Correlation Between Cephalometric Measures and End-of-Treatment Facial Attractiveness

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Abstract: Sixty-nine experienced Chinese orthodontists evaluated 108 Chinese patients' facial attractiveness from set of photographs (frontal, lateral, and frontal smiling photos) taken at the end of orthodontic treatment. These 108 patients, which contained an equal number of patients with Class I, II, and III malocclusion, were randomly selected from 6 orthodontic treatment centers throughout China. Spearman rank-order correlation coefficients (r_s) analyses were performed to examine agreement in ranking between all judge pairs. Pearson correlation and multivariate regression were performed to examine the correlation between cephalometric measures and end-of-treatment Photo Attractiveness Rank.

96.68% judge pairs showed moderate correlated ($+0.4 \leq r_s < +0.7$) subjective rankings. Cephalometric measures significantly correlated with end-of-treatment Photo Attractiveness Rank included interincisal angle ($r = 0.330$, $P < 0.05$), L1/MP° ($r = 0.386$, $P < 0.05$), L1-NBmm ($r = 0.451$, $P < 0.01$), L1/NB° ($r = 0.374$, $P < 0.05$), and profile angle ($r = 0.353$, $P < 0.05$) in Class I patients with an explained variance of 32.8%, and ANB angle ($r = 0.432$, $P < 0.01$), angle of convexity ($r = 0.448$, $P < 0.01$), profile angle ($r = 0.488$, $P < 0.01$), Li to E-line ($r = 0.374$, $P < 0.05$), Li to B-line ($r = 0.543$, $P < 0.01$), and Z angle ($r = 0.543$, $P < 0.01$) in Class II patient with an explained variance of 43.3%.

There was less association than expected between objective measurements on the lateral cephalograms and clinicians' rankings of facial attractiveness on clinical photography in Chinese patients. Straight-stand lower incisor was desired for facial attractiveness of Class I malocclusion; and sagittal relationship and lip prominence influence the esthetics of Class II malocclusion in Chinese population.

Key Words: Cephalometric, Chinese population, facial attractiveness

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The subject of beauty has been the topic of much debate throughout history, and methods for the evaluation of beauty have been the focus of many research projects. An attractive facial appearance invites positive social responses, which has a profound effect on a person's self-esteem and social adjustment ability. Orthodontic patents and their parents expect that orthodontic treatment will improve their facial esthetics and consequently their popularity and social acceptance. Therefore, over the last decades orthodontists focus their treatment plans more and more on improvement of facial esthetics.

In clinic, orthodontists rely their esthetic judgments much on facial photographs that are frontal, frontal smiling, and lateral photos. These photos have become one of the important components of routine orthodontic records set for diagnosis, treatment planning, and outcome analysis. However, techniques for quantitative measurement of facial photographs and standardization of photographic orientation are much less well advanced in orthodontics. Lateral cephalograms inform us the relationship between those surface structures and their underlying skeletal and dental armature better, and have complementary roles in the evaluation of facial attractiveness by orthodontist.

Now, the question is whether a facial assessment in photographs allows any conclusions with respect to the existing lateral skeletofacial morphology. Previous research has found weak correlation between cephalometric measures and facial attractiveness, and also some cephalometric indicators in Caucasians.[1–5] But few studies consisted of a stratified sample of Angle Class I, Class II, and Class III patients, whereas different kinds of malocclusion did carry distinguished craniofacial characters. And to date, most investigations published on this aspect have been on Caucasian populations and few studies have investigated a Chinese population.

Therefore, the aim of the present study was to examine the correlation between experienced Chinese orthodontists' rankings of facial attractiveness with cephalometric measures of facial attractiveness from a stratified sample of Angle Class I, Class II, and Class III cases in Chinese patients.

