The Application of Tetragon Analysis in A Sample of Kurdish Adult Population with Class I Occlusion:A Cephalometric Study

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Abstract

Background: Visual cephalometric analysis is a simple, logical, and accurate diagnostic tool for the student, the clinician, and the researcher. The analysis is elicited from two geometric constructs, the Tetragon and the Trigon.

Objective: To determine the cephalometric norms as per Fastlicht's analysis for male and female subjects of the Kurdish population and to compare these cephalometric norms with Fastlicht's norms, average Caucasian norms, and Iraqi (non-Kurdish) norms.

Patients and Methods: The cephalometric radiographs of 63 individuals, 25males, mean age 23.01 ±2.9 years, and 38 females, mean age 23 ± 3.2 years, were selected. FACAD 3.4.0.3, an orthodontic tracing software for cephalometric analysis and treatment planning, was used to digitally trace the reference points and reference lines for the tetragon analysis.

Results: The statistical differences between the data of the Iraqi Kurdish population and the data of Fastlich, average Caucasian, and Iraqi non-Kurdish population were significant.

Conclusion: The data of the Kurdish population is different from that of Fastlich and non-Kurdish Iraqi data. It is recommended to use this study's findings to get a more accurate result for the Iraqi Kurdish population when using tetragon analysis.

Keywords: Tetragon Analysis; Cephalometric; Visual cephalometric analysis

Introduction

Originally cephalometry was used as a method for researching craniofacial growth and development. It is gradually applied to study the facial form and develop criteria to describe orthodontic treatment objectives [1]. Moreover, recently it was used to assess the progress of treatment and predict growth for individual patients. It is worth mentioning that the emerging data that was concluded from different cephalometric analyses of Caucasian norms were incomparable with other racial and ethnic backgrounds [2,3]. Many researchers reported the variation in craniofacial morphology in various ethnic

groups. They revealed that one group's average measurements do not necessarily represent the norm for other ethnic groups [4-7]. It is essential to compare each individual's cephalometric data with standards applicable to his / her ethnic background for an accurate diagnostic evaluation to achieve the favored treatment outcomes [8]. Visual cephalometric analysis is a simple, logical, and accurate diagnostic tool for the student, the clinician, and the researcher [9]. The analysis is elicited from two geometric constructs. Firstly, the "Tetragon" a polygon representing the maxillo-dento-mandibular complex, made up of reliable and familiar cephalometric landmarks the palatal plane, the mandibular plane, and the axes of the maxillary and mandibular central incisors Figure (1A). Secondly, the "Trigon," a complementary triangle situated above the Tetragon and formed by one plane that is intrinsic to the Tetragon-the palatal plane (PNS-ANS) and other two extrinsic planes -the pterygoorbital plane (Pt-Or) and the pterygopalatal plane (Pt-PNS) Figure (1B)[9]. This research's objectives were to set the normal values of visual cephalometric analysis (the Tetragon) in the Kurdish population with average class I occlusion, examine the gender variations if any, and compare Iraqi Kurdish data with other data.

Patients and Methods

In this study, a total of 63 digitally taken lateral cephalometric radiographs belong to 25 males, mean age 23.01 ±2.9 years, and 38 females, mean age 23 ± 3.2 years, were included. These radiographs were collected archive of faculty of dentistry,Tishk International University, Erbil, Iraq.

The following selection criteria were applied:

1.The molar, Canine, and Incisor were in class I relationship

2.The overjet and the overbite were within the normal range

3.The maxillary and mandibular dental arches were well-aligned with a range of 1-2 mm dental crowding

4.No history of either orthodontic, or prosthodontic treatment and facial trauma/surgery were recorded

Each lateral cephalogram was recorded while the head was in a natural head position using the NewTom GiANO digital X-ray unit. FACAD 3.4.0.3, an orthodontic tracing software for cephalometric analysis and treatment planning, was used to digitally trace the reference points and reference lines for the tetragon analysis.

Cephalometric landmarks

For this study, the implemented cephalometric reference points were identified according to Rakosi [10]:

1.Pterygomaxillary fissure (Pt)
2.Nasion (N)
3.Sella turcica (S)
4.Point A (Subnasale)
5.Point B (Supramentale)
6.Pogonion (Pog)
7.Gonion (Go)
8.Menton (Me)
9.Anterior nasal spine (ANS)
10.Posterior nasal spine (PNS)
11.Orbitale (Or)
12.Root apices and incisal edges of the most proclined maxillary and mandibular central incisors.

