Original Article

Reliability of reference distances used in photogrammetry

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ABSTRACT

Objective: To determine the reliability of the reference distances used for photogrammetric assessment.

Materials and Methods: The sample consisted of 100 subjects with mean ages of 22.97 $\pm$ 2.98 years. Five lateral and four frontal parameters were measured directly on the subjects' faces. For photogrammetric assessment, two reference distances for the profile view and three reference distances for the frontal view were established. Standardized photographs were taken and all the parameters that had been measured directly on the face were measured on the photographs. The reliability of the reference distances was checked by comparing direct and indirect values of the parameters obtained from the subjects' faces and photographs. Repeated measure analysis of variance (ANOVA) and Bland-Altman analyses were used for statistical assessment.

Results: For profile measurements, the indirect values measured were statistically different from the direct values except for Sn-Sto in male subjects and Prn-Sn and Sn-Sto in female subjects. The indirect values of Prn-Sn and Sn-Sto were reliable in both sexes. The poorest results were obtained in the indirect values of the N-Sn parameter for female subjects and the Sn-Me parameter for male subjects according to the Sa-Sba reference distance. For frontal measurements, the indirect values were statistically different from the direct values in both sexes except for one in male subjects. The indirect values measured were not statistically different from the direct values for Go-Go. The indirect values of Ch-Ch were reliable in male subjects. The poorest results were obtained according to the P-P reference distance.

Conclusions: For profile assessment, the T-Ex reference distance was reliable for Prn-Sn and Sn-Sto in both sexes. For frontal assessment, Ex-Ex and En-En reference distances were reliable for Ch-Ch in male subjects. (*Angle Orthod.* 2010;80:670–677.)

KEY WORDS: Photogrammetry; Reference distances

INTRODUCTION

One of the most important factors in the planning of orthodontic treatment and the assessment of treatment changes is to evaluate the soft tissue.[1,2] For this purpose, quantitative assessments of soft tissue have been performed by using lateral cephalometric radiographs classically, and several cephalometric analyses have been developed and proposed.[3–5]

It is not possible to evaluate the soft tissues from the frontal view by using cephalometric radiographs. In addition to cephalometric radiographs, soft tissue evaluation has been carried out by means of different methods such as anthropometry,[6–10] two- or three-dimensional photogrammetry,[11–23] and three-dimensional imaging techniques.[24,25] Among these methods, two-dimensional photogrammetry has the advantage of being a basic, noninvasive, cost-effective, and quick method that requires minimal time and equipment in the assessment of soft tissue.[26–28]

Most of the studies about soft tissue evaluation on standardized two-dimensional life-sized photographs reported the assessment or comparison of racial characteristics, differences between genders, and treatment changes.[13,16–18,20–22,29] Only one study concluded the reliability of reference distances for facial

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asymmetry assessment.[19] Since then, researchers have never attempted to study the reliability of reference distances that can be used for photogrammetric assessment. Nonetheless, such information is important for clinicians because the reliability of the measurements obtained from the photographs depends on the reliability of the reference distances used on photographs. Therefore, the aim of our study is to classify the reliability of the five reference distances used for photogrammetric assessment on subjects' two-dimensional extraoral photographs obtained under three postural conditions (centric relation, relaxed lip posture, natural head orientation, and sitting position). These reference distances are Sa-Sba (superior auricula-subauricula), T-Ex (tragus-exocanthion) on the profile view, and Ex-Ex (exocanthion-exocanthion), En-En (endocanthion-endocanthion), and P-P (pupil center-pupil center) on the frontal view.

MATERIALS AND METHODS

The sample consisted of 100 healthy subjects (50 male and 50 female). The mean ages of the male and female subjects were 23 $\pm$ 3.39 and 22.94 $\pm$ 2.41 years, respectively. All subjects had facial symmetry, no history of trauma and no craniofacial anomaly. The subjects were informed about the procedures; they accepted to participate in this study and signed informed consents.