METHODS

Subjects

Ethical approval was obtained from Peking University before the start of the study. Six orthodontic treatment centers in China collaborated in the study, including the Peking University School of Stomatology, the West China College of Stomatology at Sichuan University, the School of Stomatology at the Fourth Military Medical University, the Beijing Stomatological Hospital and School of Stomatology Capital Medical University, the Stomatological Hospital and College of Nanjing Medical University, and the Hospital of Stomatology at Wuhan University. At each center, a list of no fewer than 300 nonorthognathic surgical patients with full record for whom orthodontic treatment had been completed between 2005 and 2008 was collected. The initial lists from the 6 centers, which totaled 2383 patients, were forwarded to the Peking University School of Stomatology for further processing including randomization. A stratified random sample of 108 patients (30 males and 78 females; age range, 12–29 years) was drawn from the larger sample, balanced to contain 18 patients from each collaborating center and equal number of Angle Class I, Class II, and Class III malocclusions. This sample was further randomized with adaptive allocation to produce 9 groups containing 12 patients each. Each group contained 4 Angle Class I, 4 Angle Class II, and 4 Angle Class III treated patients. The procedure for sampling and grouping is shown in Figure 1.

Subjective Attractiveness Evaluation

The judges for the experiments were 69 experienced orthodontists (38 males and 31 females) in China, who had more than 10 years of experience in clinical experiments. They were asked to rank the orthodontic set of photographs (the frontal, frontal smiling, and lateral photography after orthodontic treatment, as shown in Fig. 2) of each group in the order of "the most attractive" to "the least attractive." The ranking was done on a scale of 1 to 12, with 1 assigned "the most attractive" and 12 "the least attractive" rank.

Objective Measurements on Lateral Films

Three operators identified landmarks on lateral films using customized software produced by Key Laboratory of Machine

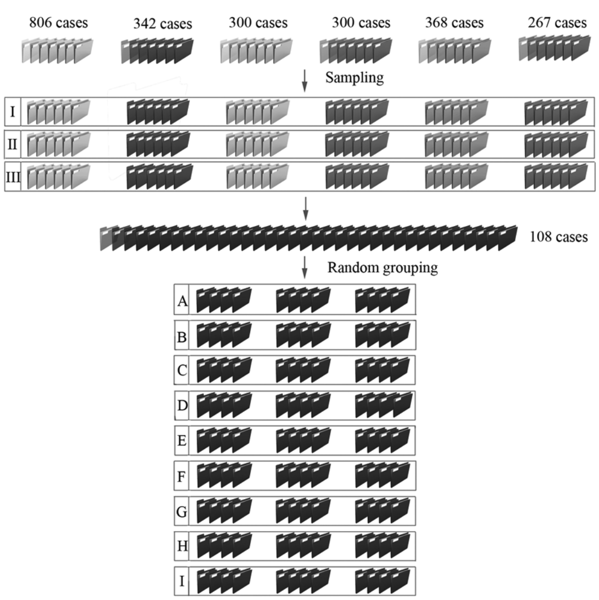

FIGURE 1. Procedure for sampling and grouping. The subjects included 2383 patients who underwent orthodontic treatment without orthognathic surgery in the 6 universities during 2005 to 2008. Eighteen patients were selected randomly from each of the universities, with an equal number of Class I, Class II, and Class III malocclusion patients. These 108 patients were randomly arranged into 9 groups containing 12 patients each, among whom 4 were classified as Class I before treatment, 4 as Class II before treatment, and 4 as Class III before treatment.

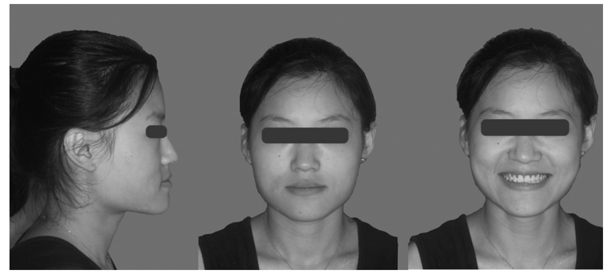

FIGURE 2. Orthodontic triplet.

