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Research Article

PHOTOMETRY: IS IT AS RELIABLE AS SOFT TISSUE CEPHALOMETRY?

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In orthodontics, the understanding of soft tissues of the face in relation to the underlying dentoskeletal tissues is an essential guide in aesthetic treatment plan

A B S T R A C T

Background: In orthodontics, the understanding of soft tissues of the face in relation to the underlying dentoskeletal tissues is an essential guide in aesthetic treatment plan. deleterious effects of radiation exposure from dental radiographs and inaccuracies in cephalometric soft tissue measurements has raised a need for an alternative method of facial analysis. Photogrammetry is the evaluation of an object by means of a photograph, is an inexpensive and non-invasive method of quantifying facial esthetics. **Objectives:** this study compares photometric and the cephalometric methodsto determine the soft tissue measurements, the to assess the reliability of photogrammetric facial analysis. Statistical **Analysis:** The data obtained were tabulated and was subjected to Kolmogorov-Smirnov Normality test, parametric test (paired t test)and Karl Pearson's correlation coefficient method. Results:In general, the study had shown statistically significant values on correlation of manual cephelometric and photometric methods. It can be said that the photometric analysis with AUTOCAD software is as reliable as the conventional cephalometric method and that the minimal variations are attributed by the operator's reproducibility of the landmarks and calibration of image the circle constructed in the software. **Conclusions:** Photogrammetric analysis with AUTOCAD software can be a good adjunct in diagnosis and treatment planning of orthodontic cases by giving more importance to aesthetic concerns. Photogrammetry can be used along with lateral cephalograms. But still cannot replace cephalometry entirely.

INTRODUCTION

Facial aesthetics is considered a significant factor with regard to the perceptions of society and individuals in relation to themselves. Additionally, it plays an important role in the assessment of personality and social acceptance. The ability in recognizing a beautiful face is innate and the development of aesthetic perception happens since childhood.[1]

In orthodontics, determining the facial type and soft tissue measurements is a key element in the prescription of a correct diagnosis. The understanding of soft tissues of the face in relation to the underlying dentoskeletal tissues is an essential guide in aesthetic treatment plan. In the early days of our specialty, observation and measurement of craniofacial structures were done directly on the face. With the development of radiographic methods, cephalometric analysis replaced the direct facial analysis. Photogrammetry, the evaluation of an object by means of a photograph, is an inexpensive and non-invasive method of quantifying facial esthetics. Photogrammetry has long been utilized in orthodontics to evaluate facial proportions and assess changes during treatment [2,3]Peck and Peck[4] utilized 9 photographs of 52 young adults, who were judged to have pleasing facial esthetics, to quantify measurements that correspond with facial beauty. Frontal and sagittal facial photographs are standard pre- and post-treatment orthodontic records, but historically have only been used for qualitative evaluation of treatment goals and outcomes[5]. Advances in digital photography and computer software have increased the usefulness of photographs for quantitative linear and angular facial analysis. Now, digital photographs may be viewed immediately, rather than waiting for film negatives to be developed, as well as modified and measured using specialized computer programs. Photographs, which may easily be taken from multiple angles, allow facial soft tissue dimensions to be fully evaluated, a benefit not possible with cephalometric

The validity of any measurement obtained from cephalometric radiographs is dependent on the reliability of the landmarks identified[6]. This concept emphasizes the importance of reliable landmarks for cephalometric facial analysis and should be considered for angular and linear soft tissue measurements on facial photographs. The reliability of skeletal landmarks on lateral cephalometric radiographs has been well documented[6,7]. However, there is limited evidence about the reliability of facial soft tissue landmarks on photographs, especially inter-examiner reliability[8,9,10].

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Seeking to validate the analysis of facial soft tissues, this work compares two different methods used to determining the soft tissue measurements, the photometric and the cephalometric methods.

METHODOLOGY

30 standardized facial profile photographs (right lateral) along with the lateral cephelogram of patients that had reported to our Department of Orthodontics.

In Selecting the Sample, the Following Inclusion Criteria were Applied

1. The subjects should be Indian.
2. Should not wear orthodontic appliances or any other intraoral device that could influence the profile
3. Should not present facial asymmetry.