Linear measurements

1.(N-Pog-UI): Distance from the incisal edge of the maxillary central incisor (UI) to N-Pog line

2.(N-Pog-LI): Distance from incisor edge of mandibular central incisor (LI) to N-Pog line

3.(UI-PP): Long axis of upper incisor to the palate

4.(LI-MP): Long axis of lower incisor to mandibular plane

Angular measurements

The Tetragon is composed of four sides that creates four angles with a total of 360º constantly as per Faslicht [9] Figure (1A).

1.UI-PP: The angle is formed by the palatal plane's intersection with a line passing through the incisal edge and the apex root of the maxillary central incisor.

2.UI-LI: The angle is established by passing a line through the incisal edge and the apex root of the maxillary and mandibular central incisors.

3.LI-MP: The angle is formed by the mandibular plane's intersection with a line passing through the incisal edge and the apex root of the mandibular central incisor.

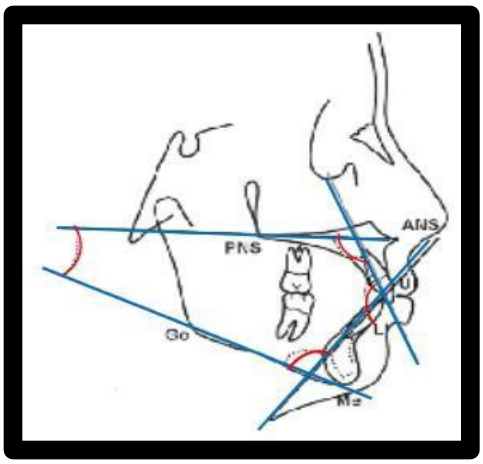
4.MP-PP: the angle is constructed between the mandibular plane and palatal plane.

5.Others: SNA, SNB, and ANB. The Triagon consists of three sides that creates three angles with a total of 180º constantly as per Faslicht (9) (Figure 1B).

6.Pt-Or/Pt-PNS: The angle between the Pt-Or plane and Pt-PNS plane called "upper Pt."

7.Pt-PNS/PP: The angle between the Pt-PNS and the palatal plane called "lower Pt."

8.Pt-Or/PP: The angle between the Pt-Or plane and the palatal plane.



Figure(1A): First geometric

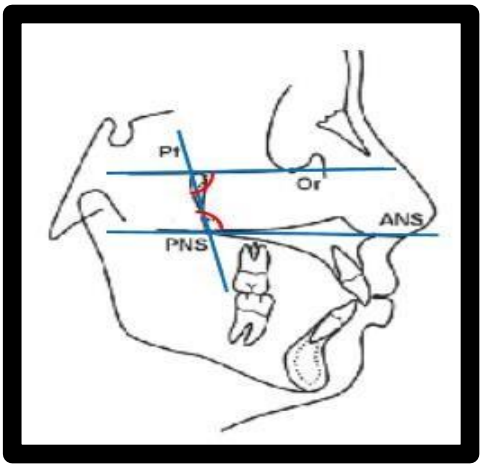


Figure (1B): Second geometric

Method error

Ten random samples were selected and retraced by another examiner and by the same operator after two weeks. Intraclass Correlation Coefficient (ICC) was used to test operators' inter-examiner and intra-examiner reliability, where the ICC ranges from 0 to 1, with 1 indicating perfect agreement. Intra-class correlation (ICC) results for both intra-examiner measurements showed high levels of agreement (>0.9).

Statistical analysis

Statistical Package for Social Science (Version 25; SPSS Inc., Chicago, IL, USA) was used to perform statistical analyses. Measurements were described as frequencies,

means, standard deviations (SD), and minimum and maximum values were calculated for each variable. The Shapiro Wilks test assessed the normal distribution fitness of the variables, and the data were found to be fit to normal distribution. To compare the data with norms from Fastlicht's average, Caucasian, and non-Kurdish Iraq and to compare male and female data , one sample t test and an independent t test were used, respectively.

A p-value cutoff was applied to estimate the levels of significance, as following: Non-significant NS $P > 0.05$, Significant * $0.05 \geq P > 0.01$, Highly-significant ** $0.01 \geq P > 0.001$, and Very highly significant *** $P \leq 0.001$.

Results

The values for the cephalometric parameters are described in Table (1). Table (2) compares cephalometric values between the Iraqi Kurdish sample and Fastlicht's data using a one-sample t-test. Significant differences were found between the Iraqi Kurdish and the Fastlicht's data in 10 of the 14 total parameters. The differences were found to be highly significant, $P < 0.001$.