Perception, Peking University. The operator was asked to reidentify any landmark that was determined to be outside the acceptable discrete range of landmarks[6] as defined by the software, so that all landmarks identified by each of the 3 operators would be inside the acceptable discrete range. In total, 23 variables on the lateral films were calculated from the mean of 3 operators. *Z* score of the deviation of an individual variable (v) from its "ideal" target (t) was calculated as $z = (v - t)/SD$ (with *SD* as the standard deviation of the individual). Descriptions of measures, with the "ideal" targets of Chinese population, are given in Table 1.[7]

Statistical Analysis

All statistical analyses were performed using Statistical Product and Service Solutions (SPSS) software (V20.0; IBM SPSS Statistics, IBM Corp, Armonk, NY). Spearman rank-order correlation coefficients (r_s) analyses, which were used to assess reliability between pairs of judges ranking data that were distributed nonnormally, were computed to show agreement in ranking between all judge pairs.

A frequency chart of all the rankings was made for each patient (Fig. 3). The 4 adjacent bars in the central area, which account for the largest percentage of rankings, were reserved, and the rest of the data was eliminated. This was done to eliminate inconsistent data that did not agree with the majority. Then, the weighted mean was calculated for each patient, which was defined as Photo Attractiveness Rank and used in the correlation analysis and multivariate regression with objective measurements.

Photo Attractiveness Rank of each Angle classification was statistically analyzed by one-way ANOVA. One-way analysis of variance (ANOVA) was used under the assumption that the samples were drawn from normal populations. Individual z-scores after treatment were used as input for Pearson correlation analysis with Photo Attractiveness Rank for each kind of Angle classification respectively, the result of which is shown in Table 3. Subsequently, multivariate regression was preformed to ascertain the combined effect of the significant variables on end-of-treatment Photo Attractiveness Rank.

In examining associations between variables, we have chosen to report Pearson rho values rather than Spearman rho values that are frequently used for ranked data. We reasoned that, since Photo Attractiveness Rank for each patient in this study is the weighted mean of 69 individual values, they would be expected to be approximately normally distributed by the central limit theorem. In addition, the cephalometric variables did not appear to have grossly non-normal distributions. Therefore, the Pearson correlation would be expected to have good properties for detecting linear associations between the Photo Attractiveness Rank and the cephalometric variables. Furthermore, the advantage of using Pearson correlation over the Spearman was that its square (r^2) could be used as a measure of explained variance, thus facilitating a

TABLE 1. Definition of Measures Used in This Study

Measures	Description	Target	SD
ANB (°)	Point A-nasion-point B	2.1	1.45
Wits appraisal	The distance between projection of Point A and Point B on functional occlusal plane	−1.35	2.56
Facial angle (°)	Nasion-pogonion/Frankfort horizontal plane	87.8	4.22
Angle of convexity (°)	Nasion-point A-pogonion	2.4	3.38
Mandibular plane angle (°)	Gonion-menton/Frankfort horizontal plane	25.4	5.3
Cant of occlusal plane (°)	Occlusal plane/Frankfort horizontal plane	9.7	5.29
ALFH (%)	Anterior lower facial height, Subnasale'-menton'/nasion'-menton'	50	2.00
U1/L1 (°)	Upper incisor axis/lower incisor axis	130.8	6.88
U1 /SN (°)	Upper incisor axis/sella-nasion	103.7	5.67
L1/MP (°)	Lower incisor axis/mandibular plane	90.5	5.73
U1/NA (°)	Upper incisor axis/nasion-point A	22.6	5.33
L1/NB (°)	Lower incisor axis/nasion-point B	24.6	4.4
U1-NA (mm)	Upper incisor tip to A-nasion line distance	5.5	2.41
L1-NB (mm)	Lower incisor tip to B-nasion line distance	5.6	1.86
Pg-NB (mm)	Pogonion to B-nasion line distance	2.1	1.3
Ls to E-line (mm)	Anterior-most point on upper lip (Ls) to E-line	−1.3	1.68
Li to E-line (mm)	Anterior-most point on lower lip (Li) to E-line	0.5	1.68
Ls to B-line (mm)	Ls to B-line	5.3	1.22
Li to B-line (mm)	Li to B-line	4.4	1.53
Profile angle (°)	Nasion'- subnasale' –pogonion'	164.6	3.65
Nasiolabial angle (°)	Columella'-subnasale'-Ls	97.4	9.98
Mentolabial sulcus (°)	Li-point B'-pogonion'	130.5	10.06
Z angle (°)	Profile line/Frankfort horizontal plane	68.33	9.56