Sample size was defined on the basis of convenience.The distribution of male and female patient was randomly distributed. Standardized photographs of the right profile were taken with a digital camera (Canon 600 D). In order to standardize the photographs, they were obtained by a single operator, in the same environment,at the same distance between the researchsubject and the camera(5 ft). Moreover, all the other photographic parameters were also standardized, namely: aperture f11, shutter speed 1/125 and ISO 200.Patients were at rest position, completely relaxed and positioned in a cephalostat. Photographs were stored in a JPEG format. To eliminate distortion between the actual size of the face and the size of the photograph, the metal screw of the cephalostat, which is well defined on the photograph, served as a reference. Its actual size was measured with the use of a digital calliper. The actual diameter of the screw of the cephalostat is 8.04 mm.(FIG1)Thus, a circle with the same diameter of the cephalostat screw was designed in the AutoCad software. Then, the images of the screws in each photograph were adjusted to fit the circle drawn in the software. Consequently, the measurements obtained in the software are equivalent to the actual measurements, thus,eliminating the need for obtaining a correction factor. (FIG 2)The facial point's markings and measurements were performed by the same operator. The markings were done in two days and the measurements were taken within 6 days in order to avoid fatigue and, as a consequence, operator's error. The photographic reference points, angular, vertical and proportionality measurements were obtained according to Trevisan and Gil[11] as well as Sutter and Turley[12]using an AutoCAD software tool.

RESULTS

The data obtained were tabulated and statistically analysed. Initially, the Kolmogorov-SmirnovNormalitytest was done. All measurements of different parameters in photometric and cephalometric analysis follow a normal distribution. Therefore, the parametric test i.e. paired t test was applied.

Angular Measurements

Table 1 showedcomparison of values using manual cephalometric tracing and photometric tracing with parameters according to the study conductedby Trevisan and Gil as well as Sutter and Turley is done. All values show significant difference ($p<0.05$) assessment of angular measurements by paired t test.

Table 1 Comparison of photometric and cephalometric analysis with respect to assessment of angular measurements by paired t test.

Parameters	Analysis	Mean	Std.Dv.	Mean Diff.	SD Diff.	% of change	Paired t	P-value
Total facial convexity angle	Photometric	144.43	9.30					
	Cephelometric	140.74	10.95	3.70	4.53	2.56	3.9151	0.0007*
Facial convexity abgle	Photometric	164.35	7.32					
	Cephelometric	159.61	8.82	4.74	5.68	2.88	3.9996	0.0006*
Nasolabial angle	Photometric	91.52	12.45					
	Cephelometric	95.22	12.62	-3.70	7.19	-4.04	-2.4655	0.0220*
Mentolabial angle	Photometric	116.26	16.39					
	Cephelometric	109.09	20.12	7.17	12.90	6.17	2.6677	0.0141*
Lower third angle	Photometric	115.22	7.73					
	Cephelometric	117.13	8.25	-1.91	3.23	-1.66	-2.8386	0.0096*

*p<0.05

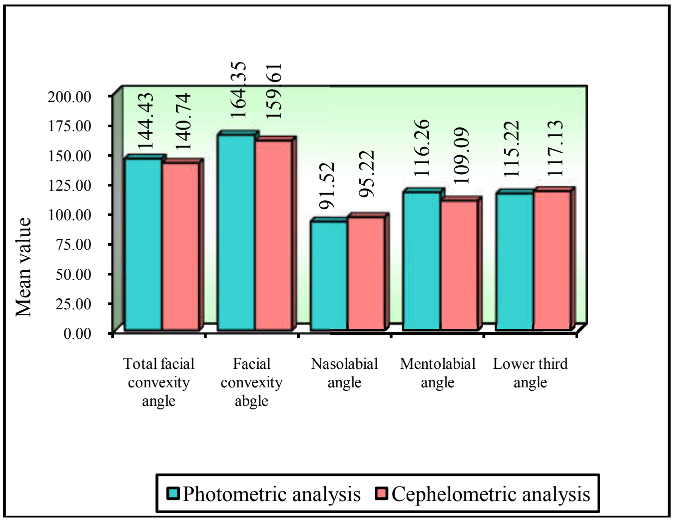

Figure Comparison of photometric and cephelometric analysis with respect to assessment of angular measurements

Table 2 showed comparison of values using manual cephalometric tracing and photometric tracing with respect to verticalparameters conductedby Trevisan and Gil as well as Sutter and Turley is done. All values show significant difference ($p<0.05$) exceptgonion to subnasale(G' TO Sn). No differences were observed between manual cephalometric and photometric measurements in other parameters.

