

A Two-Dimensional Comparative Analysis of the Credibility of Profile Photographs Countered to Lateral Cephalograms, Based on Special Equivalent Dimensions in Class III Malocclusions

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Abstract

Background: This study aims to make a two-dimensional comparative analysis of profile photographs in the diagnosis of growth patterns of skeletal class III malocclusions with the equivalent cephalometric analysis. The study aims to develop a non-invasive method for diagnosing anteroposterior skeletal discrepancy and growth patterns, to use photographs as an alternative to lateral cephalograms for initial diagnosis, as this will reduce the risk of radiation exposure to patients, to explore the new dimensions in photogrammetry as well as cephalometry for preliminary diagnosis of sagittal and vertical skeletal discrepancy and to re-evaluate the credibility and importance of new dimensions (Tau and R angle) used in the study. Research question is “Is photogrammetry self-sufficient?” **Materials and Methods:** Pre-treatment lateral cephalograms and pre-treatment profile photographs at rest of the 50 patients with skeletal Class III malocclusion who reported to the department for orthodontic treatment were calibrated and compared. **Results:** On comparing the angular cephalometric and photographic parameters significantly high correlation was found. Pearson’s correlation test was done to see the similarity between the two methods. $P < 0.001$ suggests the method was statistically highly significant. High correlation was found between the cephalometric R angle and photographic Gonial angle for vertical growth assessment and high correlation was found between cephalometric tau angle and photographic facial convexity angle. **Conclusion:** Photogrammetry can be used as a simple and feasible alternative to cephalometry for sagittal and vertical growth assessment.

Keywords: Class III malocclusion, Photogrammetry, R angle, Sagittal and vertical growth assessment, Tau angle.

INTRODUCTION

One of the main reasons for any patient to opt for orthodontic treatment is external facial appearance, i.e., Aesthetics. Hence, the first aim of the treatment for any orthodontist is to achieve a harmonious and balanced facial structure. The treatment plan and outcome of treatment in orthodontics entirely depend on the proper diagnosis of Malocclusion and craniofacial morphology. Malocclusions can be mainly classified as dental or skeletal, i.e., dental class I, class II, and class III and skeletal class I, class II, and class III. As the class III malocclusions are not very often to see and rarely discussed compared to others, we wanted to do a study on the same. The etiology of the class III malocclusions may be purely dental or skeletal as discussed before. Etiology of the skeletal class III is due to the retrognathic or short maxilla, prognathic or large mandible, or a combination of both. While treating class III malocclusions differentiation of whether the particular malocclusion is

Dental or skeletal is very significant, as the treatment plan depends entirely on the same. While all the dental class III malocclusions can be treated by orthodontic treatment, skeletal discrepancies are vivid. Treatment of skeletal class III malocclusions depends on the age of the patient. In growing children, skeletal class III can be treated by functional therapy whereas in non-growing adults it can be treated either by camouflage or by orthognathic surgery depending on the

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severity and the choice of the patient. Hence, identifying whether the particular case is skeletal or dental class III is very essential for the initiation of the treatment. For the diagnosis of any particular craniofacial abnormality, several records of the patient are considered such as case history, study models, photographs, lateral cephalograms, and OPG. Although lateral cephalography is a standard diagnostic aid for diagnosing any skeletal abnormality, unfortunately, it is associated with hazardous radiation exposure, especially in children which emphasizes the need for other non-invasive alternatives.^[1] It is a known fact that children and adolescents are the majority of patients that attend to the orthodontic department. As there would be phase of active growth, i.e., in which body cells actively divide by mitosis in children and adolescents, the risk of cessation of growth due to radiation is evident. Formation and development of permanent teeth in dental follicles is one such good example of active mitosis occurrence in children. As discussed before though cephalograms are the golden standard for diagnosing the skeletal discrepancy they are associated with risk of radiation exposure. The hazardous effects of radiation are classified into two categories; (a) Deterministic and (b) stochastic. Deterministic effects depend on the threshold dose. The threshold dose is generally the optimal dose in which exposure under this level does not cause any effect but the exposure higher than this dose causes visible effects on the system these effects, which develop when the subjects are exposed to higher than the threshold dose are known as the deterministic effects. On the other hand, stochastic effects are independent on the threshold dose, i.e., even very small amount of radiation can also have the probability of causing adverse effects on the system. Basically when the living cells are exposed to radiation free radicals will be generated. These free radicals have an unpaired electron in the valence shell; hence, they try to attain a stable configuration by reacting with the nearby molecules leading to the molecular changes known as mutations. Mutations in the genes are responsible for the formation of cancers. Though the effective dose of lateral cephalograms is only 5.1–5.6 μ Sv the risk of stochastic effects cannot be neglected. Hence, need for the non-invasive alternative method to cephalograms is evident. Photography in dentistry has seen tremendous progress since 1839.^[2] It is usually helpful in quantifying the facial aesthetics. From the Daguerre concept Alexander S Wolcott, a dentist turned photographer has designed and patented the first camera.^[2] Photography has given great importance by many veteran orthodontists such as Simon and Graber who included facial photography as an essential diagnostic aid.^[2] Stoner was the first to propose photogrammetry in orthodontics, who compared pre- and post-treatment profiles with ideal profiles.^[3] Photogrammetry is defined as “the art, science, and technology of obtaining reliable information about physical objects through processes of recording, measuring, and interpreting photographic images.”^[2] Unlike lateral cephalometry which is hectic and time-consuming, photogrammetry is a feasible and simple alternative. Photogrammetry uses several soft-tissue parameters which help in diagnosing the skeletal as