Target base[7]: 90 males and 90 females, with normal occlusion and balanced profile, 12–28 yr; ' means soft-tissue landmark.
SD, standard deviation.

straightforward assessment of increased association when combinations of cephalometric variables were considered in multivariate regression.

RESULTS

Among 2346 ($C_{69}{}^2$) separate pairings between judges, there was ranking of no pair of judges correlated negatively. This is to say that there was no situation, in which 2 judges had concepts of attractiveness so that the face that 1 judge tended to find attractive were consistently found unattractive by the other. It was also true that the level of agreement among pairs of judges was highly variable, ranging from 0.021 to 0.902. Among the total of 2346 judge-pair correlations (r_s), 14.66% were lower than +0.4 (slightly correlated); 96.68% were lower than +0.7 (moderately correlated); and only 3.32% were greater than +0.7 (highly correlated).

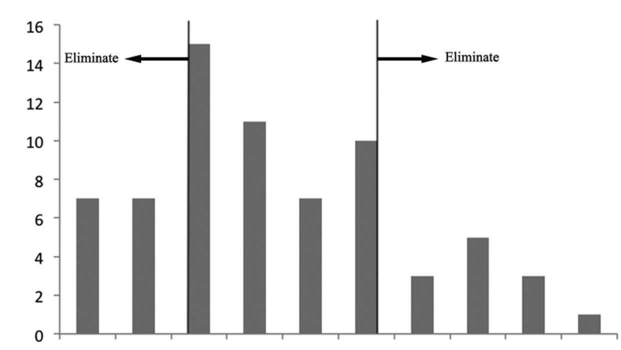

FIGURE 3. Frequency chart for patient A1.

As shown in Table 2, there was significantly difference among Photo Attractiveness Rank of each Angle classification ($P < 0.05$). The correlation between measures' *Z* score and end-of-treatment Photo Attractiveness Rank is listed in Table 3. As shown, all measures related to lower incisor were found to be significantly correlated with Photo Attractiveness Rank of Angle Class I patients, including Interincisal angle ($r = 0.330$, $P < 0.05$), L1/MP° ($r = 0.386$, $P < 0.05$), L1-NBmm ($r = 0.451$, $P < 0.01$), and L1/NB° ($r = 0.374$, $P < 0.05$), as long as Profile angle ($r = 0.353$, $P < 0.05$). The explained variance of this combination of the 5 measures was 32.8%. In Angle Class II patient, 2 hard-tissue measures, concerning sagittal relationship, ANB angle ($r = 0.432$, $P < 0.01$), and angle of convexity ($r = 0.448$, $P < 0.01$), were found to be significantly correlated with end-of-treatment Photo Attractiveness Rank; other significantly correlated measures included the profile angle ($r = 0.488$, $P < 0.01$), Li to E-line ($r = 0.374$, $P < 0.05$), Li to B-line ($r = 0.543$, $P < 0.01$), and Z angle ($r = 0.543$, $P < 0.01$). The explained variance of this combination of the 6 measures was 43.3%. There was not any

TABLE 2. Difference of Photo Attractiveness Rank Among Each Angle Classification (ANOVA)

	Angle Class I		Angle Class II		Angle Class III			
	Mean	SD	Mean	SD	Mean	SD	*F* Value	*P* Value
Photo Attractiveness Rank	5.35	3.39	6.55	3.25	7.52	2.94	4.13	0.019*

SD, standard deviation.
* $P < 0.05$.