Table 2 Comparison of photometric and cephalometric analysis with respect to assessment of vertical measurements by paired t test

Parameters	Analysis	Mean	Std. Dv.	Mean Diff.	SD Diff.	% of change	Paired t	P-value
G'-Sn	Photometric	66.78	4.93					
	Cephelometric	65.13	5.36	1.65	3.68	2.47	2.1518	0.0427*
Sn-St	Photometric	21.30	2.95					--
	Cephelometric	20.13	3.88	1.17	4.15	5.48	1.3466	0.1918
Sn-Me'	Photometric	61.61	6.02					
	Cephelometric	60.39	7.55	1.22	3.92	1.97	1.4874	0.1511

*p<0.05

Table 3 showed comparison of values using manual cephalometric tracing and photometric tracing with respect to proportionalparameters conductedby Trevisan and Gil as well as Sutter and Turley is done. The valuedoes not show significant difference ($p<0.05$)

Table 3 Comparison of photometric and cephelometric analysis with respect to assessment of Proportional measurement i.e. lip chin proportionalby paired t test

Analysis	Mean	Std. Dv.	Mean Diff.	SD Diff.	% of change	Paired t	P-value
Photometric	1.31	0.21					
Cephelometric	1.39	0.30	-0.08	0.29	-6.32	-1.3449	0.1924

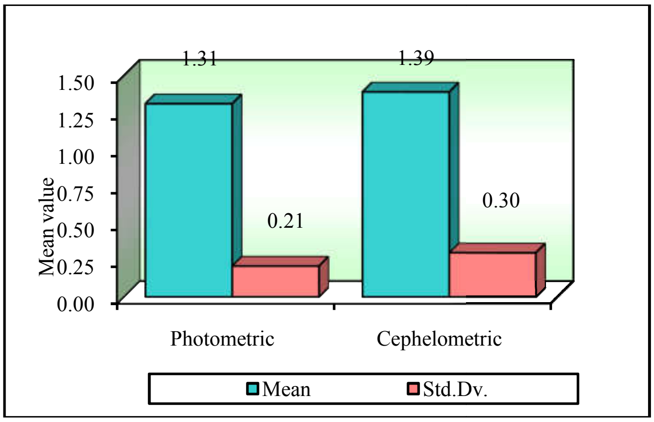

Figure Comparison of photometric and cephelometric analysis with respect to assessment of Proportional measurement i.e. lip chin propotional

In the final table, table 4, which shows the correlation between the manual cephalometric and photometric measurements by KarlPearson's method. It shows significant and positive relationship between manual cephalometric and photometric measurements in all parameters. This means that the correlation between manual cephalometric and photometric methods are statistically significant.

Table 4 Correlation between photometric and cephalometric analysis in assessment of measurements of different parameters by Karl Pearson's correlation coefficient method

Parameters	Correlation between photometric and cephelometric analysis in assessment of		
	r-value	t-value	p-value
Total facial convexity angle	0.9128	10.2393	0.0001*
Facial convexity abgle	0.7674	5.4840	0.0001*
Nasolabial angle	0.8356	6.9704	0.0001*
Mentolabial angle	0.7690	5.5126	0.0001*
Lower third angle	0.9203	10.7780	0.0001*
G'-Sn	0.7472	5.1527	0.0001*
St-Me'	0.8284	6.7765	0.0001*
Sn-Me'	0.8567	7.6127	0.0001*
Lip chin proportional	0.3985	1.9914	0.0500*

*$p<0.05$

DISCUSSION

In order to meet the aesthetic expectations of patients, orthodontic treatment must include a detailed analysis of soft tissues. For many years, lateral cephalometric radiographs were used for this purpose. Standardized photographs have currently gained significant importance both clinically and in research, mainly because they reproduce the soft tissues in detail.