Table (1): Descriptive statistics for the cephalometric variables

		Variable	N	Minimum	Maximum	Mean	Standard deviation
Linear measurements (mm)		N-Pog-LI	63	-7.30	3.70	-1.837	2.416
		N-Pog-UI	63	-0.50	8.80	4.729	2.149
		UI-PP	63	17.60	34.20	27.522	2.954
		LI-MP	63	33.90	48.10	40.243	3.195
Angular measurements	Tetragon	UI-PP	63	97.80	130.90	115.67 6	5.293
		UI-LI	63	115.90	138.40	126.16 8	4.219
		LI-MP	63	86.70	99.80	92.070	3.649
		MP-PP	63	19.40	34.30	25.692	3.225
	Trigon	UpperPt	63	74.40	87.20	78.643	2.979
		LowerPt	63	85.40	100.50	94.811	3.075
		Pt-Or/PP	63	-2.50	17.00	7.319	4.415
	Others	SNA	63	74.00	92.00	82.362	3.966
		SNB	63	72.40	88.60	79.943	3.757
		ANB	63	-3.00	7.80	2.414	2.324

Table (2): Comparison of the cephalometric variables for the Iraqi Kurdish individuals versus Fastlicht's average

Variable	Kurdish	Fastlich	Mean difference	T-test	Degree of freedom	P-value
UI-PP	115.67	110	5.676	8.511	62	0.000
UI-LI	126.16	130	-3.832	-7.209	62	0.000
LI-MP	92.06	90	2.070	4.502	62	0.000
MP-PP	25.69	30	-4.308	-10.601	62	0.000
Pt-Or/PtPNS	78.64	85	-6.357	-16.938	62	0.000
Pt-PNS/PP	94.81	87	7.811	20.16 3	62	0.000
Pt-Or/PP	7.31	8	-0.681	-1.224	62	0.225
N-Pog-UI	4.72	2	2.729	10.07 8	62	0.000
N-Pog-LI	1.83	1	-2.837	-9.319	62	0.000
UI-PP	27.522	34	-6.478	-17.405	62	0.000
LI-MP	40.2482	43	-2.757	-6.849	62	0.000
SNA	82.36	82	0.362	0.724	62	0.472
SNB	79.49	80	-0.057	-0.121	62	0.904
ANB	2.41	2	0.414	1.415	62	0.162

To compares cephalometric values between the Iraqi Kurdish sample and the Iraqi (non-Kurdish) data, a one-sample t-test was used. Significant differences were found between the Kurdish and the Fastlicht's norm in 8 of the 14 total parameters (Table 3). Two (U1-PP L1-MP) were not comparable due to different methods of measurements.

Table (3): Comparison of the cephalometric variables for the Iraqi Kurdish individuals versus Iraqi non-Kurdish individuals using a one-sample t-test

Variable	Iraqi Kurdish	Non-Kurdish Iraqi	Mean difference	T-test	Degree of freedom	p-value
UI-PP	115.67	114.95	0.726	1.09	62	0.280
UI-LI	126.16	121.1	5.068	9.54	62	0.000
LI-MP	92.06	103.975	-11.905	-25.90	62	0.000
MP-PP	25.69	19.7	5.992	14.75	62	0.000
Pt-Or/PtPNS	78.64	78.75	-0.107	-0.29	62	0.776
Pt-PNS/PP	94.81	95.95	-1.139	-2.94	62	0.005
Pt-Or/PP	7.31	5.475	1.869	3.36	62	0.001
N-Pog-UI	4.72	0.676	4.051	14.96	62	0.000
N-Pog-LI	1.83	0.44	-2.277	-7.48	62	0.000
UI-PP	27.522					
LI-MP	40.2482					
SNA	82.36	83.75	-1.388	-2.78	62	0.007
SNB	79.49	80.65	-0.707	-1.49	62	0.140
ANB	2.41	3.933	-1.519	-5.19	62	0.000

Highly Significant differences P <0.001 were found between the Kurdish and the Caucasian norm in 10 of the 14 total parameters when comparing cephalometric values using a one-sample t-test Table(4).