well as a dental abnormality.^[4,5] In our study we want to re-emphasize the photogrammetry for the diagnosis of growth pattern and sagittal craniofacial discrepancies by considering simple angular parameters of soft-tissue landmarks and also to retrospect the new dimensions in cephalometry, i.e., Tau angle^[6] (t angle) and R angle^[7] in classifying skeletal malocclusion. Thereby this research is done to understand and develop a non-invasive and self-sufficient photogrammetry diagnostic method.

MATERIALS AND METHODS

This is an independent study with individualistic research work. In this cross-sectional study, the right-sided Lateral cephalograms and profile photographs of 50 subjects (26 males and 24 females) with class III malocclusion were obtained and compared. Inclusion criteria include patients with permanent dentition irrespective of third molar eruption, class III malocclusions, and without Masticatory disharmony. Exclusion criteria include Patients with a history of previous orthodontic treatment, history of craniofacial trauma, anomalies, and temporomandibular disorder.

Photographs were shot with DSLR camera (Nikon Eos D3400, Thailand) with a Macro portrait lens (AF 18–55 mm, 1:3.5–5.6G, NIKKOR) in a manual position, the shutter speed was 1/125/s, the opening of the diaphragm was f/11. The distance of 100 cm and 5 feet from subject to background and camera was maintained, respectively. The mirror was mounted 120 cm away from the subjects. Patients were asked to bend their heads up and down until they feel relaxed to attain the Natural Head Position.^[8] The subjects were asked to take a few steps ahead facing mirror and, look into their own eyes with their body extremities in a relaxed position. The subjects were asked to keep their eyes open, lips relaxed with maximum intercuspation of their teeth and not to smile while photographing. During the photography each patient stood with their Frankfurt Horizontal (FH) plane parallel to the floor.

All the radiographs were taken using the VATECH-PCH2500 X-ray machine under uniform light. While radiographing the patients were again asked to perform neck bending exercises to attain Natural Head Position. NOVAJET medical imaging film of 175 microns has been chosen and all the radiographs were traced manually on a polyester acetate tracing paper having a thickness of 50 microns with a sharp 3H drawing pencil to evaluate the Growth pattern and sagittal discrepancies.

Landmark identification in cephalometry: 10 hard tissue landmarks were selected to rule out the growth pattern as well as sagittal discrepancy they are Porion, orbitale, Articulare, Gonion, Menton, point T, G, M, N and C. The growth pattern was assessed through Frankfurt mandibular plane angle (FMA), Gonial angle R angle, and sagittal discrepancy was assessed by Tau angle.

Landmark identification in photography: 7 soft tissue landmarks, i.e., Tragus (Tr), Orbitale' (Or'), Gonion' (Go'),

Menton' (Me'), Glabella' (G'), Subnasion' (Sn') and Pogonion' (Pg') were identified in the right lateral photographs. Linear parameters in photography include FH plane, Gonial plane, Mandibular plane, and one angular parameter Angle of facial convexity is considered. The FH plane is constructed using points Tr' and Or', Gonial plane is constructed using Tr' and Go', Mandibular plane is constructed using Go' and Me', Angle of facial convexity is constructed using soft-tissue points G', Sn' and Pg'. Growth pattern in photography was assessed through soft-tissue FMA and Gonial angle and sagittal discrepancy was assessed through angle of facial convexity.

To know the growth pattern first of all the cephalometric growth pattern was assessed through conventional FMA and Gonial angle and a new parameter called R angle. Similarly, the same parameters, i.e., soft-tissue FMA' and Gonial angle' were measured in photographs and have been compared with the analogous cephalometric parameters and also with R angle

to see the similarity between the two. The sagittal discrepancy in the cephalometry was assessed through a new parameter called Tau angle and in photography through the angle of facial convexity. Although there is no similarity between the cephalometric tau angle and photographic Angle of facial convexity the evaluated values of both the parameters were compared with their subsequent ideal values given in their original articles to rule out the particular sagittal skeletal discrepancy.