Direct Measurement

Direct measurements on each subject's face were done with a millimetric compass (Sylvac, Fowler, OPTO-RS232 Simplex/Duplex, Sweden) in centric relation, relaxed lip posture,[30] natural head orientation,[31] and sitting position. Eight frontal and eight lateral distances were measured directly. The parameters measured are shown in Figures 1 and 2.

Indirect Measurement

Standardized lateral and facial photographs of each subject were taken for the indirect measurements. All subjects were positioned on a line marked on the floor during the recording. The photographic set-up consisted of a tripod supporting a digital camera (Nicon Coolpix L1, 6.2 Megapixels, 5$\times$ zoom) 60 cm away from the subject. No optical focus was used during the taking of the photograph. Photographs were taken with each subject in natural head orientation,[31] centric relation, and relaxed lip posture[30] as in the direct method. The photographic records were transferred to the computer and analyzed with the software for Windows, Image Tool version 3.0 (UTHSCSA, San Antonio, Tex). The parameters used in the direct method were measured on photographic records using two reference distances on the profile view (Sa-Sba, T-Ex) and three reference distances on the frontal view (Ex-Ex, En-En, P-P). Each measurement was repeated three times by the same investigator following a 1-week interval, and the mean values were used. Magnification error was calculated from a basic proportion using reference distances: $X = A \times B/C$, where A is the selected reference plane distance measured on the subject's face, B is any parameter measured on the subject's extraoral photograph, and C is the same reference plane distance measured on the subject's extraoral photograph. Two different values on the profile view and three different values on the frontal view were obtained for each parameter according to the reference distances using this proportion. These values were compared with the direct values obtained from the patients. When the differences between the indirect values measured according to reference distances and the direct values measured on subjects' faces were no greater than 1 mm, the reference distance was considered reliable.

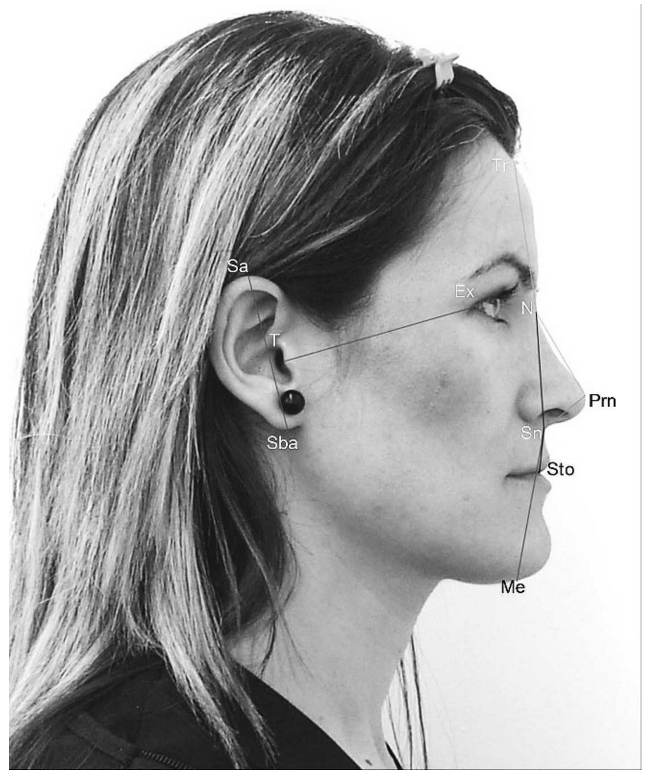

Figure 1. Soft tissue parameters measured on the profile view: T-Ex (tragus-exocanthion) tragus-exocanthion distance, Sa-Sba (superaurale-subaurale) ear length, Tri-N (trichion-nasion) superior facial third, N-Sn (nasion-subnasale) nose height or middle facial third, N-Prn (nasion-pronasale) nasal bridge length, Prn-Sn (pronasale-subnasale) nasal tip protrusion, Sn-Sto (subnasale-stomion) upper lip height, and Sn-Me (subnasale-menton) inferior facial third.