Table (4): Comparison of the cephalometric variables for the Iraqi Kurdish individuals versus average Caucasian data using a one-sample t-test

Variable	Kurdish	Caucasian	Mean difference	T-test	Degree of freedom	P-value
UI-PP	115.67	113	2.676	4.013	62	0.000
UI-LI	126.16	128	-1.832	-3.446	62	0.001
LI-MP	92.06	93	-0.930	-2.023	62	0.047
MP-PP	25.69	26	-0.308	-0.758	62	0.451
Pt-Or/PtPNS	78.64	81	-2.357	-6.28	62	0.000
Pt-PNS/PP	94.81	90	4.811	12.41 9	62	0.000
Pt-Or/PP	7.31	9	-1.681	-3.022	62	0.004
N-Pog-UI	4.72	2	2.729	10.07 8	62	0.000
N-Pog-LI	1.83	1	-2.837	-9.319	62	0.000
UI-PP	27.522	34	-6.478	-17.405	62	0.000
LI-MP	40.2482	43	-2.757	-6.849	62	0.000
SNA	82.36	82	0.362	0.724	62	0.472
SNB	79.49	80	-0.057	-0.121	62	0.904
ANB	2.41	2	0.414	1.415	62	0.162

An independent t-test was used to compares cephalometric values between the Kurdish sample's male and female groups. The differences were found to be statistically significant P <0.05 in three of the total 14 parameters, namely, LIMP, LIMPAng, and PtOrPP Table (5).

Table (5): Comparison of cephalometric values of (male) and (female)

		Independent T-Test								
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F-value	Significant	t-value	Degree of freedom	Significant (2tailed)	Mean Difference	Standard Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
NPogUI	Equal variances assumed	2.177	0.145	0.883	61	0.381	0.48214	0.54584	-0.60933	1.57362
	Equal variances not assumed			0.904	60.987	0.369	0.48214	0.53309	-0.58385	1.54813
NPogLI	Equal variances assumed	4.517	0.038	-0.708	61	0.481	-0.43571	0.61500	-1.66548	0.79405
	Equal variances not assumed			-0.734	60.390	0.466	-0.43571	0.59330	-1.62234	0.75091
UIPP	Equal variances assumed	1.600	0.211	0.907	61	0.368	0.68000	0.75007	-0.81987	2.17987
	Equal variances not assumed			0.936	60.790	0.353	0.68000	0.72682	-0.77347	2.13347
LIMP	Equal variances assumed	0.502	0.481	3.318	61	0.002	2.49429	0.75172	0.99114	3.99744
	Equal variances not assumed			3.258	53.093	0.002	2.49429	0.76563	0.95869	4.02988
UIPPAng	Equal variances assumed	0.005	0.944	-0.564	61	0.575	-0.76071	1.34958	-3.45937	1.93794
	Equal variances not assumed			-0.561	56.708	0.577	-0.76071	1.35696	-3.47828	1.95685

UILIAng	Equal variances assumed	0.224	0.638	-0.019	61	0.985	-0.02000	1.07835	-2.17630	2.13630
	Equal variances not assumed			-0.018	51.895	0.986	-0.02000	1.10260	-2.23264	2.19264
LIMPAng	Equal variances assumed	0.028	0.869	2.132	61	0.037	1.91857	0.89981	0.11929	3.71785
	Equal variances not assumed			2.126	57.321	0.038	1.91857	0.90248	0.11161	3.72553
MPPP	Equal variances assumed	0.130	0.720	-1.093	61	0.279	-0.89214	0.81649	-2.52482	0.74053
	Equal variances not assumed			-1.099	59.143	0.276	-0.89214	0.81188	-2.51663	0.73234
UpperPt	Equal variances assumed	0.964	0.330	-0.025	61	0.980	-0.01929	0.76149	-1.54198	1.50341
	Equal variances not assumed			-0.026	59.654	0.980	-0.01929	0.75490	-1.52950	1.49093
LowerPt	Equal variances assumed	0.698	0.407	0.738	61	0.463	0.57786	0.78251	-0.98687	2.14259
	Equal variances not assumed			0.752	60.748	0.455	0.57786	0.76842	-0.95882	2.11453
PtOrPP	Equal variances assumed	0.362	0.549	-3.005	61	0.004	-3.16500	1.05317	-5.27094	-1.05906
	Equal variances not assumed			-2.999	57.509	0.004	-3.16500	1.05545	-5.27810	-1.05190
SNA	Equal variances assumed	1.080	0.303	0.583	61	0.562	0.58929	1.01084	-1.43201	2.61058

