60	2·90	4·32	0·42	4·30	5·30	3·20	0·5018
TangGs-ANS (mm)	2·31	0·59	2·40	3·60	0·04	2·40	0·52	2·35	3·60	1·50	2·31	0·56	2·20	3·60	1·30	0·5496
Tang-Ar-ANS (mm)	1·41	0·57	1·45	2·90	0·04	1·51	0·49	1·50	2·50	0·50	1·49	0·53	1·40	2·80	0·50	0·6256

* $p < 0.025$.

TABLE 2 *Descriptive statistics and Kruskal-Wallis one-way analysis by ranks for the three groups selected according to skeletal vertical relationships*

	Groups according to skeletal vertical relationships															
	Normal				$n = 60$	Low angle				$n = 60$	High angle				$n = 60$	Kruskal-Wallis
	Mean	S.D.	Median	Max	Min	Mean	S.D.	Median	Max	Min	Mean	S.D.	Median	Max	Min	p
Age	9·03	1·39	9·00	12·00	7·00	9·25	1·32	9·00	12·00	7·00	9·20	1·46	9·00	12·00	7·00	0·6518
ANB (°)	2·81	3·12	3·00	9·00	4·00	2·74	3·55	3·00	9·00	−7·00	3·38	3·07	3·30	9·00	−4·00	0·5803
T-Fs′ (mm)	1·84	0·30	1·90	2·60	1·10	1·78	0·29	0·80	2·70	1·10	1·79	0·34	1·80	2·50	0·80	0·5320
T-Ar′ (mm)	2·03	0·30	2·00	2·80	1·40	1·98	0·30	2·00	2·90	1·30	2·02	0·42	2·00	2·80	0·04	0·6092
ML-NSL (°)	35·32	1·31	35·50	38·30	32·60	25·88	2·38	26·00	29·30	17·00	44·65	2·79	44·00	52·00	41·00	0·0000*
Fs-Fs′ (mm)	1·98	0·30	1·90	2·60	1·20	2·16	0·30	2·20	2·70	1·40	1·88	0·32	1·85	2·50	1·20	0·0000*
Ar-Ar′ (mm)	2·89	0·32	2·80	3·60	2·10	3·00	0·33	3·10	3·70	2·10	2·81	0·34	2·80	3·70	2·10	0·0035*
SBL-Go (mm)	6·98	0·45	7·00	8·30	5·90	7·25	0·61	7·30	8·80	6·00	6·71	0·49	6·65	8·10	5·90	0·0000*
SBL-PNS (mm)	4·19	0·35	4·15	5·00	3·40	4·14	0·65	4·20	5·10	3·00	4·21	0·34	4·20	5·10	3·50	0·8593
TangGs-PNS (mm)	2·18	0·30	2·20	2·90	1·50	2·00	0·29	2·00	3·00	1·40	2·32	0·31	2·40	3·00	1·70	0·0000*
Tang-Ar-PNS (mm)	1·28	0·25	1·30	1·90	0·70	1·19	0·27	1·20	2·00	0·70	1·40	0·27	0·40	1·90	0·80	0·0001*
SBL-Me (mm)	10·14	0·58	10·00	11·60	8·80	9·70	0·65	9·70	11·10	7·50	10·69	0·73	10·70	12·60	9·20	0·0000*
SBL-ANS (mm)	4·30	0·46	4·20	5·40	2·90	4·20	0·38	4·20	5·30	3·20	4·52	0·45	4·50	5·60	3·30	0·0002*
TangGs-ANS (mm)	2·35	0·47	2·40	3·60	1·50	2·06	0·42	2·10	3·20	1·30	2·62	0·62	2·55	3·60	0·04	0·0000*
Tang-Ar-ANS (mm)	1·45	0·46	1·50	2·50	0·40	1·20	0·46	1·30	2·20	0·04	1·75	0·53	1·80	2·90	0·60	0·0000*

* $p < 0.025$.