Historically, heavy emphasis has been placed on the evaluation of lateral cephalometric radiographs, using linear and angular analyses of predefined dentoskeletal standards, for orthodontic treatment planning[13,14].Despite being a part of standard orthodontic records, frontal and sagittal photographs are rarely analysed quantitatively and merely are used as an adjunct to diagnosis and treatment planning. With increased attention being given to radiation exposure from dental radiographs, less reliance on cephalometric analysis and increased utilization of facial photographs in a quantitative manner for diagnosis is justified.[15,16] As patients are not accustomed to interpreting radiographs, facial photographs as diagnostic records may be a more comprehensible tool. Additionally, the variability in the amount of soft tissue covering facial skeletal structures may mask the appearance of dentoskeletal deformities, thus rendering dentoskeletal standards unreliable when attempting to achieve facial balance. This increased focus on facial esthetics has led to multiple qualitative and quantitative analyses of facial esthetics.[3,4,17,18]

A study by Erkan and his associates had stated the importance of standardisation in comparative studies like this study. The intra-examiner error is lesser than the inter-examiner error, thus, this study was standardised by having only one examiner for both manual cephalometric method and photometric measurements using AUTOCAD software to reduce the possibility of errors.[18]

The reliability of dentoskeletal landmark identification on cephalometric radiographs has been widely investigated.[6,7] Two major sources of error occur when locating cephalometric landmarks, errors of projection, a two-dimensional representation of three-dimensional structures, and errors of identification, differences in locating landmarks. Additionally, representativeness of radiographs, representativeness of examiners, machine errors in point identification and 13 errors in superimposition of tracings have been cited as possible sources of error that may affect cephalometric reliability.[7] The reliability of cephalometric measurements depends on the reliability of landmarks possibly affected by these sources of error. This was investigated in a meta-analysis of cephalometric landmark reliability by Trpkova *et al.*[6] It was recommended that a total error of less than 0.59 mm in the X-axis and 0.56 mm in the Yaxis be achieved for a landmark to be considered sufficiently reliable. Of the 15 landmarks investigated, only 5 landmarks, B point, A point, pterygomaxillary fissure inferior, sella and gonion, reached this level of reliability in the X-axis. In the Y-axis, only pterygomaxillary fissure inferior, A point and sella exhibited sufficient reliability. This meta-analysis, however, did not investigate the reliability of soft tissue cephalometric landmarks, which have been found to be fairly unreliable.[20,21] In conventional methods , tracing errors can be contributed by the human eye's perceptive limits, pencil line thickness and mechanical errors caused by drawing lines between the cephalometric landmarks and during measurement with a protractor and ruler.[22]Therefore, repeatability of photogrammetric landmark measurements is a more suitable method for evaluating the reliability than comparing absolute values to other methods of facial evaluation.

According to the master thesis by Dr.Michael G. Payne of Marquette Universityshowed a statistical difference in Total facial convexity angle (G'.Pn.Pg'),Facial convexity angle (G'.Sn.Pg'),Nasolabial angle (UL.Sn.Co),Mentolabial angle (Pg'.B'.LL) measurements between the manual cephelometric group and the photometric group is due to the difficulty in reproducing the landmarks like glabella,soft tissue pogonion , labraisuperioris and labraiinferioris due to the gender charecteristics (eg:thick eyebrows, facial hair) on the photograph.[23]

The statistical difference between the Lower third angle (Sn.Me'.C) between the photometric and conventional cephelometric group is due to the low reliability of throat point (C) in Y-Axis when plotted manually

In general, the study had shown statistically significant values on correlation of manual cephelometric and photometric methods. It can be said that the photometric analysis with AUTOCAD software is as reliable as the conventional cephalometric method and that the minimal variations are attributed by the operator's reproducibility of the landmarks and calibration of image the circle constructed in the software. In terms of the radiation exposure and patient management photometric analysis can change the empathises of treatment planning from a dentoskeletal aspect to facial soft tissue aspect

CONCLUSIONS

In order to meet the aesthetic expectations of patients, orthodontic treatment must include a detailed analysis of soft tissues. Photogrammetric analysis can be a good adjunct in diagnosis and treatment planning of orthodontic cases by giving more importance to aesthetic concerns. But still cannot replace lateral cephalograms as they give us a detailed picture of dentoskeletal structures.

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