	Equal variances not assumed			0.568	50.925	0.572	0.58929	1.03677	-1.49218	2.67075
SNB	Equal variances assumed	0.580	0.449	0.665	61	0.508	0.63643	0.95678	-1.27676	2.54962
	Equal variances not assumed			0.656	54.388	0.515	0.63643	0.97024	-1.30846	2.58132
ANB	Equal variances assumed	0.020	0.888	-0.087	61	0.931	-0.05143	0.59403	-1.23927	1.13641
	Equal variances not assumed			-0.086	55.722	0.932	-0.05143	0.59953	-1.25256	1.14971

Discussion

The Tetragon and the Trigon provide a clear picture of the position of the maxillo-dentomandibular structures within the craniofacial complex. This visual cephalometric analysis can be a useful diagnostic tool for treatment planning, surgical preparation, and evaluation of growth, treatment progress, and post-treatment results.

In addition to conventional cephalometric measurements such as SNA, SNB, and ANB, the Tetragon is able to show whether the malocclusion problem lies in the mandible, maxilla, or both as well. The Tetragon's analysis enables the operator to identify the need for suitable tooth movement (intrusion, extrusion, and retraction) as it represents the axial inclinations of the maxillary and mandibular central incisors and their positions in the oral cavity.

This study aimed to set the normal values of the visual cephalometric analysis, the Tetragon analysis, for a sample of Iraqi Kurdish people. As a result, malocclusion categories could be described using the concluded analysis from Iraqi Kurdish individuals accurately and enables clinicians to establish a treatment plan as per the ethnic variation.

Tetragon

Compared to Fastlich, more proclination of the upper and lower incisor were found in the Kurdish population reflected by increased upper incisors to palatal plane angle, increased lower incisors to mandibular plane angle, and decreased inter-incisal angle. The same results were reported by Nanda et al. and Valiathan *et al*. [6, 11]. Interestingly, the current study showed a reduction in the mandibular plane's angulation to the Kurdish population's palatal plane. This indicates the tendency of upper and lower jaw bases to converge, lower anterior facial height to decrease, and horizontal growth pattern. Compared to Iraqi data, the LI-MP is decreased, MP-PP is increased, and the inter-

incisal angle is increased than that of the Iraqi population. These differences can be explained in part by the difference in ethnic background. This study shows a statistically significant increase of upper incisor to palatal plane compared to average Caucasian data while other data of the Tetragon did not differ significantly than that of Caucasian sample.

Trigon

This study reveals that there is an increase in the angulation of Pt-PNS/PP and a decrease in the angulation of Pt-Or/ PP & Pt-Or/Pt-PNS when comparing with Fastlich's. All these differences are statistically significant. Compared to the Iraqi data, there was an insignificant difference in Pt-Or/Pt-PNS; however, there is a decrease in the angulation of Pt-PNS/PP and an increase in the angulation of Pt-Or/PP, which are both statistically significant differences.

The different ethnic backgrounds can explain these differences again[14]; the Iraqi data is collected from Baghdad University, where most of the students are expected to be of Arabic ethnicity, although this detail is not mentioned in that study. When compared to average Caucasian data, Pt-Or/Pt-PNS & Pt-Or/PP were statistically higher. In contrast, Pt-PNS/PP were statically lower[9]. Our data indicate a clockwise rotation of the palatal plane, the Trigon in this sample is rotated clockwise compared to Fastlich's sample and average Caucasian [9], and that is represented by the increase in Pt- PNS/PP angle. This was in agreement with Ahmed [14], Prakash et al[15], and Gupta et al[16]. Other angles, SNA, SNB & ANB, did not show significant differences compared to Fastlich and Average while comparing to Iraqi SNA, & ANB were significantly different. Linear measurement was statistically different when compared to our Kurdish data to Fastlich and Average Caucasian data. In the current study, the differences between males and females were statistically significant in three of the total 14 parameters: LIMP, LIMPAng, and PtOrPP. Variations in the cephalometric values that deal with the head and face measurements of alive and dead bodies are regarded as one of the disciplines of anthropometry. The existing variations between the Kurdish sample and others can be attributed to many factors such as ethnic background, environmental factors, nutrition, heredity, and socio-economic status.

Conclusions

This study showed various differences when comparing finding with the study by Fastlicht and other subsequent studies. Accordingly, patient cephalometric data is mandatory to be compared with the standards of similar ethnic backgrounds for an accurate diagnostic evaluation.

Recommendations

This study's recommendation is to utilize this study's standards when applying tetragon analysis to acquire more accurate results concerning Iraqi Kurdish people.

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Conflict of interest: The author declares that there is no conflict of interest regarding the publication of this article.

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