Figure 2. Soft tissue parameters measured on the frontal view: Ex-Ex (right exocanthion-left exocanthion) biocular width, En-En (right endocanthion-left endocanthion) intercanthal width, P-P (midpoint of right pupil-midpoint of left pupil) interpupillary width, Al-Al (right alare-left alare) alar width, Ch-Ch (right cheilion-left cheilion) mouth width, Go-Go (right gonion-left gonion) gonial width, and Sn-Sto (subnasale-stomion) upper lip height.

Statistical Analysis

To determine the differences of reference distances between the female and male subjects, independent sample *t*-test was used. For the profile and frontal measurements in both sexes, differences between the values measured on the subject's face and photograph were calculated with repeated measure analysis of variance (ANOVA). Pair-wise comparisons were made by using Bonferroni correction when the differences between the direct and indirect measurements were statistically significant. To find the reliability of reference distances, Bland- Altman analysis was used. Intra-investigator reliability was assessed with intraclass correlation coefficient for repeated measurements.

RESULTS

The reliability of the investigator was 0.97–0.99 for repeated measurements, indicating excellent reliability.

The sample was divided into two groups as female and male because Sa-Sba, T-Ex, Ex-Ex, En-En, P-P distances were statistically different between the sexes according to the independent samples *t*-test ($P < .05$; Table 1).

Table 1. Comparison of Linear Values (in mm) of Reference Lines Between Male and Female Subjects

	Male (n = 50)		Female (n = 50)		
Reference Line	Mean	SD	Mean	SD	*P*
Sa-Sba	61.42	3.85	56.87	3.44	.00
T-Ex	85.92	3.42	80.89	2.43	.00
Ex-Ex	94.03	3.62	91.09	3.60	.00
En-En	34.11	2.33	33.03	2.60	.03
P-P	48.31	4.44	51.35	3.38	.00

SD indicates standard deviation. $P < .05$.

For profile measurements, the indirect values measured according to the Sa-Sba reference distance were statistically different from the direct values measured on faces of male and female subjects ($P < .05$). In male subjects, the indirect values measured according to the T-Ex distance were statistically different from the direct values measured on subjects' faces ($P < .05$), except for one parameter (Sn-Sto, $P = .91$). In female subjects, the indirect values measured according to the T-Ex distance were also statistically different from the direct values measured on subjects' faces ($P < .05$), except for two parameters (Prn-Sn, $P = .57$; Sn-Sto, $P = .55$) (Table 2).

The indirect values of two parameters (Prn-Sn and Sn-Sto) according to the T-Ex reference distance were reliable in both sexes. In male and female subjects, the indirect values measured according to the T-Ex reference distance were shorter than the direct values measured on subjects' faces and closer to the direct values than the indirect values measured according to the Sa-Sba reference distance in both sexes. The poorest results were obtained in the indirect values of N-Sn parameter for female subjects and Sn-Me parameter for male subjects according to the Sa-Sba reference distance. Among the indirect values measured according to the T-Ex reference distance, the greatest difference was in Sn-Me for male subjects and N-Prn for female subjects (Tables 3 and 4).

For frontal measurements, the indirect values measured according to Ex-Ex, En-En, and P-P distances were statistically different from the direct values measured on subjects' photographs in both sexes ($P < .05$), except for one in male subjects. The indirect values measured according to Ex-Ex and En-En distances were not statistically different from the direct values measured on subjects' faces for the Go-Go parameter ($P = .06$ for Ex-Ex line; $P = .09$ for En-En line) in male subjects (Table 5).

Of the four parameters, the indirect values of Ch-Ch according to the Ex-Ex and En-En reference distances were reliable in male subjects. The indirect values measured according to the En-En reference distance were closer to the direct values measured on subjects' faces in both sexes except for two parameters (Al-Al

Table 2. Soft Tissue Parameters Measured on Subjects' Faces and Photographs From Profile View (in mm)[a]