TABLE 3 *Mann-Whitney U test for the comparisons among the different groups*

Cephalometric measurements	Skeletal Class I vs. Skeletal Class II	Skeletal Class I vs. Skelatal Clas III	Skeletal Class II vs. Sieletal Class III
	p	p	p
A-N-B (°)	0·0000*	0·0000*	0·0000*
T-Fs′ (mm)	0·6152	0·0544	0·0068*
T-Ar′ (mm)	0·5243	0·0478	0·0071*
	Normal vs. Low angle	Normal vs. High angle	Low angle vs. High angle
	p	p	p
ML-NSL (°)	0·0000*	0·0000*	0·0000*
Fs-Fs′ (mm)	0·0024*	0·0715	0·0000*
Ar-Ar′ (mm)	0·0507	0·1289	0·0010*
SBL-Go (mm)	0·0064*	0·0017*	0·0000*
TangFs-PNS (mm)	0·0013*	0·0050*	0·0000*
Tang-Ar-PNS (mm)	0·0341	0·0067*	0·0000*
SBL-Me (mm)	0·0002*	0·0000*	0·0000*
SBL-ANS (mm)	0·2091	0·0068*	0·0000*
TangFs-ANS (mm)	0·0005*	0·0035*	0·0000*
Tang-Ar-ANS (mm)	0·0093	0·0024*	0·0000*

* $p < 0.008$.

posterior in skeletal Class II when compared with skeletal Class III. These results are in agreement with those by Droel and Isaacson (1972), who found that the horizontal sella-glenoid fossa distance had a significant positive correlation to the angle ANB. In the present study the reference point for the assessment of the horizontal position of the glenoid fossa was point T instead of point S. Point T was chosen in order to avoid uncontrolled variability of the reference structures due to the remodelling of the floor and of the posterior wall of sella turcica along with growth (Melsen, 1974). In addition, the homogeneous age distribution of the examined groups in the present investigation should be emphasized, as point Ar is displaced backward and downward during growth and it is affected by the direction of condylar growth and of mandibular rotation (Björk, 1969; Popovich and Thompson, 1977; Björk and Skieller, 1983).

Vertical measurements

Statistically significant differences for vertical measurements were found in the comparisons among groups showing different skeletal vertical relationships. The position of the fossa summit relative to the basicranial structures was more inferior in low angle subjects when compared with subjects with normal or high angle vertical relationships. These data again fully confirmed the results by Droel and Isaacson (1972).

Moreover, in our opinion, the diagnostic importance of the vertical position of the fossa summit in relation to the posterior nasal spine should be stressed. According to the results of the present study, the vertical level of the glenoid fossa relative to point PNS appears to be an important element in the diagnostic assessment of vertical skeletal relationships. In high angle subjects the glenoid fossa is placed more cranially in relation to the position of the posterior extremity of the palate. On the contrary, subjects presenting with low angle vertical relationships show a more caudal position of the fossa summit in relation to the posterior nasal spine. Noteworthy enough, the distance from the posterior nasal spine to the basicranial line did not show significant differences in different vertical facial types, as previously already shown (Baccetti *et al*., 1994). Consequently, the variability in the vertical position of the glenoid fossa seems to play a more determinant role in the establishment of vertical relationships than the vertical position of posterior nasal spine, measured as posterior height of the maxillary complex (SBL-PNS). The same conclusions may not be drawn for the vertical position of the glenoid fossa in relation to the anterior nasal spine. In fact, the distance from the anterior nasal spine to the basicranial structures varied significantly according to vertical facial relationships.

The variations in the position of point articulare in relation to the basicranial structures and to both nasal spines were in the same direction as the variations in the position of point Fs. However, the position of point Ar showed significant differences mainly between extreme vertical facial types. This could be due to the fact that point Ar does not belong to the temporal bone as it is constructed at the intersection between the inferior surface of the cranial base and the posterior surfaces of the mandibular condyles (Riolo *et al*., 1974). In contrast with a previous investigation (Droel and Isaacson, 1972), in fact, the present study analysed not only groups of subjects with extreme facial disharmonies, but also groups of subjects with normal facial relationships. The linear distances from the fossa summit to both nasal spines were able to reflect the different vertical features both between extreme vertical facial types, and between normal and extreme vertical facial types. On the contrary, the horizontal position of the glenoid fossa showed significant differences only between subjects with extreme sagittal facial types (skeletal Class II and skeletal Class III). It may be concluded that the vertical measurements for glenoid fossa position represent a more sensitive diagnostic tool in the evaluation of facial vertical features than the sagittal measurements for glenoid fossa position in the appraisal of antero-posterior skeletal relationships.

Conclusions

The present investigation identified some significant elements regarding glenoid fossa position in different sagittal and vertical facial types:

1. Class II skeletal disharmony is associated with a more posterior position of the glenoid fossa when compared to Class III skeletal disharmony.
2. Subjects presenting with high angle vertical relationships show a more cranial position of the glenoid fossa in relation to the cranial base when compared to subjects with either normal or low angle vertical relationships.
3. Both a more cranial position of the glenoid fossa in high angle subjects and a more caudal position of the glenoid fossa in low angle subjects can be also assessed by using the posterior nasal spine as a reference point.

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