TABLE 3. Pearson Correlations Between Measures' *Z* Score and End-of-Treatment Photo Attractive Rank

	Angle Class I		Angle Class II		Angle Class III	
	r	*P*	*r*	*P*	*r*	*P*
ANB (°)	0.258	0.129	0.432**	0.008	−0.049	0.775
Wits appraisal	0.071	0.681	0.312	0.064	−0.129	0.453
Facial angle (°)	−0.158	0.357	0.190	0.268	−0.039	0.820
Angle of convexity (°)	0.229	0.179	0.448**	0.006	0.018	0.916
Mandibular plane angle (°)	−0.084	0.625	0.110	0.524	0.200	0.242
Cant of occlusal plane (°)	−0.254	0.135	0.083	0.629	0.229	0.179
ALFH (%)	−0.091	0.599	0.084	0.627	0.000	0.999
Interincisal angle (°)	0.330*	0.049	0.114	0.508	−0.109	0.528
U1 /SN (°)	−0.165	0.336	0.146	0.396	−0.104	0.544
L1/MP (°)	0.386*	0.020	0.065	0.706	0.033	0.849
U1/NA (°)	0.053	0.759	0.010	0.953	−0.152	0.377
L1/NB (°)	0.374*	0.025	0.308	0.067	0.050	0.772
U1-NA (mm)	0.038	0.828	0.022	0.899	−0.259	0.127
L1-NB (mm)	0.451**	0.006	0.270	0.111	−0.031	0.856
Pg-NB (mm)	−0.172	0.315	−0.215	0.209	0.018	0.916
Ls to E-line (mm)	0.287	0.089	0.297	0.079	0.317	0.060
Li to E-line (mm)	0.318	0.059	0.374*	0.025	0.285	0.092
Ls to B-line (mm)	0.212	0.215	0.264	0.120	0.063	0.713
Li to B-line (mm)	0.290	0.087	0.543**	0.001	0.071	0.679
Profile angle (°)	0.353*	0.035	0.488**	0.003	0.198	0.248
Nasiolabial angle (°)	0.188	0.271	0.123	0.473	−0.012	0.945
Mentolabial sulcus (°)	0.310	0.066	0.180	0.293	−0.103	0.548
Z angle (°)	0.290	0.087	0.543**	0.001	0.071	0.679

* $P < 0.05$.
** $P < 0.01$

measure, which was significantly correlated with end-of-treatment Photo Attractiveness Rank of Angle Class III patients.

We can see from the result, although different concept about facial attractive was shown among orthodontic specialists, some agreements were also appeared in the result. First, angle classification did affect facial appearance; patients with Class I molar relationship usually got a better score than others. Second, several significant items were found in Class I and Class II malocclusion; there were 5 significant measurements in Class I malocclusion, which all closely related with lower incisor. In Class II malocclusion, 6 significant items were found; 2 of them reflex sagittal relationship of hard tissue, and the other 4 were all related to lip prominence. We can believe from the result, straight-stand lower incisor was desired for facial attractiveness of Class I malocclusion; and sagittal relationship and lip prominence influence the esthetics of Class II malocclusion in Chinese population.

DISCUSSION

Validity and reliability are 2 basic necessities for any evaluation system. In this study, we were concerned with the agreement among 69 experienced Chinese orthodontists of their perception of facial attractiveness. 96.68% judge pairs showed moderate correlated ($+0.4 \leq r_s < +0.7$) agreement. The agreement level of our study was distinctly lower than those in many other studies of facial attractiveness, which reported correlations on the order of 0.8 and 0.9.[8,9] We believe the difference between those findings and ours is a property of the fact that somewhat different questions were asked. In most previous orthodontic studies of facial attractiveness, the responses of a group of judges were pooled in an attempt to discern overall judge preferences for particular subjects. In our study, we focused on the smallest unit of comparison between judges, that of 1 judge with 1 other judge. We did so because the comparison between 2 judges seems to model well the clinical situation in which 2 clinicians exchange views concerning patients of common interest. However, averaging the correlations of a large number of judges leads to higher absolute *R* value. Our previous study, which was concerned with ranking of facial attractiveness by pairs of Chinese and US orthodontists, also shared the same level of agreement between pairs of judges.[10]

Based on the assumption that average faces are attractive and that average facial proportions could provide a basis for quantitative assessment of facial esthetics, orthodontic society believes that neither higher nor lower values for the cephalometric measures would tend to be associated with high Photo Attractiveness Ranks, and average values are considered to be ideal. Although recent studies reported that average faces were not the particularly attractive ones, they did attract people.[11] So the ideal value and standard deviation of each measure for Chinese ethnicity from Table 1 was used to transform the raw value of each subject.