		Direct Values (A)	Indirect Values According to Sa-Sba (B)	Indirect Values According to T-Ex (C)	*P*		
Parameter	Sex	Mean ± SD	Mean ± SD	Mean ± SD	ABC	AB	AC
N-Sn	Male	56.44 ± 4.09	48.88 ± 4.35	53.17 ± 3.78	.00*	.00*	.00*
	Female	53.29 ± 4.10	46.83 ± 4.05	50.29 ± 3.94	.00*	.00*	.00*
N-Prn	Male	49.99 ± 3.89	42.95 ± 4.21	46.65 ± 3.91	.00*	.00*	.00*
	Female	45.35 ± 4.25	39.34 ± 3.21	42.32 ± 3.24	.00*	.00*	.00*
Prn-Sn	Male	21.33 ± 1.80	18.79 ± 1.55	20.44 ± 1.54	.00*	.00*	.00*
	Female	19.70 ± 1.39	18.08 ± 1.55	19.45 ± 1.58	.00*	.00*	.57
Sn-Sto	Male	22.58 ± 2.47	20.64 ± 2.35	22.43 ± 2.42	.00*	.00*	.91
	Female	20.46 ± 1.78	18.98 ± 1.85	20.37 ± 1.90	.00*	.00*	.55
Sn-Me	Male	74.34 ± 6.06	65.02 ± 5.92	70.62 ± 5.53	.00*	.00*	.00*
	Female	66.07 ± 4.26	60.11 ± 3.67	64.68 ± 4.20	.00*	.00*	.00*

[a] SD indicates standard deviation. $P < .05$.

* Indicates that the direct values measured on subjects' faces are statistically different from the indirect values measured on subjects' photographs according to Sa-Sba and T-Ex lines.

and Sn-Sto) in male and one parameter (Go-Go) in female subjects. The poorest results were obtained according to the P-P reference distance (Tables 6 and 7).

DISCUSSION

Two-dimensional photogrammetry has been used for evaluating the soft tissues in orthodontic treatment. The method was shown to be sufficiently reproducible since it was simple to achieve in a conventional setting, without the need for special equipment.[27,28] Several authors have published the profile and frontal characteristics of the face by collecting the data via anthropometric measurements[6–10] or by using three-dimensional imaging techniques.[15,19,23,25,32] The determination of the reliability of 2-dimensional photogrammetry for soft tissue evaluation might provide clinicians the ability to assess soft tissue from both profile and frontal views after orthodontic treatment.

This study was designed to classify the reliability of the five reference line distances used for photogrammetric assessment on subjects' two-dimensional extraoral photographs obtained under three postural conditions (relaxed lip posture, natural head orientation, and sitting position). Until now, there has been evidence about the usefulness of photographic assessment.[11,28,33–36]

The usefulness of the patients' photographs is limited unless the prints are of standardized view and size. Farkas et al.[37] compared a large number of facial measurements taken from standardized photographs. Determination of absolute sizes on photographs necessitates the calibration of the image such as marking on the subject's face and using a millimeter ruler unless life-size photographs are used. In our study, a basic proportion using reference distances served as a standard of image calibration. To reduce method error, all measurements were made with each subject in natural head orientation,[31] centric relation, sitting position, and relaxed lip posture.[30]

The reliability of the investigator was excellent, indicating that soft tissue landmarks can be located consistently. The arguments for using the ear and eye are that the main development of these parts of the

Table 3. For Profile Measurements, Differences Between the Direct and Indirect Measurements According to T-Ex and Sa-Sba Reference Distances In Male Subjects[d⁻*]