RESULTS

The mean value of the sagittal cephalometric parameter, i.e., t angle of the present study population is 34.41 ± 3.55 while photographic facial convex angle was 175.91 ± 4.10 (Table 1).

The mean gonial angle by cephalometry was 135.91 ± 4.73 , FMA was 28.58 ± 3.50 and R angle was 73.83 ± 2.94 while

Table 1: Determining the growth pattern and sagittal discrepancy of each patient through comparing the lateral cephalograms and profile photograph of the same

Method	Angles	Ideal value	Mean	SD	No of participants	%
Cephalometric	FMA	Average growth (Class I): 26°	28.58	3.50	50	Average=40% High=60%
		Low growth (Class II): $<26^\circ$				
		High growth Class III: $>26^\circ$				
	Gonial	Average growth (Class I): $123-137^\circ$	135.91	4.73	50	Average=48% High=52%
		Low growth (Class II): $<123^\circ$				
		High growth Class III: $>137^\circ$				
	R angle	Average growth (Class I): $70.5-75.5^\circ$	73.83	2.94	50	Average=48% High=52%
		Low growth Class II: $<70.5^\circ$				
		High growth Class III: $>75.5^\circ$				
Photographic	FMA	Average growth Class I: 26°	28.25	2.00	50	Average=40% High=60%
		Low growth Class II: $<26^\circ$				
		High growth Class III: $>26^\circ$				
	Gonial	Average growth (Class I): $123-137^\circ$	136.50	4.77	50	Average=48% High=52%
		Low growth (Class II): $<123^\circ$				
		High growth (Class III): $>137^\circ$				
Cephalometric	Tau angle	Class I - $28-34^\circ$ Class II - $<28^\circ$ Class III - $>34^\circ$	34.41	3.55	50	Skeletal class I =32% Skeletal class III =68%
Photographic	Angle of Facial convexity	Class I: $165-175^\circ$ Class II: $<165^\circ$ Class III: $>175^\circ$	175.91	4.10	50	Skeletal class I =32% Skeletal class III =68%

Table 2: Correlation between cephalometric and photographic methods

Parameters	Cephalometric	Photographic	n	Pearson correlation	P-value
Vertical	FMA	FMA	50	0.727	0.001**
	Gonial	Gonial	50	0.994	0.001**
	R angle	FMA	50	0.851	0.001**
	R angle	Gonial	50	0.823	0.001**
Sagittal	Tau angle	Facial convexity	50	0.791	0.001**

Pearson correlation, *Significant, FMA: Frankfurt mandibular plane angle

the mean of the photographic gonial angle was 136.50 ± 4.77 and FMA was 28.25 ± 2.00 (Table 1).

Chi-square test was done to find out a significant difference between the cephalometric and photographic methods. The *P*-value showed non-significant difference between cephalometric and photographic methods for FMA, gonial angle assessment.

According to the Pearson co-relation test, there was a high correlation found between Cephalometric and photographic methods. The vertical methods showed a correlation value of 0.727 between FMA of both methods, 0.790 between FMA(cephalometric) and Gonial angle (photographic), 0.994 between gonial angle of both methods, 0.747 between gonial angle (cephalometric) and FMA (photographic), 0.851 between R angle (cephalometric) and FMA (photographic) and 0.823 between R angle (cephalometric) and Gonial angle (photographic). The sagittal methods showed a correlation value of 0.791 between Tau angle and facial convexity (Table 2).

DISCUSSION

The purpose of this study is to re-emphasize the angular parameters of photogrammetry in the evaluation of sagittal and vertical growth patterns and also to retrospect the new parameters of cephalometry, i.e., tau and r angle. Although ANB, Wit's, Beta angle, and w angle are the most frequently used parameters to assess the sagittal discrepancy each of these parameters has their own drawbacks. The most popular W angle uses point S, M and G. Though point M and G are unaffected by the growth of the patient, point S (sella) is unstable on the growth of the patient.^[6] Hence, we chose Tau angle to rule out the sagittal discrepancy. Similarly, to assess the vertical growth pattern a new parameter called R angle has been chosen along with conventional FMA and Gonial angles.