As shown in Table 3, significant correlated cephalometric measures explained 32.8% of the variance of Photo Attractiveness Rank in Angle Class I patients, and the explained variance of that in Angle Class II patient was 43.3%. Shafiee et al[12] studied the weight of each type of image in the facial esthetic evaluation of the orthodontic triplet, and found that the smiling photo plays the more important role than frontal and lateral photos. As cephalometric measures could only reflect lateral information, the relative weak predictability in Angle Class I and Class II patients seemed to be acceptable. Although they explained no more than half of their facial attractiveness, they well reflect the information of the profile, which was still quite important for orthodontists.

The stimulus used in this study consisted of a stratified sample of Angle Class I, Class II, and Class III patients. This stratification was only performed to have a wide range of dental and skeletal variation, covering the whole spectrum of orthodontic patients, whereas there seems to be quite weak predictability of Photo Attractiveness Rank in Class III patients. While exclusion of orthognathic surgery patients had been performed in our sample, for the sake of analyzing purely the changes coming from orthodontic treatment. So the Class III patients in this sample did not include severe ones. That may be the reason why we could not find the significant correlations in Table 3. Studies on Caucasians found that the distribution of Class III malocclusion was around 2% to 5%.[13,14] Although the incidence rate in Asian population was much higher, it was still the least population in all 3 kinds of malocclusion.[15] Whether rarity makes skeletal Class III malocclusion far more than acceptable than other malocclusion in population? Higher percentage of surgery performed in Class III malocclusion may lead our Class III sample to loose representativeness. Further researches are needed to study the character that Class III malocclusion carried.

Profile angle was an easy and common facial profile examination method in orthodontic clinic, indicating whether the jaws are proportionately positioned in the anteroposterior plane of space. It was supposed to be a nearly straight line in well-profiled Caucasians, whereas Asians tend to have anteriorly divergent faces.[16,17] Our data supported that Class I and Class II malocclusion with slightly divergent profile was preferred in Asians; the less the angle deviates from the ethnic target 164.6°, the closer to the top they would be placed in Photo Attractiveness Rank.

Lower incisor and its position in the lower arch were considered to be of prime importance at the time of planning an orthodontic treatment, having been recognized as one of the keys in the orthodontic diagnosis.[18] Tweed[19] established the importance of the relation between the inclination of the lower incisor and the mandibular plane, establishing between them a determined angular measure, which was thought to be important for facial esthetics. From our data (Table 3), lower incisor position seemed to be particularly important for facial esthetics in Class I malocclusion. Straight-stand lower incisor was preferred, which also benefit for the health of periodontal tissue.[20] Hernández-Sayago et al[21] observed a relation statistically significant between the inclination of the lower incisor and the mandibular plane in the different malocclusions. In Class II and Class III malocclusion, lower incisor adapted to compensate the sagittal maxilla-mandibular discrepancy developed during growth. This compensation made their incisor inclination away from the target.

CONCLUSIONS

In general, correlations between cephalometric measures and rankings of facial attractiveness were less strong than had been expected in Chinese population. It seems fair to infer that lateral films only reflect the esthetic of profile, which covers no more than half of the information that viewers use in the evaluation of facial attractiveness.

For Chinese population, profile analysis with profile angle close to ethnic target was sensitive in both Class I and Class II malocclusion. Straight-stand lower incisor was preferred for end-of-treatment facial attractiveness in Class I malocclusion. Sagittal discrepancy and lip position influenced end-of-treatment facial attractiveness in Class II patients.

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