Measurements	$\bar{d}$	SD	Confidence Interval for Agreement: $\bar{d} - 1.96 * SD$	Confidence Interval for Agreement: $\bar{d} + 1.96 * SD$
$N\text{-}Sn_{(direct)} - N\text{-}Sn_{(T\text{-}Ex)}$	3.271	1.360	0.605	5.937
$N\text{-}Sn_{(direct)} - N\text{-}Sn_{(Sa\text{-}Sba)}$	7.563	2.030	3.585	11.541
$N\text{-}Prn_{(direct)} - N\text{-}Prn_{(T\text{-}Ex)}$	3.338	1.495	0.408	6.267
$N\text{-}Prn_{(direct)} - N\text{-}Prn_{(Sa\text{-}Sba)}$	7.034	1.993	3.127	10.942
$Prn\text{-}Sn_{(direct)} - Prn\text{-}Sn_{(T\text{-}Ex)}$	0.891	1.167	−1.396	3.179
$Prn\text{-}Sn_{(direct)} - Prn\text{-}Sn_{(Sa\text{-}Sba)}$	2.547	1.037	0.514	4.580
$Sn\text{-}Sto_{(direct)} - Sn\text{-}Sto_{(T\text{-}Ex)}$	0.155	1.051	−1.906	2.215
$Sn\text{-}Sto_{(direct)} - Sn\text{-}Sto_{(Sa\text{-}Sba)}$	1.942	1.313	−0.632	4.516
$Sn\text{-}Me_{(direct)} - Sn\text{-}Me_{(T\text{-}Ext)}$	3.723	2.579	−1.332	8.779
$Sn\text{-}Me_{(direct)} - Sn\text{-}Me_{(Sa\text{-}Sba)}$	9.325	2.959	3.525	15.124

[d⁻*] $\bar{d}$ indicates mean values of the differences between the direct and indirect measurements; SD, standard deviation.

Table 4. For Profile Measurements, Differences Between the Direct and Indirect Measurements According to T-Ex and Sa-Sba Reference Distances in Female Subjects[a]

Measurements	$\bar{d}$	SD	Confidence Interval for Agreement: $\bar{d} - 1.96 * SD$	Confidence Interval for Agreement: $\bar{d} + 1.96 * SD$
$N\text{-}Sn_{(direct)} - N\text{-}Sn_{(T\text{-}Ex)}$	3.004	2.255	−1.415	7.423
$N\text{-}Sn_{(direct)} - N\text{-}Sn_{(Sa\text{-}Sba)}$	6.454	3.087	0.403	12.505
$N\text{-}Prn_{(direct)} - N\text{-}Prn_{(T\text{-}Ex)}$	3.029	3.085	−3.018	9.075
$N\text{-}Prn_{(direct)} - N\text{-}Prn_{(Sa\text{-}Sba)}$	6.008	3.394	−0.644	12.660
$Prn\text{-}Sn_{(direct)} - Prn\text{-}Sn_{(T\text{-}Ex)}$	0.242	0.879	−1.481	1.966
$Prn\text{-}Sn_{(direct)} - Prn\text{-}Sn_{(Sa\text{-}Sba)}$	1.618	1.068	−0.475	3.712
$Sn\text{-}Sto_{(direct)} - Sn\text{-}Sto_{(T\text{-}Ex)}$	0.090	1.058	−1.984	2.164
$Sn\text{-}Sto_{(direct)} - Sn\text{-}Sto_{(Sa\text{-}Sba)}$	1.488	1.145	−0.757	3.733
$Sn\text{-}Me_{(direct)} - Sn\text{-}Me_{(T\text{-}Ext)}$	1.388	2.972	−4.438	7.214
$Sn\text{-}Me_{(direct)} - Sn\text{-}Me_{(Sa\text{-}Sba)}$	5.954	3.148	−0.217	12.124

[a] $\bar{d}$ indicates mean values of the differences between the direct and indirect measurements; SD, standard deviation.

face occurs in the early ages and are stable during growing.[38–41]

In our study, Sa-Sba, T-Ex, Ex-Ex, En-En, and P-P distances were different between male and female subjects. Therefore, we assessed the subjects separately as male and female.

Of the five parameters obtained from the profile views, the difference between direct and indirect measurements of Prn-Sn and Sn-Sto were less than 1 mm in both sexes according to the T-Ex line. The highest difference was seen in Sn-Me (3.72 mm) for the male group and in N-Prn (3.03 mm) for the female group when the T-Ex reference distance was used. However, the differences between direct and indirect measurements were higher (1.48–9.32 mm) when the Sa-Sba reference distance was used. The poorest results were obtained with the Sa-Sba reference distance. The results of this study for the profile measurements showed that the indirect measurements according to T-Ex distance were closer to direct measurements than the indirect measurements according to the Sa-Sba distance for both sexes. The elasticity of the ear might account for some error during the assessment.