As discussed before though the cephalometry is golden standard for diagnosing the craniofacial skeletal discrepancy, the harmful effects of the radiation cannot be abandoned.^[1,9-11]

Several earlier studies state that photography is an easy, reliable, and non-invasive alternative to cephalograms.^[12-16] Although Anthropometry is also a good alternative it is associated with the presence of the subjects all the time or whenever there is a need to review the anthropometric values which is hardly possible.^[12] Hence, need for the learning and development of

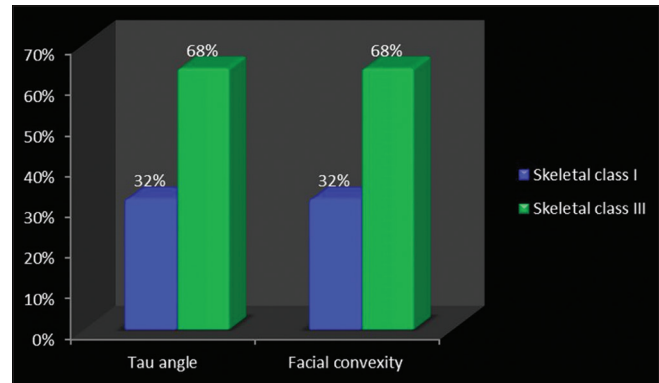


Figure 1: Agreement of cephalometric and photogrammetric sagittal skeletal assessment

photogrammetric methods was essential. The photogrammetric method has many advantages such as the subjects, do not move while taking the measurements, and the data photographic data can be stored permanently, and reviewed whenever required and also makes it the best alternative for epidemiological studies.^[13] Besides its advantages there are also some drawbacks in photogrammetry such as distortion from the distance between the lens to the subject,^[12,14] i.e., the objects close to the lens appear larger than those farther from the lens. Hence, there will be error in the study if liner measurements are considered. To avoid this problem the position of the camera and patient were prefixed to 5 feet of distance and only angular parameters were considered.

On comparing the ideal values of cephalometric Tau angle to the ideal values of photogrammetric angle of facial convexity they were found to be in agreement with each other and found 68% of patients were skeletal class III and 32% of patients were of skeletal class I (Figure 1). These values suggest that out of 100% of cases 68% were skeletal class III and 32% were of Dental class III and skeletal class I (Table 1). The angular parameters for the growth pattern, i.e., the cephalometric and photographic FMA and Gonial angle were in agreement with each other and also almost in agreement with the R angle. High correlation is seen between Gonial and R angle compared to R angle and FMA (Figure 2). According to FMA 60% of patients were found to be skeletal class III and 40% of patients were found to be skeletal class I. While according to Gonial and R angle 52% of the patients were found to be skeletal class III and 48% of patients fall under skeletal class I (Table 1 and Figure 2). The 8% of error between FMA and

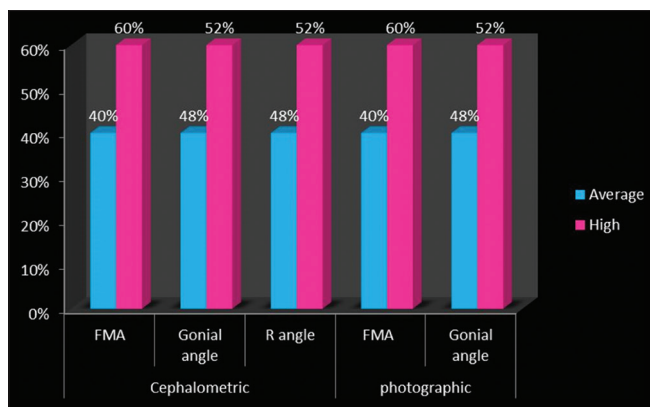


Figure 2: Agreement of cephalometric and photogrammetric vertical skeletal pattern

Gonial angle is acceptable hence at times there would be a minute difference in the vertical growth pattern of skeletal class I and class III, i.e., at times patients were found to have slightly high growth pattern but exhibit skeletal class I relation.

Pearson correlation test is carried out to see the similarity between cephalometric and photogrammetric parameters and found the value as $P < 0.001$ which suggests high correlation between the two methods (Table 2). Similar findings for FMA were found in other studies also.^[4,17]

CONCLUSION

A high statistically significant correlation has been found between the cephalometric and photographic sagittal and vertical diagnostic variables. Chi-square test suggests no significant difference between the two methods. Hence photogrammetric method can be used as an alternative to cephalograms for the preliminary diagnosis of any craniofacial skeletal discrepancy. Although lateral cephalograms are accurate compared to photographs for diagnosis, their use can be reduced for the uncomplicated cases.

Caution must be taken to mark the point Menton (Me') by palpating and attaching a visible marker over it which is visible in photographs to assess the FMA and Gonial angle.

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