Of the four parameters obtained from the frontal views, the difference between direct and indirect measurements of Ch-Ch was less than 1 mm in male subjects according to the Ex-Ex and En-En reference distances. In contrast to our results, Farkas et al.[37] and Tanner and Weiner[42] showed that the difference between the indirect and direct measurements for Ch-Ch parameter was more than 1 mm. The difference in the other remaining parameters was less than 2 mm except for the parameter Go-Go in female subjects. The differences between direct and indirect measurements were dramatically higher when P-P reference distance was used. It must be kept in mind that all subjects were asked to look straight ahead to a distant point at eye level during the assessment. The use of a stable point might eliminate possible errors resulting from pupils and might give different results. Ras et al.[19] concluded that the best reference line among four reference distances (exocanthion-exocanthion, endocanthion-endocanthion, superalare-superalare, and

Table 5. Soft Tissue Parameters Measured on Subjects' Faces and Photographs From Frontal View (in mm)

Parameter	Sex	Direct Values (A) Mean SD	Indirect Values According to Ex-Ex (B) Mean ± SD	Indirect Values According to En-En (C) Mean ± SD	Indirect Values According to P-P (D) Mean ± SD	P ABCD	P AB	P AC	P AD
Al-Al	Male	37.93 ± 2.60	39.48 ± 2.70	39.60 ± 2.74	29.42 ± 3.19	.00*	.00*	.00*	.00*
	Female	33.94 ± 1.99	35.77 ± 2.32	35.74 ± 2.31	28.87 ± 2.21	.00*	.00*	.00*	.00*
Ch-Ch	Male	52.11 ± 3.07	52.96 ± 3.26	53.03 ± 3.26	39.40 ± 4.01	.00*	.02*	.00*	.00*
	Female	47.99 ± 3.46	49.72 ± 3.71	49.63 ± 3.91	40.24 ± 3.62	.00*	.00*	.00*	.00*
Go-Go	Male	124.37 ± 5.18	122.59 ± 5.75	122.71 ± 5.83	89.87 ± 8.85	.00*	.06	.09	.00*
	Female	118.46 ± 5.72	112.11 ± 6.34	111.96 ± 6.42	90.69 ± 6.50	.00*	.00*	.00*	.00*
Sn-Sto	Male	22.08 ± 2.58	23.63 ± 2.64	23.66 ± 2.66	17.58 ± 2.29	.00*	.00*	.00*	.00*
	Female	20.01 ± 1.72	21.24 ± 1.89	21.19 ± 1.87	17.17 ± 1.84	.00*	.00*	.00*	.00*

SD indicates standard deviation. $P < .05$.

* Indicates that the direct values measured on subjects' faces are statistically different from the indirect values measured on subjects' photographs according to Ex-Ex, En-En, and P-P lines.

Table 6. For Frontal Measurements, Differences Between the Direct and Indirect Measurements According to Ex-Ex, En-En, and P-P Reference Distances in Male Subjects[a]

			Confidence Interval for Agreement	
Measurements	$\bar{d}$	SD	$\bar{d}$ − 1.96 * SD	$\bar{d}$ + 1.96 * SD
$Al\text{-}Al_{(direct)} - A\text{-}Al_{(ex\text{-}ex)}$	−1.552	1.010	−3.531	0.428
$Al\text{-}Al_{(direct)} - Al\text{-}Al_{(en\text{-}en)}$	−1.671	0.988	−3.608	0.266
$Al\text{-}Al_{(direct)} - Al\text{-}Al_{(p\text{-}p)}$	8.504	2.790	3.035	13.973
$Ch\text{-}Ch_{(direct)} - Ch\text{-}Ch_{(ex\text{-}ex)}$	−0.855	2.011	−4.797	3.086
$Ch\text{-}Ch_{(direct)} - Ch\text{-}Ch_{(en\text{-}en)}$	−0.920	1.901	−4.648	2.803
$Ch\text{-}Ch_{(direct)} - Ch\text{-}Ch_{(p\text{-}p)}$	12.707	3.965	4.936	20.478
$Go\text{-}Go_{(direct)} - Go\text{-}Go_{(ex\text{-}ex)}$	1.536	4.261	−6.815	9.887
$Go\text{-}Go_{(direct)} - Go\text{-}Go_{(en\text{-}en)}$	1.429	4.269	−6.939	9.797
$Go\text{-}Go_{(direct)} - Go\text{-}Go_{(p\text{-}p)}$	33.036	8.951	15.492	50.580
$Sn\text{-}Sto_{(direct)} - Sn\text{-}Sto_{(ex\text{-}ex)}$	−1.555	1.369	−4.237	1.128
$Sn\text{-}Sto_{(direct)} - Sn\text{-}Sto_{(en\text{-}en)}$	−1.577	1.339	−4.201	1.046
$Sn\text{-}Sto_{(direct)} - Sn\text{-}Sto_{(p\text{-}p)}$	4.495	1.848	0.874	8.116

[a] $\bar{d}$ indicates mean values of the differences between the direct and indirect measurements; SD, standard deviation.

cheilion-cheilion) was formed by the one which is perpendicular and bisects the line that connects the landmarks exocanthion. However, Farkas et al.[37] found that Ex-Ex was not reliable while En-En was reliable. In our study, the distortion caused by photographing, measuring without previously indicated landmarks on the face, might have accounted for the unreliability of reference distances. Farkas et al.[37] stated that the magnitude of the error depends on the thickness of the soft tissue covering the bony landmark, and measurements of some landmarks (eg, Al, Sa, Sba) may not be precise if photographs are not sharp enough to allow accurate identification of these landmarks.

Our results showed that some of the measurements according to reference distances are less reliable when compared with direct measurements, while few but reliable indirect measurements exist. The measurement precision is important for evaluating the reliability of direct and indirect methods. In this study, the measurement precision was 1 mm. The reliability of our results depends on the clinic sense of the orthodontist. Also, the results could change if life-sized photographs are used.

CONCLUSIONS

- For profile measurements, the T-Ex reference distance is reliable for the indirect values of Prn-Sn and Sn-Sto in both sexes. The poorest results were obtained for the Sa-Sba reference distance and the indirect values of N-Sn parameter in female and Sn-Me parameter in male subjects.
- For frontal measurements, Ex-Ex and En-En reference distances are reliable only for the indirect values of one parameter (Ch-Ch) in male subjects. The poorest results were obtained for the indirect values measured according to P-P reference distance and for Go-Go parameter in both sexes.

Table 7. For Frontal Measurements, Differences Between the Direct and Indirect Measurements According to Ex-Ex, En-En, and P-P Reference Distances in Female Subjects[a]

			Confidence Interval for Agreement	
Measurements	$\bar{d}$	SD	$\bar{d}$ − 1.96 * SD	$\bar{d}$ + 1.96 * SD
Al-Al(direct) − Al-Al(ex-ex)	−1.831	1.331	−4.439	0.778
Al-Al(direct) − Al-Al(en-en)	−1.799	1.517	−4.772	1.174
Al-Al(direct) − Al-Al(p-p)	5.072	1.663	1.813	8.330
Ch-Ch(direct) − Ch-Ch(ex-ex)	−1.729	2.052	−5.751	2.292
Ch-Ch(direct) − Ch-Ch(en-en)	−1.635	2.418	−6.375	3.105
Ch-Ch(direct) − Ch-Ch(p-p)	7.753	2.475	2.903	12.604
Go-Go(direct) − Go-Go(ex-ex)	6.343	4.039	−1.574	14.260
Go-Go(direct) − Go-Go(en-en)	6.497	4.477	−2.277	15.272
Go-Go(direct) − Go-Go(p-p)	27.762	5.953	16.094	39.429
Sn-Sto(direct) − Sn-Sto(ex-ex)	−1.225	1.528	−4.219	1.770
Sn-Sto(direct) − Sn-Sto(en-en)	−1.182	1.484	−4.0192	1.727
Sn-Sto(direct) − Sn-Sto(p-p)	2.842	1.831	−0.748	6.431

[a] $\bar{d}$ indicates mean values of the differences between the direct and indirect measurements; SD, standard deviation.

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